European Commission

JRC SCIENCE FOR POLICY REPORT

Scientific, Technical and Economic Committee for Fisheries (STECF)

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Mediterranean Stock Assessments 2017 part I

(STECF-17-15)

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Joint Research Centre

Report EUR 28359 EN

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JRC109350

EUR 28359 EN

PDF	ISBN 978-92-79-67487-7	ISSN 1831-9424	doi:10.2760/897559
STECF		ISSN 2467-0715	

Luxembourg: Publications Office of the European Union, 2017

How to cite: Scientific, Technical and Economic Committee for Fisheries (STECF) – Mediterranean Stock Assessments 2017 part I (STECF-17-15). Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-67487-7, doi:10.2760/897559, JRC109350

Abstract

Commission Decision of 25 February 2016 setting up a Scientific, Technical and Economic Committee for Fisheries, C(2016) 1084, OJ C 74, 26.2.2016, p. 4–10. The Commission may consult the group on any matter relating to marine and fisheries biology, fishing gear technology, fisheries economics, fisheries governance, ecosystem effects of fisheries, aquaculture or similar disciplines. An Expert Working Group of the STECF on Mediterranean stock assessments was held in Split, Croatia, from 23 - 29 September 2017 A total of 13 area/species combinations were evaluated. The EWG has carried out seven age based analytical assessments with short term forecasts, F target and catch advice for 2018.

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EWG-17-09 report:

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SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES (STECF) - Mediterranean Stock Assessments 2017 part I (STECF-17-15)

The EWG-17-09 report was reviewed during the STECF plenary meeting held in Brussels, 6 to 10 November 2017.

Request to the STECF

STECF is requested to review the report of the STECF Expert Working Group meetings, evaluate the findings and make any appropriate comments and recommendations.

STECF observations

The Expert Working Group was held in Split, Croatia, from 23rd to 29th September 2017. The meeting was attended by 19 experts in total, including 2 STECF members, 2 JRC experts and 1 expert from a non- EU country.

The objective of the EWG 17-09 was to carry out small pelagic stock assessments defined in the ToRs. In line with the previous Mediterranean assessment meeting (STECF-16-17) EWG17-09 had two additional days to answer the ToRs. STECF notes that this additional time was of considerable help, allowing a completion of the assessments and a full review of the work and agreement on conclusions during the meeting.

STECF comments

STECF considers that the EWG successfully addressed all the ToRs. STECF notes that the EWG carefully reviewed the quality of the assessments produced. Some analyses were considered to be suitable for short term forecasts, others were only considered sufficiently reliable to estimate F-status, but no forecast was produced; and one assessment was judged to be too unreliable to determining stock status or to provide advice.

A total of 13 area/species combinations were evaluated (Tables 1 and 2). STECF highlights below the main outcomes by stock. Statements about changes in catches or landings refer to 2018 compared with 2016 following the short-term forecast (Table 2):

- **Anchovy GSA 6** – Fishing mortality is fluctuating at about 1.2 times F_{MSY} and landings should decrease by 14%.
- **Anchovy GSA 7** – Fishing mortality is unknown. Biomass is fluctuating but increasing slowly. Landing should decrease by 7%.
- **Sardine GSA 6** – Fishing mortality has been increasing over the last ten years and it is about 2.5 times F_{MSY}. Landings should decrease by 49%.
- **Sardine GSA 7** - Fishing mortality is unknown. Biomass is relatively stable. Landings should decrease by 46%.
- **Atlantic horse mackerel GSA 1-5-6-7** - Fishing mortality is unknown. Biomass is relatively stable. Landings should decrease by 4%.
- **Anchovy GSA 9-10-11** – Fishing mortality is decreasing, but it is still at 1.5 times F_{MSY}. Catches should decrease by 19%.
- **Sardine GSA 9-10-11** - Fishing mortality is unknown. Biomass is increasing. Landings could increase by 27%.
- **Atlantic Horse mackerel GSA 9-10-11** - Fishing mortality is decreasing, but it is still at 2.5 times F_{MSY}. Catches should decrease by 69%.
- **Anchovy GSA 17-18** – Fishing mortality is increasing and it is 2.3 times F_{MSY}. Catches should decrease by 63%.
- **Sardine GSA 17-18** - Fishing mortality has been increasing over a long period, but it is estimated to have declined in the last two years and is now around 3 times F_{MSY}. Catches should decrease by 61%.
- **Atlantic horse mackerel GSA 17-18-19-20** – Due to data deficiencies no advice can be provided.

- **Anchovy GSA 22** – Stock status is poorly estimated due to lack of data in some years. Fishing mortality is estimated to be close to F_{MSY}. Catch advice is not provided.
- **Sardine GSA 22** – Stock status is poorly estimated due to lack of data in some years. Fishing mortality is estimated to be close to F_{MSY}. Catch advice is not provided.

STECF also points out that additional considerations about biomass reference points B_{lim}, B_{pa} and MSY $B_{trigger}$ for anchovy and sardine in GSA 17-18 are provided in the section 5.7 of this plenary report.

Summary sheets by stock are provided in the EWG report (section 5). The report summarises the available data for each area/species combination; assessment or index analyses and catch options whenever suitable. Where possible, stock status and catch estimates are provided, as well as a short term forecast in terms of changes in F.

The EWG has carried out five age-based analytical assessments with short term forecasts, using a proxy for F_{MSY} target (based on exploitation rate E=F/Z=0.4) and catch advice for 2018 (Sardine in GSA 6, and GSAs 17-18; Anchovy in GSAs 9,10 & 11 and GSAs 17-18 and horse mackerel in GSAs 9-10&11). A full analytic assessment with MSY based catch advice was obtained for another stock using surplus production method (Anchovy in GSA 6). Overall STECF considers these six assessments are suitable for evaluation of stock status and catch advice.

STECF notes that for four stocks (Anchovy in GSA7, Sardine in GSA 7; horse mackerel in GSAs 1, 5, 6 & 7; Sardine in GSA 9 & 10) the data was considered insufficient to run an analytical assessment, but a suitable biomass index was identified for each of these stocks and precautionary catch advice is provided. A precautionary buffer (an additional 20% reduction in catches in 2018) was advised when the length indicator showed the stock was being exploited above MSY. Only in the case of Sardine in GSA 9&10 did the length analysis indicate the exploitation was below MSY.

STECF notes though that there are still a lot of challenges linked with the use of length-based indicators to estimate stock status, as explored in STECF EWG 17-07, and further developments are still required. STECF also notes that for three stocks in this category the disparity between reported catch from biological (MED & Black sea data call) and economic (annual economic report) databases, particularly from France, is contributing to the uncertainty of stock status for these stocks. The reasons for these discrepancies would need to be addressed

STECF notes that for all the stocks in GSAs 6, 7 9, 10 and 11, the time series of data are short; the quality of the assessments was evaluated based on retrospective patterns and the assessment of three stocks were accepted as sufficiently consistent for catch advice. STECF endorses these assessments. STECF also agrees with the use of E=0.4 as a F_{MSY} proxy for these stocks.

STECF notes that for both sardine and anchovy in GSAs 17 and 18, some reservations were made regarding the older landings data (pre 2000). To address this issue both long time series and truncated time series assessments were evaluated and for both stocks the stock status in 2016 and catch advice for 2018 was unchanged by the truncation of the data. The models including the older data showed some improvements in model stability, and the EWG considered that while some of the detail in earlier years might be uncertain the general stock trajectories were important and acceptable and reflected real difference in stock size. Truncation can give a different perception of history, an in line with previous STECF and GFCM assessments the STECF therefore endorsed these options in preference to the truncated data. STECF also notes that there is some uncertainty in aging of anchovy in GSA 17-18, particularly for the surveys. STECF recommends that future work is carried out to adopt a common otolith reading protocol and carry out an intercalibration of age reading. However, STECF considers that the sensitivity tests were carried out and the assessment for anchovy in GSAs 17-18 was found to be robust to the survey aging, and is therefore acceptable for advice.

The initial assessment for anchovy GSA 9, 10 &11 was performed using the full time series of data, but this resulted in a high biomass in the early years, and with no survey data available to confirm these high levels. An assessment using a truncated time series gave very similar results for subsequent years and acceptable retrospective performance. Therefore, the final model was based on truncated data series.

STECF notes that the EWG provides estimates for MSY ranges (Table 3) that are required for Multi-annual management plans, based on regressions calculated on other stocks (mainly from North-East Atlantic waters) for which these ranges have been estimated. STECF considers that full evaluation of MSY ranges requires defining Stock-Recruit relationships or at least biomass limit reference points and recruitment dynamics over the full range of biomass. STECF considers this is not possible for most stocks dealt with in the EWG report due the short time series of data.

STECF considers that E=0.4 provided an effective proxy for F_{MSY} and thus that F_{MSY} and F_{lower} are both implicitly precautionary and can be considered valid MSY estimates that can be used for multi-annual plans directly. STECF recommends that the values of F_{upper} resulting from the calculations should not be used for management purposes. F_{upper} should be limited to F_{MSY} (see Table 3). STECF notes that for most small pelagic stocks assessed in the ICES area, F_{upper} has not been found to be precautionary (ICES, 2015) and for such stocks F_{upper} is equal to F_{MSY}.

Table 1. Summary of work was attempted and basis for any advice. A4A, XSA, and SAM are age based assessment methods; SPiCT is a surplus production model. STF is a standard short term projection with assumptions of status quo F in the intermediate year (2017) and recent historic recruitment for 2017 and 2018.

Area	Species	Previous Analysis / year	Attempted analyses and basis of advice (in bold)
GSA 5-6-7	Anchovy GSA 6	ASPIC with biomass index, /2016	Length indicator, **SPiCT, STF**
	Anchovy GSA 7	ASPIC, XSA /2016	Length indicator, **Biomass Index**
GSA 5-6-7	Sardine GSA6	XSA	Length indicator, **XSA, STF**
	Sardine GSA7	biomass index /2016	Length indicator, SPiCT, **Biomass index**
GSA 1-5-6-7	Atlantic horse mackerel	No assessment /2016	Length indicator, **Biomass index**
GSA 9-10-11	Anchovy	XSA (GSA 9) 2016	Length indicator, **XSA, STF**
GSA 9-10-11	Sardine	SepVPA (GSA 9) 2013	Length indicator, XSA, **Biomass index**
GSA 9-10-11	Atlantic horse mackerel	Biomass Index 2016	Length indicator, **XSA, STF**
GSA 17-18	Anchovy	SAM /2016	Length indicator, **SAM, STF**
GSA 17-18	Sardine	SAM/2016	Length indicator, **SAM, STF**
GSA 17-18-19-20	Atlantic horse mackerel	No assessment	No Assessment or advice
GSA 22-23	Anchovy	ICA, XSA /2012	Length indicator, SPiCT, SAM, **a4a**
GSA 22-23	Sardine	ICA, XSA /2012	Length indicator, SPiCT, SAM, **a4a**

Table 2. Summary of advice from EWG 16-17 by area and species. F 2016 is terminal F in the assessment. Anchovy and sardine in GSA 22 indicate observed catch from the assessment. Change in F is the difference as % change between target F in 2018 and the estimated F for 2016. Change in catch is % change from catch 2016 to catch 2018. Biomass status is given relative to B_{MSY} where available, (only Anchovy GSA 6) and as an indication of trend over the last 3 years for stocks with time series analytical assessments, biomass indices. (^{L} indicated landing only, not catch).

Species	Area	Method/ basis	F 2016	F 2018	Change in F	Catch 2016	Catch 2018	Change in catch	Biomass (status)
Anchovy	GSA 6	SPICT STF F_{MSY}	0.83	0.7	-16%	17830 ^{L}	15387 ^{L}	-14%	82%B_{MSY}
	GSA 7	Biomass Index				1257 ^{L}	1343 ^{L}	+7%	Stable
Sardine	GSA 6	XSA STF E 0.4	1.35	0.53	-61%	1257 ^{L}	1343 ^{L}	-49%	Stable
	GSA 7	Biomass Index				846 ^{L}	453 ^{L}	-46%	Stable
Atlantic horse mackerel	GSA 1-5-6-7	Biomass Index					No Advice	-4%	Increasing
Anchovy	GSA 9-10-11	XSA STF E 0.4	0.41	0.26	-37%	8931^{L}	7222^{L}	-19%	Increasing
Sardine	GSA 9-10-11	Biomass Index				2018	2556	27%	Increasing
Atlantic horse mackerel	GSA 9-10-11	XSA STF E 0.4	0.56	0.23	-59%	3769	1183	-69%	Stable
Anchovy	GSA 17-18	SAM STF E 0.4	1.42	0.57	-58%	33113	12195	-63%	Decreasing
Sardine	GSA 17-18	SAM STF E 0.4	1.30	0.44	-66%	79405	30679	-61%	Decreasing
Atlantic horse mackerel	GSA 17-18-19-20	No assessment							
Anchovy	GSA 22	a4a	0.46	0.47	2%	10610			Increasing
Sardine	GSA 22	a4a	0.50	0.50	-6%	9655			Stable

Table 3. F_{MSY} ranges (F_{low} and F_{upp}) for small pelagic stocks from the Mediterranean. F_{upper} as estimated by EWG 17-09 has been replaced with the value of F_{MSY} because STECF considered that the values of F_{upper} given in the EWG report are not precautionary and should be not used. STECF notes these reference points might need to be re-evaluated in a MSE framework before being used in a multi-annual plans.

GSA	Species	Ref year	F_{MSY}	F_{upper}	F_{low}
GSA 6	Anchovy	2016	0.70	0.70	0.47
GSA 7	Anchovy	2016			
GSA 6	Sardine	2016	0.53	0.53	0.35
GSA 7	Sardine				
GSA 1-5-6-7	Atlantic horse mackerel				
GSA 9-10-11	Anchovy	2016	0.26	0.26	0.18
GSA 9-10-11	Sardine				
GSA 9-10-11	Atlantic horse mackerel	2016	0.23	0.23	0.16
GSA 17-18	Anchovy	2016	0.59	0.59	0.39
GSA 17-18	Sardine	2016	0.44	0.44	0.29
GSA 17-18-19-20	Atlantic horse mackerel				
GSA 22	Anchovy	2016	0.47	0.47	0.31
GSA 22	Sardine	2016	0.50	0.50	0.34

STECF conclusions

STECF acknowledges the EWG was able to address all the terms of reference, completing evaluations by GSA aggregations requested when possible. When available information did not allow the assessment by aggregated GSAs, the assessments were done by GSA separately.

Different assessment methodologies were used depending on data availability and quality. STECF notes that the available data did not allow the EWG to assess Atlantic horse mackerel in GSA 17-18-19-20.

STECF endorses the assessments and general recommendations derived from the EWG.

The STECF notes that the EWG stressed an urgent need to re-evaluate age assignment for the assessment for anchovy in GSA 17-18. STECF agrees with this recommendation aimed adopting a common age reading protocol.

STECF recognises the improvement of the coordination and harmonization among the scientific bodies of FAO-GFCM and EU in the preparation of EWG 17-09, in line with STECF PLEN 16-01 and 16-03 recommendations.

Regarding ToR 10 (providing detailed maps juveniles and spawning aggregations areas at NUTS 2 level), STECF notes that there is no marine equivalent to NUTS 2 on the land. To provide such maps, georeferenced data on the presence of juveniles and spawning adults would be required and these data were not available to the EWG. Only MEDISEH report was available to the EWG, and maps from this report are included in EWG 17-09 report.

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REPORT TO THE STECF

EXPERT WORKING GROUP ON

Mediterranean Stock Assessments 2017 part 1

(STECF 17-09)

Split, Croatia,23-29 September 2017

Executive Summary

The working group was held in Split, Croatia, from 23 - 29 September 2017. The meeting was attended by 18 participants including two JRC experts and one STECF member. The meeting was also attended part time by two Croatian observers.

A total of 13 area/species combinations were evaluated. The EWG has carried out five age based analytical assessments with short term forecasts, MSY based F target and catch advice for 2018. (Sardine in GSA 6, and GSAs 17-18; Anchovy in GSAs 9,10 & 11 and, GSAs 17-18 and horse mackerel in GSAs 9-10&11). Some caution is required in considering the assessment for anchovy GSA 9, 10 &11, the full time series of data resulted in a high biomass coming just from incomplete year classes (not seen as age 0) and with no survey data in those years. A truncated assessment gave very similar results for subsequent years and acceptable retrospective performance, nevertheless the model instability for the early years raise some concerns. A full analytic assessment with MSY based catch advice was obtained for one stock using surplus production method (Anchovy in GSA 6).

Two stocks (anchovy and sardine) from GSA 22 were evaluated with multiple models and an age based assessment was selected to give MSY based stock status but the results were rather uncertain due to missing years of data and due to this uncertainty no catch advice is provided. For four stocks (Anchovy in GSA7, Sardine in GSA 7; horse mackerel in GSAs 1, 5, 6 & 7; Sardine in GSA 9) the data was considered insufficient to run an analytical assessment, but in each case a suitable biomass index was identified for each of these stocks and precautionary catch advice is provided. In the case of sardine in GSA 9, 10 and 11 two assessments were obtained, but these gave rather different perception of the stock, primarily resulting from different growth treatments. As it was not possible to resolve these differences the advice is based on a biomass index, not dependent on this growth. For all the stocks in GSAs 6, 7 and 9, 10 and 11, the time series of data are short; assessments were evaluated based on retrospective performance and three stocks accepted as sufficiently consistent for catch advice. For both sardine and anchovy in GSAs 17 and 18, some reservations were made regarding the older landings data (pre 2000). To address this issue both long time series and truncated time series assessments were evaluated, in both cases the stock status 2016 and catch advice for 2018 was unchanged by the truncation of the data. The models including the older data showed some improvements in model stability, and the EWG considered that while some of the detail in earlier years might be uncertain the general stock trajectories were important and acceptable and reflected real difference in stock size. Truncation can give a different perception of history, an in line with previous STECF and GFCM assessments the EWG therefore endorsed these options in preference to the truncated data. Some uncertainty in aging of anchovy in GSA 17-18 is noted, particularly for the surveys, future work is recommended to explore these further. A number of sensitivity tests were carried out and the assessment for anchovy in GSAs 17-18 were found to be robust to the survey aging.

For most of the stocks the time series of assessments was too short to provide full evaluation of MSY reference points or precautionary biomass limit reference points. In common with sardine and anchovy in GSAs 17 - 18 catch advice for stocks with assessments followed the STECF advice of July 2017 and based MSY advice on the MSY proxy of an exploitation rate of E=0.4. Full evaluation of MSY intervals requires defining Stock-Recruit relationships or at least biomass limit reference points and recruitment dynamics over the full range of biomass. This is not possible for most stocks due the short time series of data, however, MSY ranges have been calculated for stocks where E=0.4 can be evaluated, assuming that this provided an effective proxy for F_{MSY}. In all these cases F_{MSY} and F_{lower} are both explicitly precautionary and can be considered valid MSY estimates that can be used for multi-annual plans directly. The values of F_{upper} resulting from the calculations are considered indicative only, and are not recommended for use without evaluation of precautionary considerations.

1 INTRODUCTION

1.1 Approach to the work

The working group was held in Split, Croatia, from 23th to 29th Sept 2017. The meeting was attended by 18 experts in total, including two STECF members and two JRC experts. The EWG had two observers who attended part time.

The objective of the Mediterranean Methodology EWG 17-02 was to carry out assessments and provide draft advice for stocks identified in the ToR supplied by STECF. An initial plenary session commenced at 09:30 on the first day. The ToRs were discussed and examined in detail.

Stocks were allocated to participants in small groups based on expertise.

An ftp repository was created ad-hoc to share documents, data and scripts and prepare the report.

The stocks were evaluated by the GSA groups identified in the ToRs, but if data were considered to represent diverse stocks within these groups the data and analyses were maintained separately at GSA level.

Plenary sessions were held each day to monitor progress and share results. The overall conclusions of each ToR/stock were discussed and finalized in plenary on the last day.

1.2 Terms of Reference for EWG-17-09

DG MARE focal persons: Chato Osio

Chair: John Simmonds

GENERAL GUIDELINES: unless the data used and information provided comes from the official DCF data calls, the experts are requested to indicate the data source from where certain information has been taken (e.g. L-W relationships, prices) or if it is an experts' reasoned guess. Data collected outside the DCF shall be used as well and merged with DCF data whenever necessary and following quality check. Due account shall also be given to data used and assessments carried out within the FAO regional projects co-funded by the European Commission and EU-Member States in particular when using data collected through the DCF/DCR and EU funded research projects, studies and other types of EU funding. The raw data used to generate the input data, assessment scripts as well as input files should be made available to the JRC for reproducibility of the assessments and documentation.

For the stocks given in Annex I, the EWG 17-09 is requested:

ToR 1. To compile and provide the most updated information on stock identification and boundaries, length and age composition, growth, maturity, feeding, essential fish habitats, and natural mortality.

ToR 2. To compile and provide complete sets of annual data on landings and discards for the longest time series available up to and including 2016. This should be presented by fishing gear as well as by size/age structure (see Annex II for more details).

ToR 3. To compile and provide complete sets of annual data on fishing effort for the longest time series available up to and including 2016. This should be described in terms of amount of vessels, time (days at sea, soaking time, or other relevant parameter) and fishing power (gear size, boat size (linear and/or GT), engine power kW, etc.) by Member State and fishing gear. Data shall be the most detailed possible to support the establishment of a fishing effort and/or capacity baseline (see (Annex II for more details).

ToR 4. To Compile and provide indices of abundances and biomass by year and size/age structure for the longest time series available up to and including 2016 (see Annex II for more details).

ToR 5. To assess trends in historic and recent stock parameters on fishing mortality, stock biomass, spawning stock biomass, and recruitment. Different assessment models should be applied as appropriate, including retrospective analyses. The selection of the most reliable assessment shall be explained. Assumptions and uncertainties shall be specified.

ToR 6. To estimate candidate MSY point-value, MSY range values and conservation reference points (precautionary and limit) in terms of fishing mortality and stock biomass. The proposed values shall be related to long-term high yields and low risk of stock/fishery collapse and ensure that the exploitation levels restore and maintain marine biological resources at least at levels which can produce the maximum sustainable yield.

ToR 7. To provide short and medium term forecasts of spawning stock biomass, stock biomass and catches. The forecasts shall include different management scenarios, *inter alia*: zero catch, the status quo fishing mortality, and target to F_{MSY} (including the ranges) or other appropriate proxy by 2020. In particular, on the basis of the average commercial catch rates, estimate the level of fishing effort exerted by the different fleets which is commensurate with the short- and medium-term forecasts of the proposed scenarios.

ToR 8. To summarize and concisely describe all data quality deficiencies, including possible limitations with the surveys of relevance for stock assessments and fisheries. Such review and description are to be based on the data format of the official DCF data call for the Mediterranean Sea launched on the March 2017. Identify further research studies and data collection which would be required for improved fish stock assessments. This review shall be presented in a manner that is compatible with the online platform developed by the JRC for data issues[1].

ToR 9. To provide a synoptic overview of: (i) the fishery; (ii) the most recent state of the stock (spawning stock biomass, stock biomass, recruits, and exploitation level by fishing gear); (iii) the source of data and methods and;

(iv) the management advice, including MSY value, range of values and conservation reference points.

ToR 10. To provide detailed maps at NUTS 2 level and related table of correspondence with relevant spatial coordinates, of:

The recurrent areas of juveniles' aggregations

a) 1st-year juveniles;

b) Juveniles equal to or smaller than the minimum conservation reference size

The recurrent spawning aggregations areas

1 Castro Ribeiro C. (2015) Fisheries Data Collection Framework - The DCF Reporting and Implementation Cycles and the Data End-user Feedback, JRC Technical report.

ToR ANNEX I: Table I – List of suggested stocks to be assessed by the EWG 17-09

Area	Common name	Scientific name
GSA 5-6-7	Anchovy	*Engraulis encrasicolus*
GSA 5-6-7	Sardine	*Sardina pilchardus*
GSA 1-5-6-7	Atlantic horse mackerel	*Trachurus trachurus*
GSA 9-10-11	Anchovy	*Engraulis encrasicolus*
GSA 9-10-11	Sardine	*Sardina pilchardus*
GSA 9-10-11	Atlantic horse mackerel	*Trachurus trachurus*
GSA 17-18	Anchovy	*Engraulis encrasicolus*
GSA 17-18	Sardine	*Sardina pilchardus*
GSA 17-18-19-20	Atlantic horse mackerel	*Trachurus trachurus*
GSA 22-23	Anchovy	*Engraulis encrasicolus*
GSA 22-23	Sardine	*Sardina pilchardus*

2 FINDINGS AND CONCLUSIONS OF THE WORKING GROUP

A total of 13 area/species combinations were evaluated. The EWG has carried out seven age based analytical assessments with short term forecasts, F target and catch advice for 2018.

2.1 STOCK-SPECIFIC FINDINGS & CONCLUSIONS

A range of analyses were considered for all stocks based on data available to the meeting (Table 2.1). Analytical age based assessments and surplus production catch based assessments were attempted, and where these were found by the EWG to be of sufficient standard they have been used as the basis for advice; see Section 5 and the summary values in Table 2.2.

Length analyses were carried out for all species/areas where sufficient length data was available. Where relevant the results of these length analyses are included in the stock evaluations in Section 6, and the full set are given in Annex 1. The length methods applied in EWG 17-09 followed the methods used in EWG 16-13 and 17-02 which were calculated based on L_c (length at first capture on fitted 25 percentile on catch), which gave results that were much better coupled to the observed length distributions. Sensitive of resulting MSY index (L_{FeM}) is still known to be sensitive to assumptions on L infinity (L_{inf}) expert judgement was used and L_{inf} values were carefully selected for each stock.

A brief resume of the assessments and any issues are given below by area.

2.1.1 GSA 5, 6 & 7

There were conflicting signals in GSA 6 and 7 for both sardine and anchovy questioning the suitability of a single assessment, with insufficient data to evaluated GSAs 5. Evaluations of sardine and anchovy were therefore carried out separately for GSAs 6 and 7. For horse mackerel the data was sparse and variable so the area was taken as a single unit.

The assessment for sardine in GSA 6 was carried out using XSA, the assessment which was based on catch 95% of which comes from the purse sein fleet and an acoustic sur vey tuning index was considered acceptable for advice, and catch options were calculated using a standard short term forecast. For sardine in GSA 7 it was not possible to obtain a stable assessment, there was a divergence of SPiCT results when comparing recent series and full time series of acoustic biomass estimates, with no basis for selecting amongst these two options. Given the poor performance of the assessment the advice for Sardine in GSA 7 was based on the recent 5 years of the biomass index from the acoustic survey, using the ICES methodology with noise and precautionary buffers.

A long time series of catch data was available for anchovy in GSA 6 a surplus production model based on SPiCT with a STF was used for advice, as this was judged to fit the data well. In contrast with only a short time series anchovy on GAS 7 was treated in a similar way to sardine there was divergence of signal between survey and catch. For this area there was no times series on effort (only 2 years supplied), and without effort data it was not possible to explain low catch in the production model, and with only a few ages in the catch data an age based assessment cannot be fitted to the data. So similar to sardine in GSA 7 the advice is based on an acoustic survey time series biomass index, following the ICES method.

For horse mackerel the taken as a whole Spanish data appears well reported, there are diverse indications of the level of French catches and no sampling. It seems likely that despite poor reporting in the biological data, economic data suggest France take at least 20% of the catch for which there is little or no data provided. Due to this substantial and different fishery being poorly reported a full assessment could not be carried out. The MEDITS survey time series of biomass is coherent with Spanish catches; the survey shows strong recruitment and increasing biomass, mean weight and mean length from 2004, which corresponds to increasing catches. Based on these observations the advice is based on the MEDITS survey time series biomass index, following the ICES method.

2.1.2 GSA 9, 10 & 11

An assessment for sardine in 9, 10 and 11 was attempted; the results depended strongly on the different interpretations of individual growth. The different outcomes based on different growth interpretations are:

- Age length applied directly: low exploitation, which is really too low for good estimation in an based age assessment as F is calculated as 10% of M.
- Fitted a growth curve with t_0 constrained to expected values (higher or equal to -0.2) and the slicing length to ages gives substantially higher exploitation.

However, as there is no directed fishery and low catches and the length range in catch is consistent with lightly exploited sardine stock, this second assessment does not seem to be reasonable and is heavily dependent on the interpretations of individual growth. Given the current uncertainty in the assessment, the use of the survey index and advice based on the ICES approach gives a cautious response to uncertain but potentially optimistic situation.

The assessment for anchovy in GSA 9, 10 & 11 based on XSA is considered to be an acceptable assessment for advice, and catch options are provided using a STF.

For horse mackerel in GSA 9, 10 and 11 there are some catches without samples in particular there is missing information and high variability in discards requiring some filling in for poorly sampled fleet segments, though overall the catch appears to be sufficiently well documented for an assessment. The assessment for horse mackerel in GSA 9, 10 & 11 is based on XSA and is found to be quite stable (good retrospective performance) and considered to be an acceptable for advice, catch options are provided using a STF.

2.1.3 GSA 1718

Two assessments were carried out for Sardine in GSA 17 &18 using SAM. One used only recent data, and one the full time series. These assessments were similar to those at GFCM, but with Q at age in the survey set independently for each age, as examination of residuals showed that when adjacent ages were coupled bias was introduced in all years for each couple year classes. The overall fit improves and the extra survey q parameters were found to be acceptable statistically. Recent period data, uncertainties in historic data, short and long assessment show same trends for recent period, catch advice robust to both situations. The long time series is preferred by the EWG as it gives some idea of history stock; however it noted that it is more uncertain during that period, particularly for age structure, as historic length structure in catch is used. Overall the long term assessment is considered to best represent the stock and this with a STF was used as the basis of the advice.

Several assessments were carried out for anchovy in GSA 17 & 18 using SAM. As with sardine short and long assessment show same trends for recent period, catch advice robust to both situations. Long time series give some idea of history stock, but is more uncertain during that period, particularly for age structure. For anchovy in GSA 17 & 18 there is uncertainty about age structure in both recent and historic period, particularly for the survey. The survey data and catch data do not appear to be well aligned in terms of age at length. A number of options were tested to explore these differences. The current assessment based on age data supplied to the EWG is robust to different options for age in survey. The resulting assessment give very smooth year on year recruitment which probably results from difficulties in age allocation, in this situation the numbers at age in the catch are dominating the assessment age structure, and these appear to be the most consistent (see section 3.1). Overall the stock status and catch advice is robust to the range of options tested and is therefore considered suitable for advice. Catch options are provided by a STF.

For horse mackerel in GSA 17, 18, 19 &20 it was not possible to obtain a coherent time series of catch and the MEDITS survey did appear to give any clear signals. Data was missing from GAS 20. Overall there was insufficient data to give advice for this species in these areas.

2.1.4 GSA 22 (AND 23)

No data was available for area 23 and data only limited catch data from Turkey was available for GSA 22. Most of the analyses were based on recent and intermittently sampled data from the Greek fisheries and surveys in part of GSA 22.

For sardine in GSA 22 several assessments carried out using SPiCT, SAM and a4a. In both age based models difficulties were encountered due total lack of length/age structure and surveys 2007 and 2009-12 and only partial coverage in 2013 and 2015. Overall the results from these analyses are necessarily uncertain but are coherent across the three assessments (a4a SAM and SPiCT). The a4a assessment appears to deal with missing data most appropriately and is the preferred evaluation. Indications are that exploitation is above possible MSY reference points. The assessment suggests than biomass is low and some reduction in F / catch is required but the amount of reduction cannot be estimated. As stock status in terms of biomass and F are uncertain numerical catch advice for 2018 is not provided.

For anchovy in GSA 22 several assessments carried out. As with sardine, difficulties were encountered due total lack of length/age structure and surveys 2007 and 2009-12 and partial coverage in 2013 and 2015. Results are uncertain but coherent across two assessments (a4a and SAM), however, the biomass model over the longer time series was unstable, and so the results are more uncertain than for sardine in GSA 22. Both the age based assessments indicate that SSB is increasing since 2000, suggestion that F lower for anchovy compared with sardine in GSA 22. As stock status in terms of biomass and F are uncertain numerical catch advice for 2018 is not provided.

The signals for anchovy and sardine are different, but as both sardine and anchovy in GSA 22 are caught by the same vessels separate management may be difficult.

Table 2.1 Summary of work was attempted and basis for any advice. A4A, XSA, and SAM are age based assessment methods; SPiCT is a surplus production model. STF is a standard short term projection with assumptions of status quo F in the intermediate year (2017) and recent historic recruitment for 2017 and 2018.

Area	Species	Previous Analysis / year	Attempted analyses and basis of advice (in bold)
GSA 5-6-7	Anchovy GSA 6	ASPIC with biomass index, /2016	Length indicator, **SPiCT, STF**
	Anchovy GSA 7	ASPIC, XSA /2016	Length indicator, **Biomass Index**
GSA 5-6-7	Sardine GSA6	XSA	Length indicator, **XSA, STF**
	Sardine GSA7	biomass index /2016	Length indicator, SPiCT, **Biomass index**
GSA 1-5-6-7	Atlantic horse mackerel	No assessment /2016	Length indicator, **Biomass index**
GSA 9-10-11	Anchovy	XSA (GSA 9) 2016	Length indicator, **XSA, STF**
GSA 9-10-11	Sardine	SepVPA (GSA 9) 2013	Length indicator, XSA, **Biomass index**
GSA 9-10-11	Atlantic horse mackerel	Biomass Index 2016	Length indicator, **XSA, STF**
GSA 17-18	Anchovy	SAM /2016	Length indicator, **SAM, STF**
GSA 17-18	Sardine	SAM/2016	Length indicator, **SAM, STF**
GSA 17-18-19-20	Atlantic horse mackerel	No assessment	No Assessment or advice
GSA 22-23	Anchovy	ICA, XSA /2012	Length indicator, SPiCT, SAM, **a4a**
GSA 22-23	Sardine	ICA, XSA /2012	Length indicator, SPiCT, SAM, **a4a**

Table 2.2 Summary of advice from EWG 16-17 by area and species. F 2016 is terminal F in the assessment. Anchovy and sardine in GSA 22 indicate observed catch from the assessment. Change in F is the difference as % change between target F in 2018 and the estimated F for 2016. Change in catch is % change from catch 2016 to catch 2018. Biomass status is given relative to B_{MSY} where available, (only Anchovy GSA 6) and as an indication of trend over the last 3 years for stocks with time series analytical assessments, biomass indices. (^{L} indicated landing only, not catch).

Species	Area	Method/ basis	F_{2016}	F_{2018}	Change in F	Catch $_{2016}$	Catch $_{2018}$	Change in catch	Biomass (status)
Anchovy	GSA 6	SPICT STF Fmsy	0.83	0.7	-16%	17830^{L}	15387^{L}	-14%	$82\%B_{MSY}$
	GSA 7	Biomass Index				1257^{L}	1343^{L}	+6.8%	Stable
Sardine	GSA 6	XSA STF E 0.4	1.35	0.53	-61%	1257^{L}	1343^{L}	-49%	Stable
	GSA 7	Biomass Index				846^{L}	453^{L}	-46%	Stable
Atlantic horse mackerel	GSA 1-5-6-7	Biomass Index				Not Known	No Advice	-4%	Increasing
Anchovy	GSA 9-10-11	XSA STF E 0.4	0.41	0.26	-37%	8931^{L}	7222^{L}	-19%	Increasing
Sardine	GSA 9-10-11	Biomass Index				2018	2556	27%	Increasing
Atlantic horse mackerel	GSA 9-10-11	XSA STF E 0.4	0.56	0.23	-59%	3769	1183	-69%	Stable
Anchovy	GSA 17-18	SAM STF E 0.4	1.42	0.57	-60%	34252	12195	-64%	Decreasing
Sardine	GSA 17-18	SAM STF E 0.4	1.45	0.44	-70%	79405	30679	-61%	Decreasing
Atlantic horse mackerel	GSA 17-18-19-20	No assessment							
Anchovy	GSA 22	a4a	0.46	0.47	2%	10610	No Advice		Increasing
Sardine	GSA 22	a4a	0.53	0.53	0%	9655	No Advice		Stable

2.2 DISTRIBUTION OF JUVENILES AND SPAWNING AREAS

> ***ToR 10.*** *To provide detailed maps at NUTS 2 level and related table of correspondence with relevant spatial coordinates, of:*
>
> *1) The recurrent areas of juveniles' aggregations*
>
> *a) 1st-year juveniles;*
>
> *b) Juveniles equal to or smaller than the minimum conservation reference size*
>
> *2) The recurrent spawning aggregations areas*

Detailed information about juveniles and spawning ground in the Mediterranean basin has been done through project MEDISEH. (Giannoulaki et al 2013). The main objective of this work was identification of the juvenile and spawning grounds of certain small pelagic fish species within the Mediterranean basin. Following species have been analysed: *Sardina pilchardus, Engraulis encrasicolus, Trachurus trachurus, Trachurus mediterranaeus, Scomber scomber and Scomber colias*). For this purpose habitat suitability modelling was applied, that relates abundance information from surveys with environmental variables.

In order to identify the appropriateness all available surveys were taken (taking in mind the temporal overlap between the available surveys per area and the spawning / recruitment period for the target species in question). According to the report the available data was not sufficient to define spawning grounds for Scomber scombrus and Trachurus trachurus.

Ichthyoplankton surveys data were used for the identification and the modelling of spawning grounds of *Engraulis engraulis* and *Sardina pilchardus*. Data from different acoustic surveys performed in the Mediterranean were used for the identification and the modelling of nursery grounds of *Engraulis engraulis* and *Sardina pilchardus* while MEDITS trawl surveys data were used for the identification and the modelling of nursery grounds of Trachurus trachurus.

Maps of likely annual nursery and spawning area were obtained for the whole Mediterranean for all species. Additionally, a persistence map was defined to describe preferential (high mean, low std), occasional (high mean, high std) and rare (low mean, low std) juvenile and spawning grounds.

Short overview of MEDISEH project findings regarding spawning and nursery areas for *Sardine pilchardus, Engraulis encrasicolus and Trachurus trachurus* are given in the following text.

Engraulis encrasicolus

Spawning grounds

In the Aegean Sea besides the northern part and the coastal areas within gulfs spots with high probability of *Engraulis encrasicolus* eggs were also identified in the coastal areas of Asia Minor, along the Turkish coasts. In the Adriatic Sea areas with higher probability of Engraulis encrasicolus spawning were consistently indicated in the northern and the western part of the basin as well as around the coastal waters of the mid-Dalmatian islands in the eastern part. In the Strait of Sicily potential spawning grounds were consistently indicated along the coastal waters of Sicily, being more extended in the west and east. In the western Mediterranean, suitable spawning areas were located in the Gulf of Lions and off the Catalan coast, the Alboran Sea and to a lesser extent the Italian coasts of the Ligurian and Tyrrhenian Seas (Figures 2.2.1- 2).

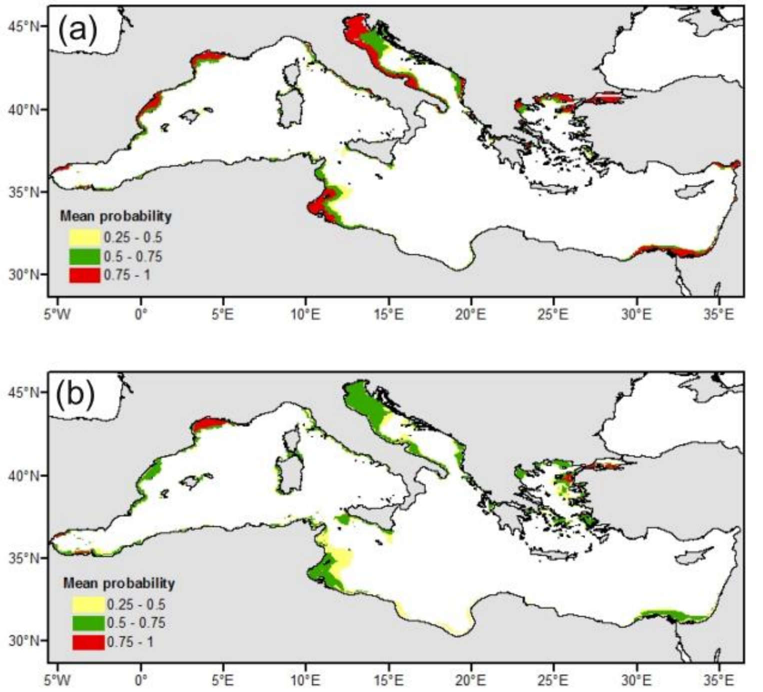


Figure 2.2.1 Mean probability maps of Engraulis encrasicolus spawning (egg) habitat in the Mediterranean Sea for the period 2003-2008. (A). June (B) July

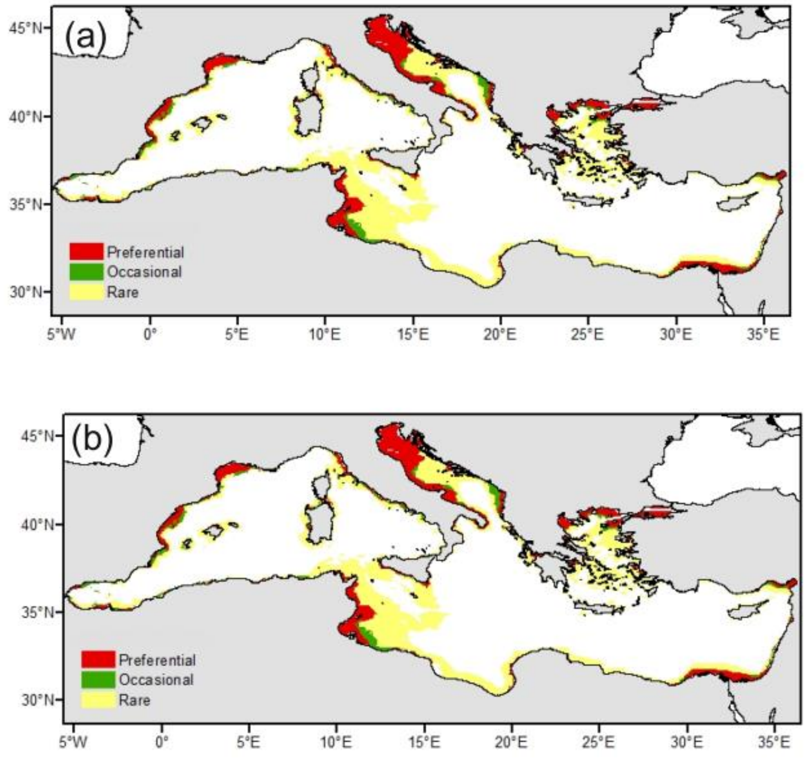


Figure 2.2.2 Persistent habitat maps of Engraulis encrasicolus spawning (egg) habitat in the Mediterranean Sea for the period 2003-2008. (A). June (B) July

Nurseries grounds

In the Western Mediterranean suitable nursery areas were identified in association with the outflow of the Rhone river in the Gulf of Lions and the Ebro river southwards in the Spanish waters. In the Adriatic Sea, suitable nurseries were located in the inner part of the continental shelf in the coastal part of the basin. They were closely associated with the Po river outflow area, also extending southwards along the coasts of the western and the eastern part of the Adriatic Sea. Suitable areas in the Strait of Sicily were also located in coastal waters being wider in the north and south part where the continental shelf is wider (Figures 2.2.3-4).

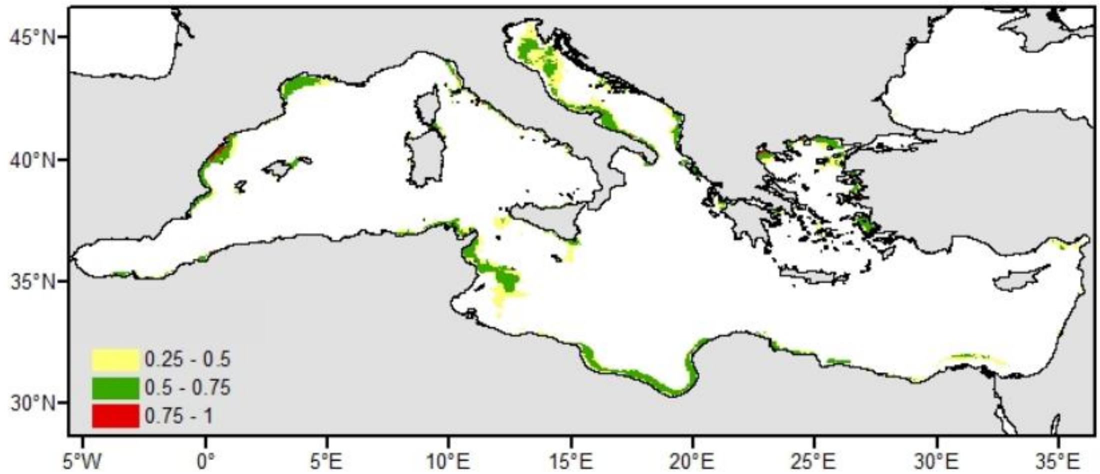


Figure 2.2.3 Mean probability maps of *Engraulis encrasicolus* nurseries habitat in the Mediterranean Sea for the period 2003-2008 during late autumn

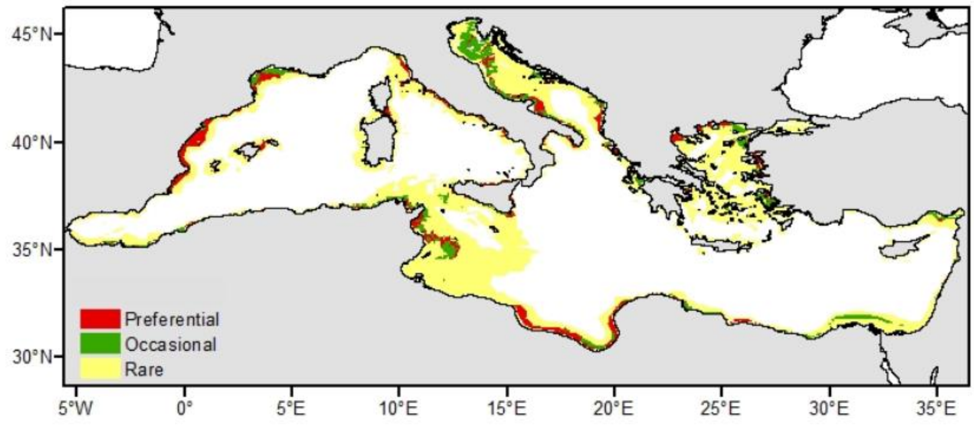


Figure 2.2.4 Persistent habitat maps of *Engraulis encrasicolus* nurseries in the Mediterranean Sea for the period 2003-2008 during late autumn

Sardina pilchardus

Spawning grounds

In the western Mediterranean areas suitable for *Sardina pilchardus* spawning were consistently identified in the surroundings of the Ebro River Delta and the North Alboran, a pattern that matches the past *Sardina pilchardus* spawning grounds in the Spanish waters. In the eastern part of the Mediterranean areas suitable for *Sardina pilchardus* spawning were identified inside the gulfs and the inshore waters of the North Aegean Sea. In the Adriatic, potential spawning grounds of Sardina pilchardus were indicated in the extended continental shelf of the North Adriatic as well as in the coastal waters of the western and the eastern part (Figures 2.2.5-6)

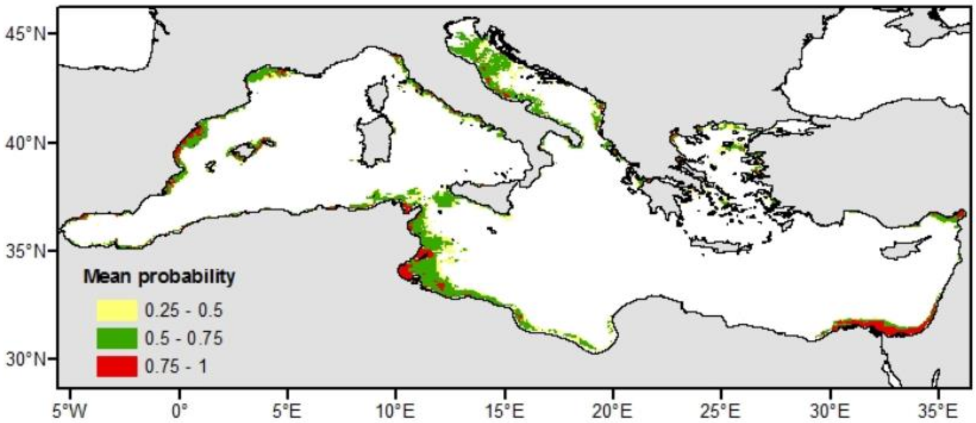


Figure 2.2.5 Mean probability maps of *Sardina pilchardus* spawning (egg) habitat in the Mediterranean Sea for the period 2003-2006 during early winter

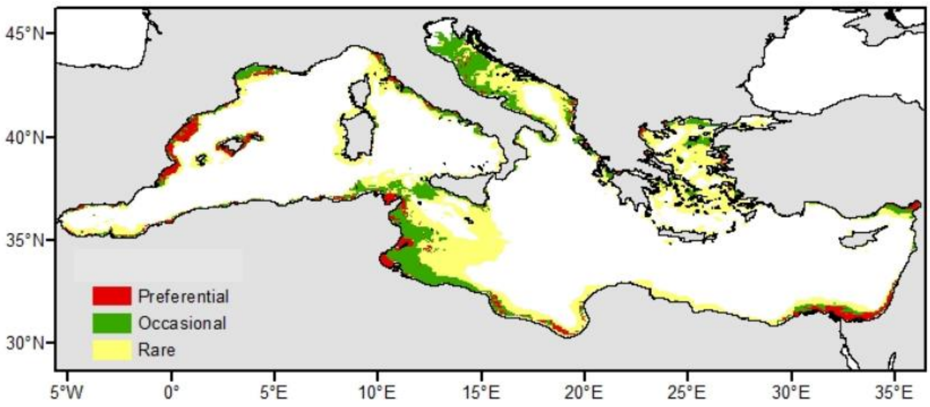


Figure 2.2.6 Persistent habitat maps of *Sardina pilchardus* spawning (egg) habitat in the Mediterranean Sea for the period 2003-2006 during early winter

Nurseries grounds

The areas with high probability of *Sardina pilchardus* juvenile presence were located in the coastal waters of the Gulf of Lions, the Catalan Sea, the northern part of the Adriatic Sea, the coastal waters of the western and eastern Adriatic, and the gulfs and coastal waters of the North Aegean Sea. Other suitable areas were indicated in the coastal waters of Morocco, Algeria, Tunisia and Libya and in the Eastern Mediterranean along the Egyptian coastline, mainly off the Nile River Delta. Locations presenting high variability as *Sardina pilchardus* nurseries were the coastal waters of the North Alboran Sea, the Sicily Channel, the western part of the Italian peninsula, the Cretan shelf in Greek seas and areas along the coastline of Levantine. These areas seem to represent occasionally suitable locations for *Sardina pilchardus* juveniles (Figures 2.2.7-8).

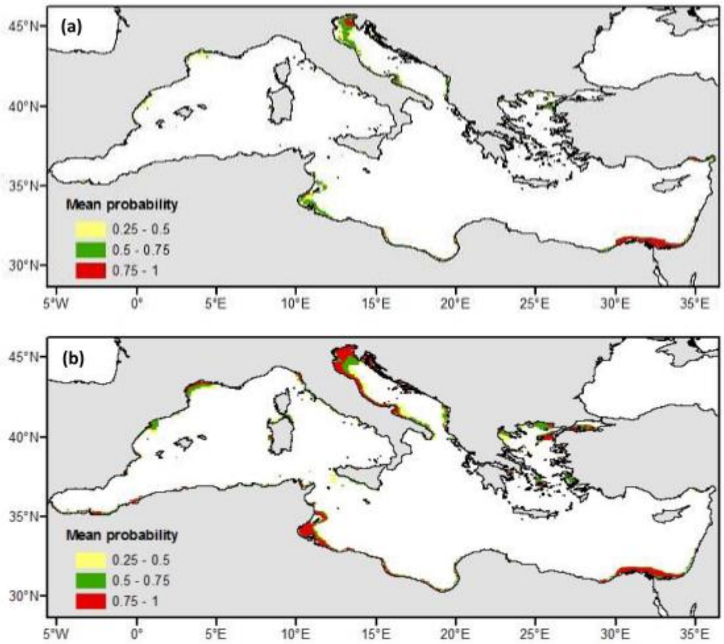


Figure 2.2.7 Mean probability maps of juvenile *Sardina pilchardus* habitat in the Mediterranean Sea for the period 2003-2008 in (a) June and (b) July

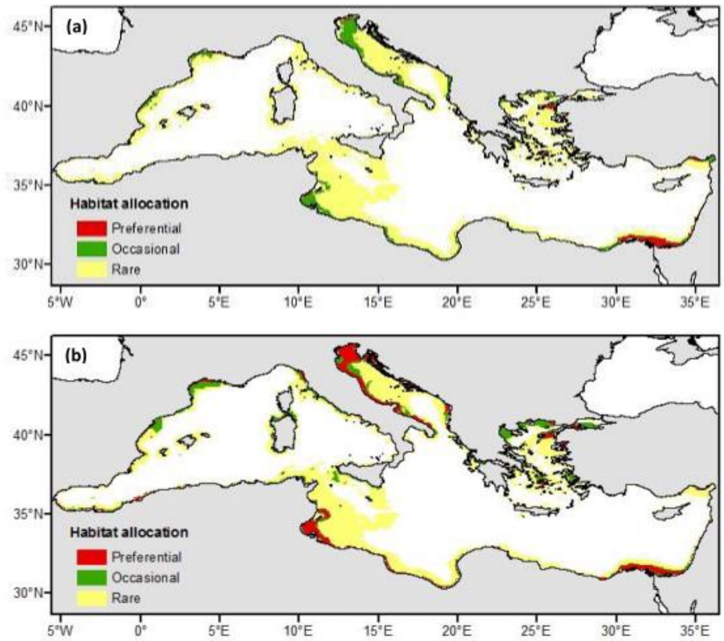


Figure 2.2.8 Persistent habitat maps of juvenile *Sardina pilchardus* habitat in the Mediterranean Sea for the period 2003-2008 in (a) June and (b) July

Trachurus trachurus

Nurseries grounds

In the western Mediterranean areas suitable for *Trachurus trachurus* nurseries were consistently identified in the northern part of the Catalan Sea, surroundings of the Ebro River Delta and the Baleares plateau, the Gulf of Lions and the coastal waters of Tyrrhenian Sea. In the Strait of Sicily suitable nurseries are indicated in the Malta plateau and the north-western part. In the Adriatic Sea, potential nurseries were indicated in the central area of the basin, covering consistently the coastal waters of both the western in the inshore waters of Thracian Sea and also inside closed gulfs like Saronikos, South Evoikos Gulf (Central Aegean) and Patraikos gulf (Ionian Sea).). Further areas were indicated in the western part of Aegean Sea along the Turkish coastal waters. In the south suitable nurseries were shown near the Nile Delta and in the offshore waters of Tunisia and the eastern part. The Mediterranean areas suitable for nurseries are shown in Figures 2.2.9-10.

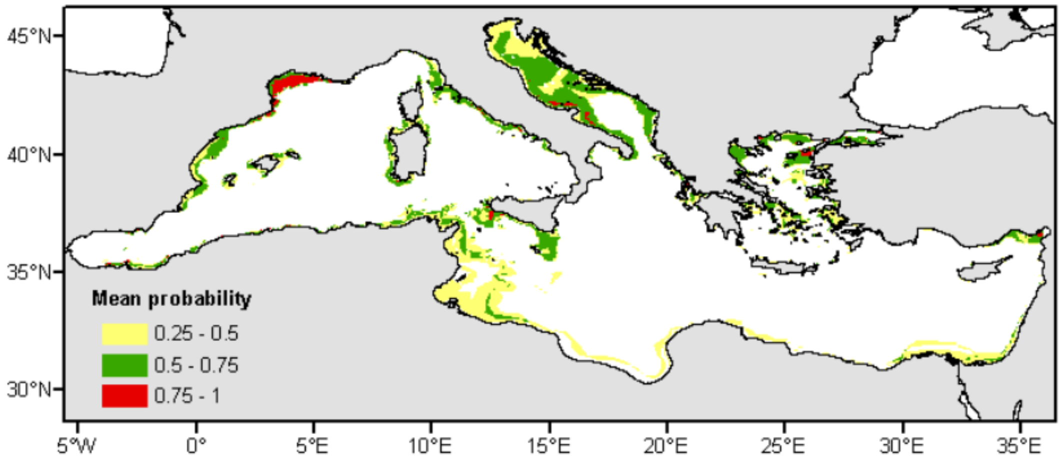
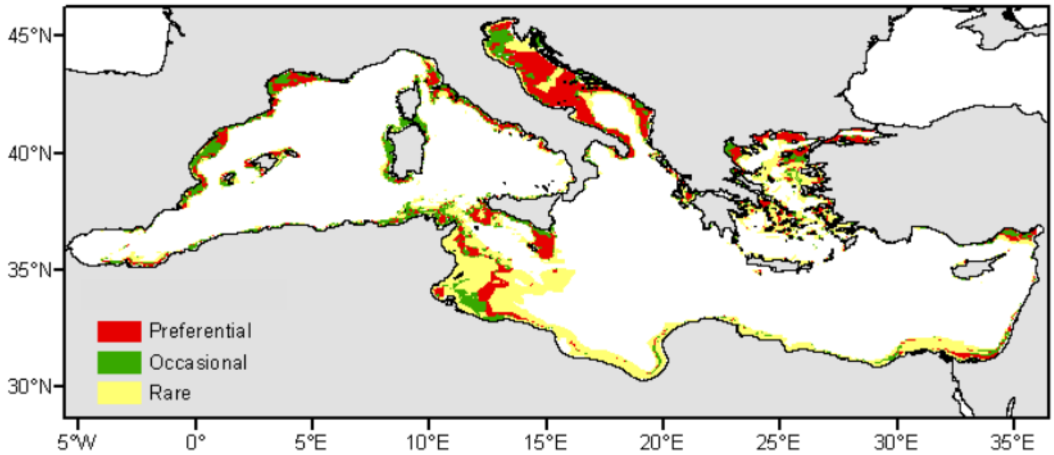


Figure 2.2.9 Mean probability maps of *Trachurus trachurus* nurseries in the Mediterranean Sea for the period 2000-2010 during summer



Figures 2.2.10 Persistent habitat maps of *Trachurus trachurus* nurseries in the Mediterranean Sea for the period 2000-2010 during summer

Comments on NUTS 2 maps

According to the current NUTS 2 classification (Nomenclature of territorial units) in the Mediterranean area which cover GSAs included in this ToR (GSA 1, 5, 6, 7, 9, 10, 11, 17, 18, 19, 20, 22 and 23), there are totally 44 different NUTS2 areas (Spain 5; France 3; Croatia 1; Italy 15; Slovenia 1; Montenegro 1, Albania 1, Greece 12 and Turkey 5) (Figure 2.2.11)

Figure 2.2.11 The NUTS 2 map in the Mediterranean area

The borders of NUTS2 do not correspond with border of GSAs other than to the national administrative borders (Figure 2.2.11-12). Due to this, some NUTS2 boarder two GSA, and vice-versa.

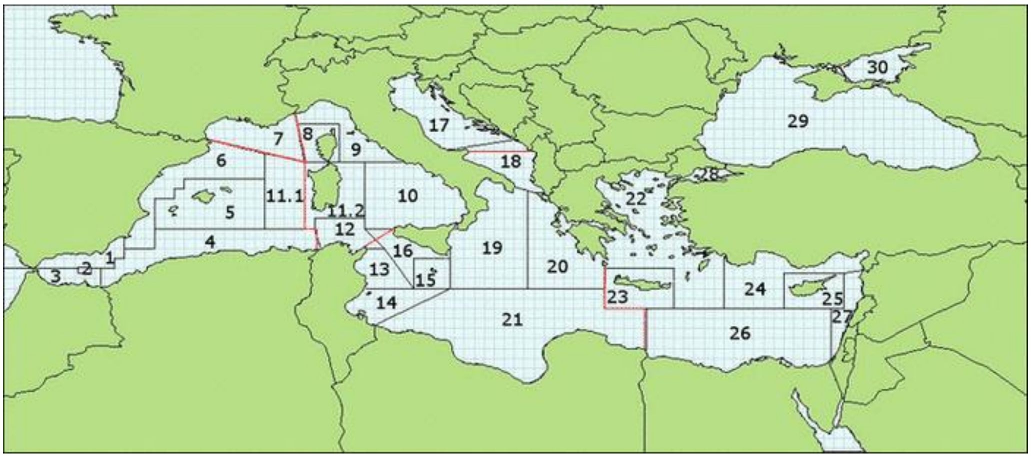


Figure 2.2.12 Map of GSA in the Mediterranean Sea

In the official maps of the NUTS2 area borders between certain NUT2 areas are defined only on the land and it is not clear which surface of the sea belong to the which NUTS2 area. In the case when only one NUTS2 area is per county, or on the boundary between two countries it is possible to use national median lines to infer NUTS2 boarders in marine areas.

Availability of other georeferenced data for identification of spawning and nursery area

Data collections through DCF are organized on the national or/and GSA level. Because of that, it is very difficult to make analyses on the NUTS 2 level using those data, especially in the case when some national NUTS2 units area has a very small surface (with low intensity of survey sampling) or in case when some NUTS2 area are divided between two GSA.

For species mentioned in the ToR 10 georeferenced data exist only through MEDITS survey and only partially. For *Sardina pilchardus* and *Engraulis encrasicolus* there is georeferenced data for biomass and abundance index and length frequency distribution. Data of age, sex and maturity stages are not collected through MEDITS. For Trachurus trachurus there is data on biomass and density indices, length frequency composition and sex and age information. Problem related with ToR10 with MEDITS data is that those data are collected only in late spring and summer period (end of May, June and July), so period of this survey is not appropriate for determination of spawning ground for *Sardina pilchardus* and *Trachurus trachurus* as these species spawn in winter.

MEDIAS surveys are organized for data collection of small pelagic species. There is three set of data: acoustic data, oceanographic data and trawl fish sampling data obtained by using pelagic trawl net. All data are georeferenced. Data collected during MEDIAS surveys include catch composition (biomass and number) as well as length frequency distribution and sex and maturity stages of target species. Despite the fact that all data collected by MEDIAS surveys are geo-referenced, these georeferenced data are not available to EWG17-09 through the data call. According to data call, only abundance and biomass data are available, with no other spatial information than GSAs are requested.

Additional problem of use MEDIAS data for ToR10 purposes is that those data are collected in periods not covering spawning season of Sardina pilchardus and Trachurus trachurus (winter period).

Conclusion ToR10

The most comprehensive maps of spawning and nursery area in the Mediterranean are provided through the MEDISEH project funded by DG MARE. Ichthyoplankton surveys data are used for the identification and the modelling of spawning grounds of Engraulis encrasicolus and Sardina pilchardus. Data from different acoustic surveys performed in the Mediterranean were used for the identification and the modelling of nursery grounds. MEDITS trawl surveys data were used for the identification and the modelling of nursery grounds of Trachurus trachurus.

It is not possible to provide maps on the NUTS2 area level because of several reasons:

There is no georeferenced data defining borders between NUTS2 regions on the sea.

Existing surveys are performed on national or GSA basis and it is not possible to provide maps on the NUTS2 level.

Existing surveys with available georeferenced data throughout DCF data call are only MEDITS surveys. As it is demersal survey, there is limited information about small pelagic with are not appropriate to produce nursery and spawning maps by NUTS2 level.

Some useful georeferenced data are collected through MEDIAS surveys, but those data are not requested and not available through DCF data call.

In conclusion the georeferenced MEDISEH output which is available in the form of GIS shape files, DGMARE should already have access to this information, or if not it can be obtained from the MAREA project coordinator. The JRC has the GIS skills to convert this to georeferenced shape files if needed.

3 FOLLOW UP ITEMS

3.1 LENGTH TO AGE FOR ANCHOVY GSA 17 AND 18

Exploration of the anchovy catch and survey data showed some inconsistency in the age year class strength indicated in surveys and in catch in both Eastern and Western surveys and catches.

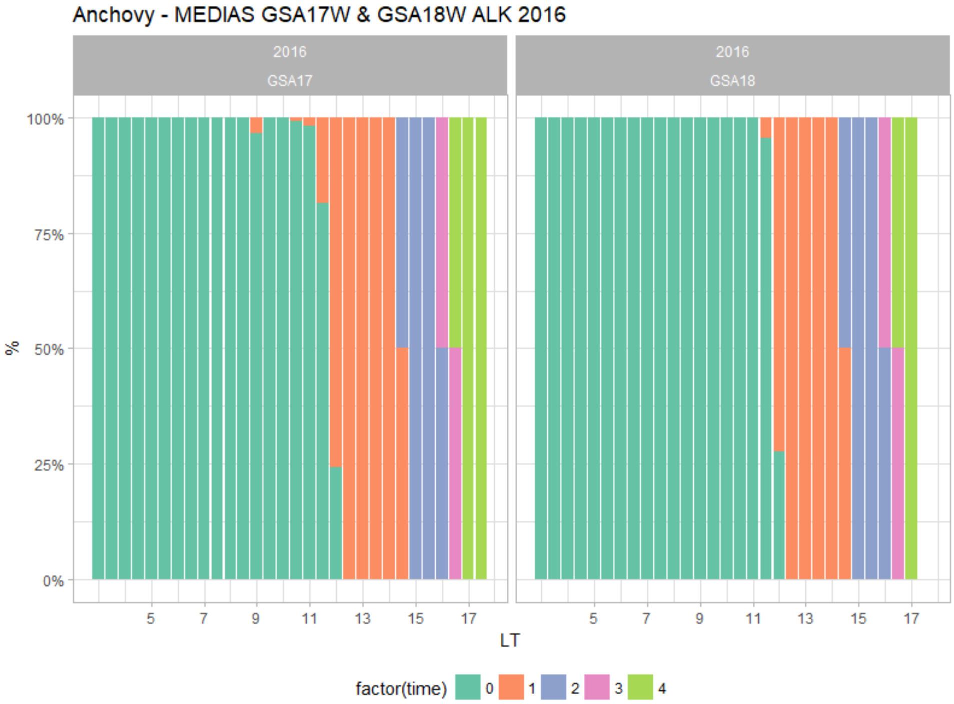
The age length keys applied in converting length to age are shown in Figure 3.1.1 and 3.1.2. The abundance data from both eastern and western acoustic surveys (Figure 3.1.1) has similar transitions between age classes 0 to 1, but differs for older ages. However these age length keys are different from those used for the conversion length data of commercial catches to catch-at-age data (Figure 3.1.2). How these age transitions relate to the sampled length frequencies are shown in Figures 3.1.3., 3.1.4. and 3.1.5.

Examination of the age length keys (Figure 3.1.1) suggests that the differences between catch and survey may have a difference in the basis of 0 and 1. There is a potential for age assignment of both 0 and 1 group in the survey to the same age, whereas for the catch the transition between ages 0 and age one occurs at 2 to 3 cm less (Figures 3.1.3, 4 and 5). Transition from age 1 to 2 in the catch occurs close to 12cm which is similar to the length used in survey for ages 0 to 1. Alignment between modes in the length distributions and transitions in age are particularly poor in the survey data, suggesting the differences are more complex than just the logical assignment of age 0. Modes are not seen in the sampled length distributions for catch, so there is no additional data to inform on age from this source. It is to be expected that a survey at one point in the year is more likely to show separate cohorts, than annual catch that contains length from throughout the year.

Comparing the relative catch at age in the survey and the catch, (figure 3.1.6) shows some but only small improvement in alignment with a shift of one age, the improvement is greatest at older ages. R improves from 0.54 to 0.72 and 0.35 to 0.51 for catch at ages 2 and 3 when age in the survey in shifted by one age. This suggests some confusion at ages 0, 1 and possibly age 2. If ages 0 and 1 are joined in the survey shifting this by one age is unlikely to improve the fit, so an absence of improvement here is not unexpected.

There is an urgent need to re-evaluate age assignment for the assessment for anchovy in GSA 17-18. The best approach might be to bring survey, catch and assessment people together with aim to adopt a common age reading protocol and eventually conduct an intercalibration of age readings. They should try to build a growth profile through the year, using aging and length observations to create a coherent picture through the year, splitting the ages in the catch down to quarters. Inspecting the survey length distributions it may be expected that transitions from age 0 to 1 and 1 to 2 will vary among years. However, because modes are visible there is a potential for there to be sufficient data to resolve this.

In order to be comparable with an annual step assessment model age 0 should be defined from the extended spawning period until 1st January, with an additional age added each subsequent 1st January.



B)

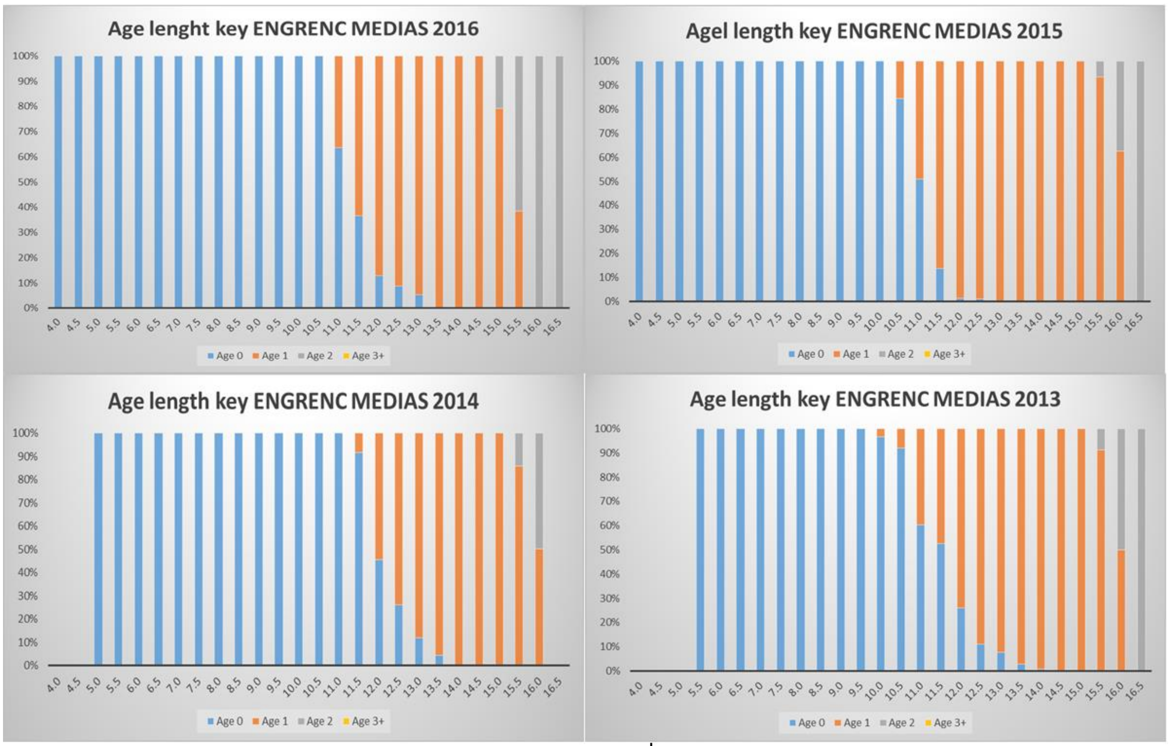
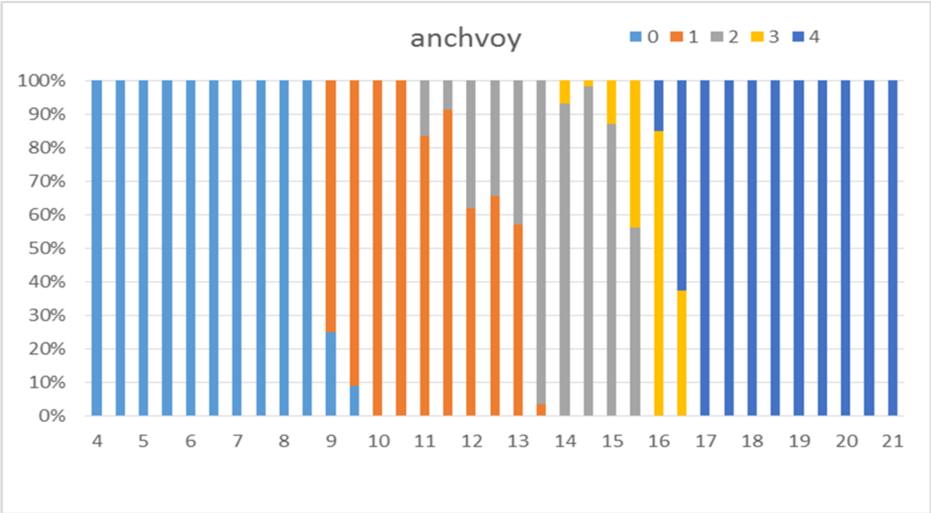


Figure 3.1.1 Anchovy GSA 17-18: age length key derived from otolith readings from MEDIAS surveys: A) surveys in western part of GSA17&18 in 2016; B) surveys in eastern part of GSA17 in 2013-2016 applied to convert survey abundance at length to abundance at age.

A)



B)

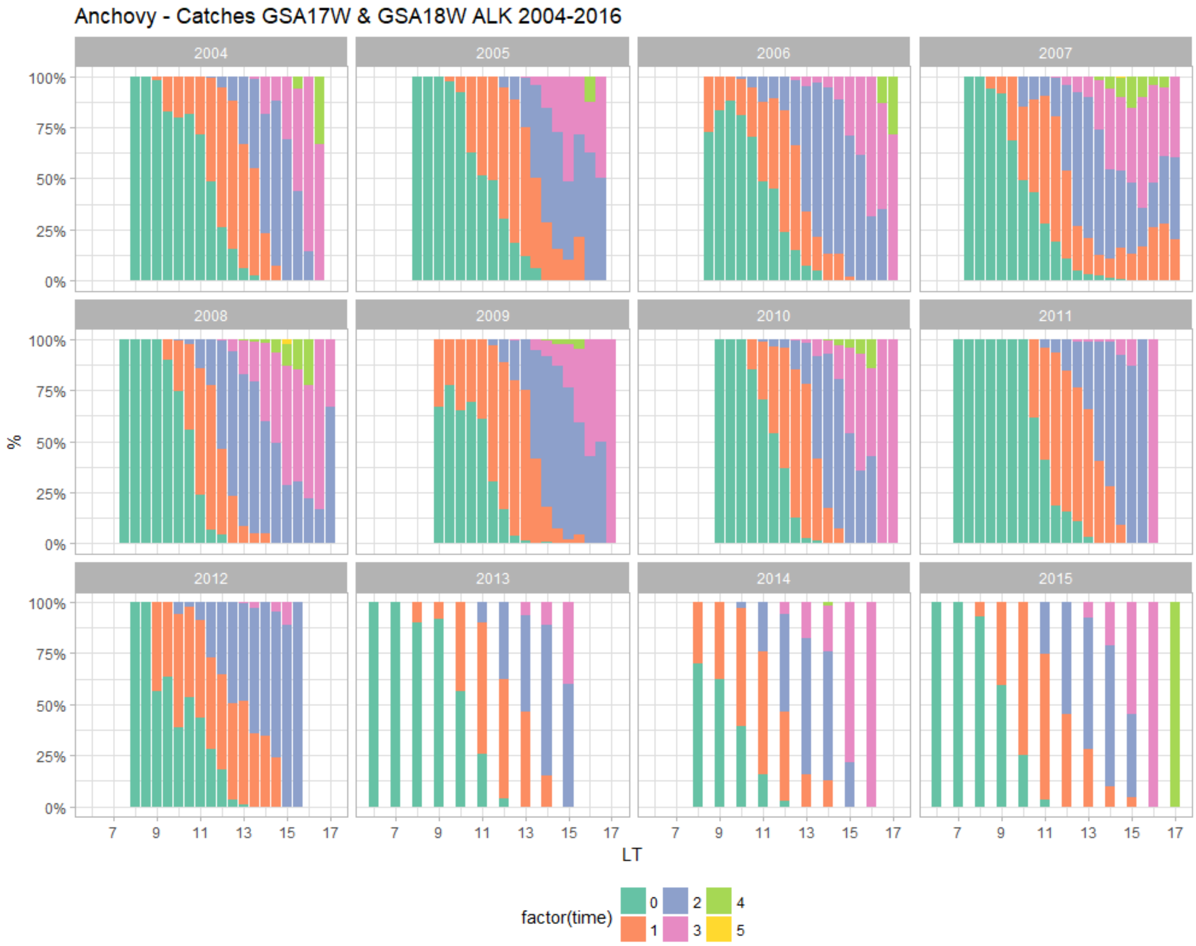


Figure 3.1.2 Anchovy GSA 17-18: age length key derived from otolith readings from Catch data from: A) Croatian catches; B) Italian catches 2004 to 20015 and applied to length frequency data to convert catch at length to catch at age.

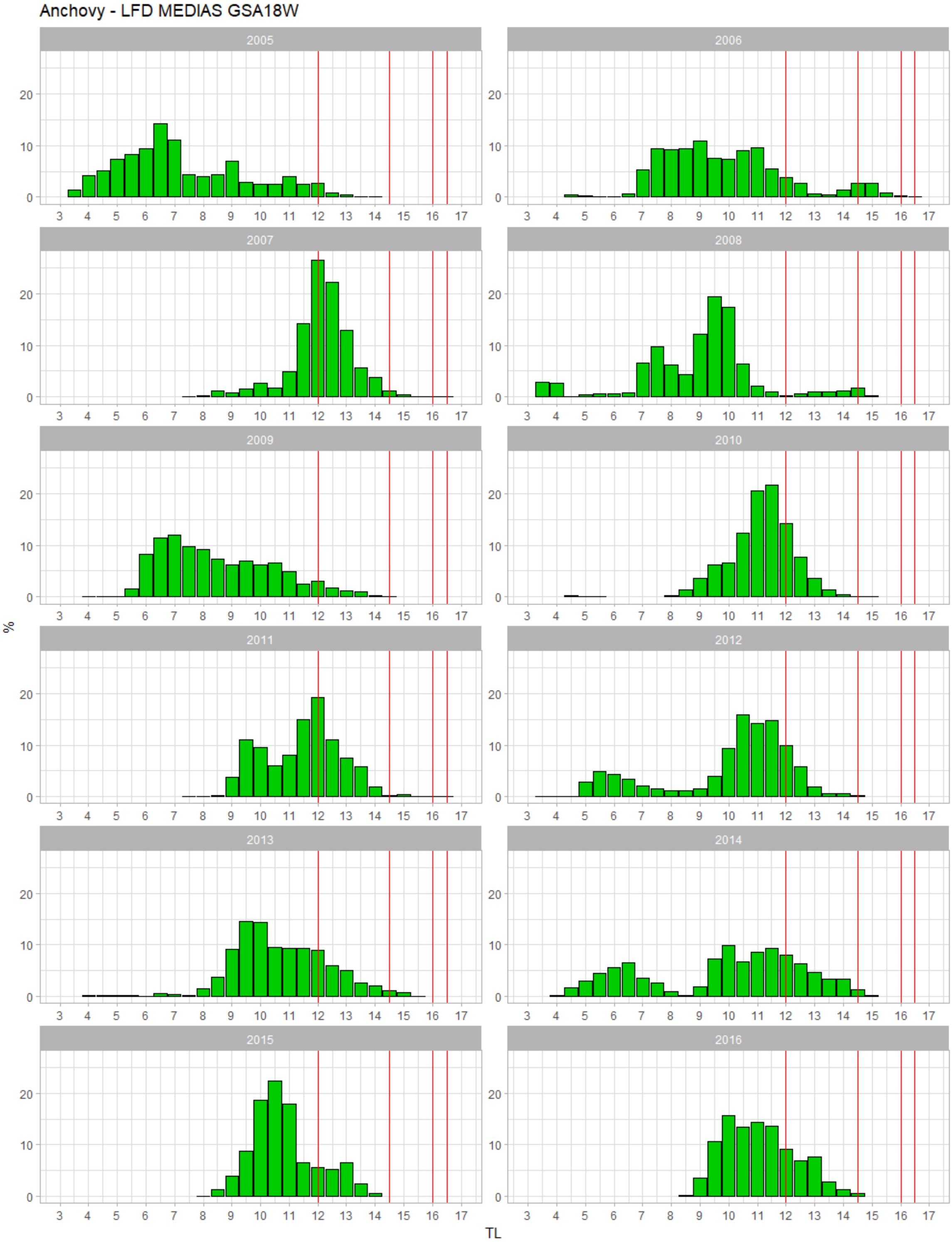
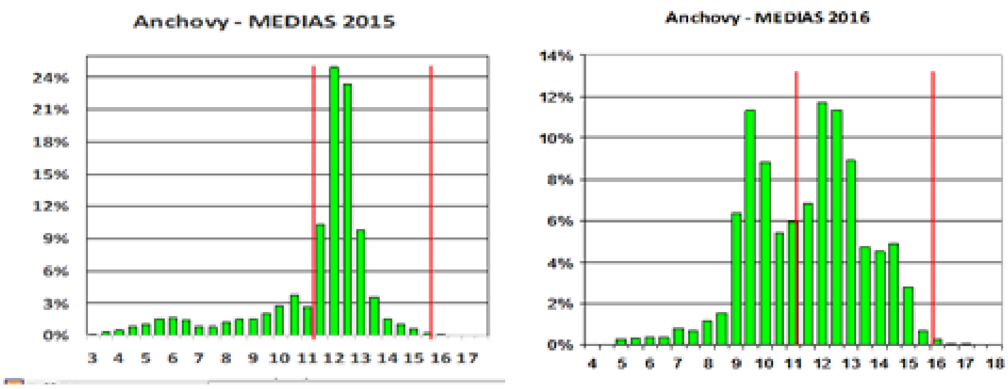


Figure 3.1.3 Anchovy length frequency by year 2005 to 2016 for MEDIAS acoustic survey (western part of GSA 18). Red lines indicate 50% age transitions 0-1, 1-2, 2-3 and 3-4 from left to right.

A)



B)

Figure 3.1.4 Anchovy length frequency by year 2004 to 2015 for catch data (combined area GSA 17 West and GSA 18 West) . Red lines indicate 50% age transitions 0-1, 1-2, and 2-3 from left to right..

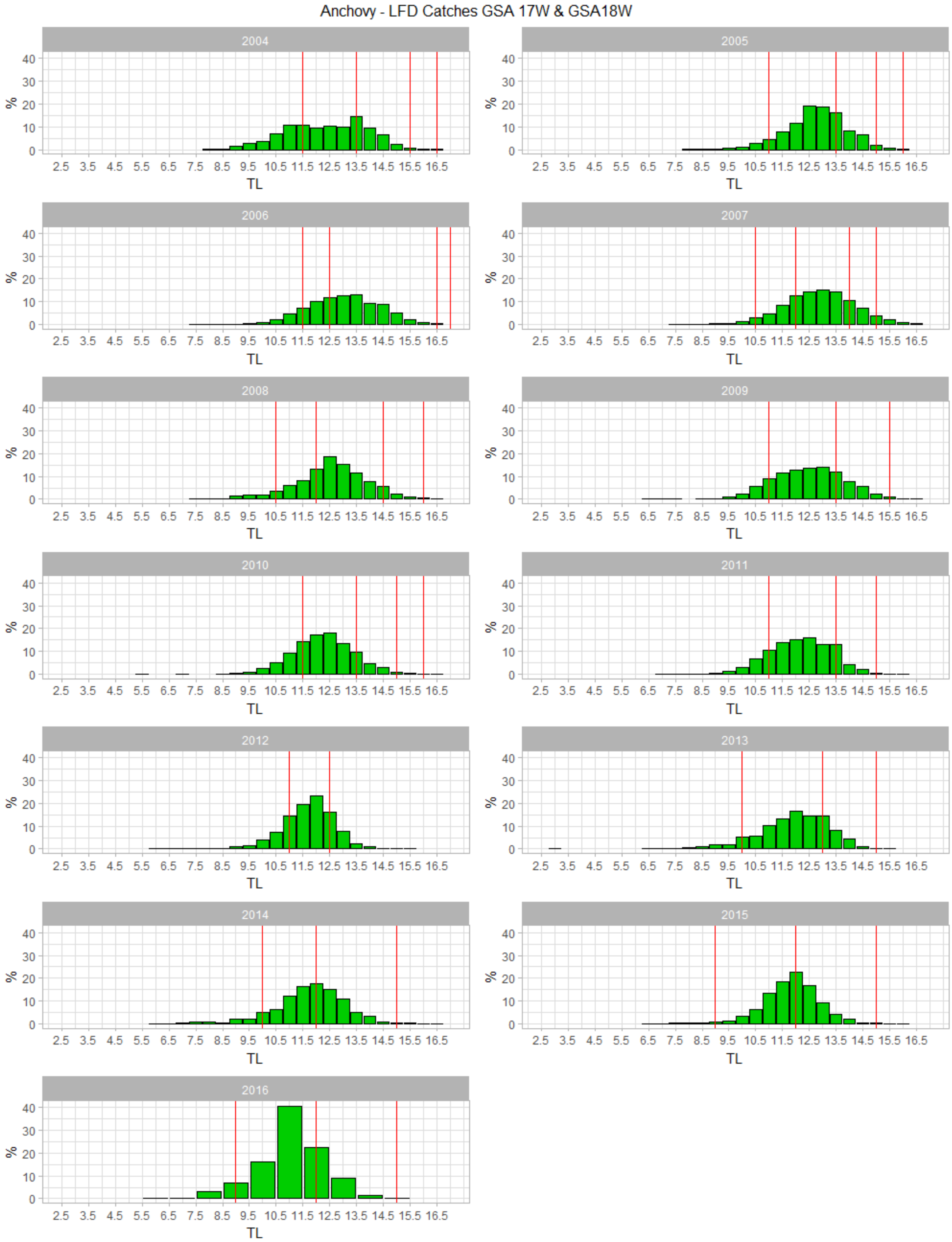


Figure 3.1.5 Anchovy length frequency by year 2004 to 2015 for catch data (combined area GSA 17 and 18). Red lines indicate 50% age transitions 0-1, 1-2, and 2-3 from left to right.

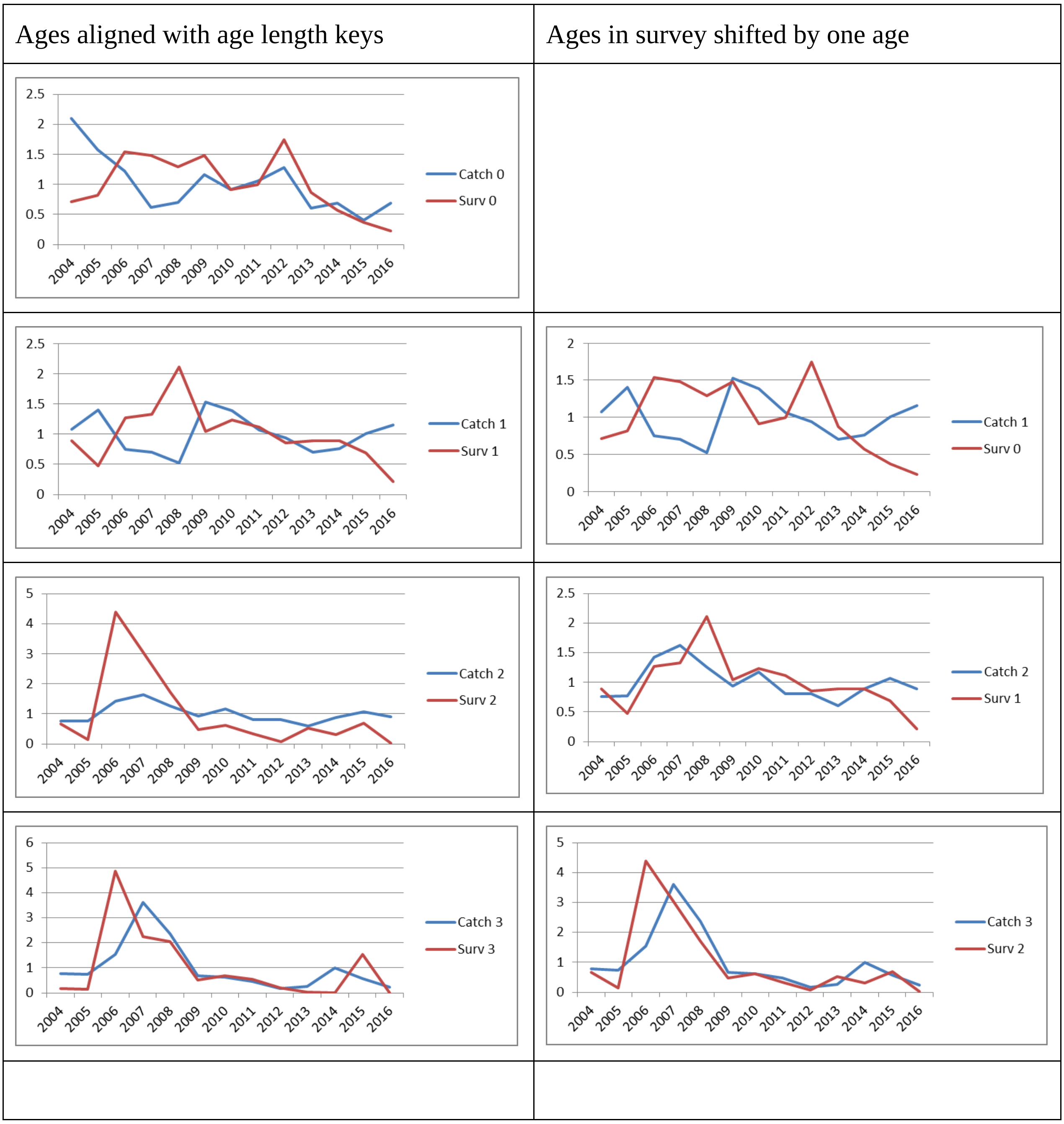


Figure 3.1.6 Anchovy GSA 17-18: Anchovy in GSA 17-18, comparison of normalised numbers at age in western survey and total catch from 2004 to 2016. There are slight improvements in correlation when comparing ages with survey displaced by one age, particularly for older ages.

4 MAIN STRUCTURE OF THE REPORT

The expert working group on Mediterranean stock and fisheries assessment part 2 STECF EWG 16-17 was held Ispra (Italy), 19-25 November 2016.

4.1 STRUCTURE AND BASIS OF THE REPORT

The summary sheets by stock, provided in Section 5 contain catch advice. The basis of this advice depends on the type and quality of information available from the analyses and is as follows:

1) Full assessment and full MSY reference points or with surplus production model with F and biomass relative to F and B_{MSY}: Catch advice at MSY based on short term forecast.
2) Full assessment without full evaluation MSY reference points due to short time historic series: Catch advice based on MSY proxy of F0.1 based on short term forecast.
3) Assessment providing SSB tend information historic F evaluation, not suitable for STF Catch / Effort advice under precautionary considerations (Patterson 1992) F=FMSY with Harvest Rate (HR) based estimated SSB in most recent year**.- not used in this report**
4) For sparse data with insufficient years for VPA type analysis, but with catch at length or age for most of the fishery: advice is based on pseudo cohort analysis at equilibrium, with estimate of current F relative to F0.1 **.- not used in this report**
5) Trend based indicator with exploitation and stock status know to be OK: Catch / Effort advice under precautionary considerations based on ICES smoothed index of trend without precautionary buffer**.**
6) Trend based indictor: Catch / Effort advice under precautionary considerations based on ICES smoothed index of trend with precautionary buffer (20% reduction) **.- not used in this report**
7) Valid length analysis: statement of stock status, indication of direction of change required.
8) No valid analysis: any advice.

4.2 CALCULATION OF E=0.4

The basis of the precautionary exploitation is closely related to the MSY concept of F=M, which is the same as E=0.5. Patterson (1992) found that F=M was too high in some circumstances. This concept is simple to calculate if M at age is constant, then the value of M would be independent of the range for F_{bar} and independent of considerations of selection in the fishery. However, with variable M at age it is necessary to consider an average M over age to relate to the average F. In providing the calculation method for this it is useful to keep in mind that the concept is to have F that relates to a fraction of M. In most small pelagic stocks F varies with age, often increasing from a low level at age 0, where M is highest and then for most stocks F at oldest true age is the same as the F in the plus group. A simple mean M over all ages will emphasise all ages equally, but this is not the case for the mortality in the fishery. Weighting the M at age with the fishery selectivity function matches the emphasis at age in the fishery with an equivalent emphasis at age in the M. This could be done over all ages, or just over the ages at F_{bar}. Use of all ages in the calculation makes mean M sensitive to the placement of the plus group, while F_{bar} is independent of that aspect. If more older ages are included, more emphasis is placed on these ages, changing the mean. F_{bar} is usually selected as these ages are considered important for the fishery, while changing the basis of F_{bar} influences the value, it also changes reference points such as $F_{0.1,}$ but as the selection on F_{bar} matches the selection on $F_{0.1}$, the two change by the same amount. As F is defined for a fixed appropriate age range mean M is calculated as the weighted mean over the ages used for F_{bar}

$M_{bar} = \Sigma\,(M_a*F_a/F_{bar})$ over a ages contributing to F_{bar}

Patterson (1992) for E=0.4 $F_{target} = M_{bar}*0.667$

$E_y = F_{bar\ y}/(M_{bar}+ F_{bar\ y})$

4.3 Evaluation of reference points

For several small pelagic stock evaluated in this assessment meeting, the number of years of S-R data is very limited and it is not possible to carry out full evaluations of MSY, because the stock-recruit relationships cannot be established. Two stocks have been evaluated

The exceptions to this are the anchovy in GSA 6 which has SPiCT assessment explicitly in terms of MSY and the sardine and anchovy stocks in the Adriatic Sea. For anchovy in GSA 7 MSY target values and biomass reference points can be inferred, but as the model is explicitly an equilibrium model it is hard to infer probabilities of SSB being below limit reference points. On previous occasions STECF (STECF 2017a) has reviewed the problems of providing robust estimates of F_{MSY} for sardine and anchovy stocks in GSAs 17 and 18 (Adriatic Sea). Such estimates are sensitive to the assumptions made in the estimation procedure, especially with regard to the stock-recruitment relationship. The time-series of stock and recruitment data indicate that for sardine and anchovy in the Adriatic, there is a strong unbounded linear relationship between spawning stock biomass (SSB) and recruitment (Fig. 6.7.XX and 6.8.XX); and conversely, there is also a strong correlation between recruitment and the following SSB: high recruitment gives rise to a large stock in subsequent years, but when the recruitment declines, so does the stock. This pattern is also evident in the time series prior to the mid-1990s, which was a period of relatively lower fishing mortality compared to the current level (although the historical mortality level remains uncertain because of the absence of age data). This indicates that the subsequent decline in recruitment may have been partly in response to environmental changes, and not only a result of declining SSB. This observation is in line with a large number of published studies that indicate that environmental conditions have a strong influence on recruitment success of small pelagic fish species. In this situation, it is difficult to resolve the issue of how dependent recruitment is on SSB and hence the form and the breakpoints of the stock-recruit relationship. Both the STECF and the GFCM Expert Groups (STECF 2015a, GFCM 2015 a,b) have approached this issue by fitting a segmented regression ('hockey stick') to the Stock-Recruit (S-R) data. In these cases, a single S-R relationship form has been selected, and the breakpoint (above which the recruitment becomes less driven by the SSB level and fluctuates around the average) has been arbitrarily assumed as a plausible one cannot be statistically fitted from the data. Below the breakpoint, recruitment is primarily dependent on SSB. The different choices are arbitrary and not supported by data, and thus are hard to defend.

An alternative approach endorsed by STECF (STECF 2017) explored the estimation of an alternative proxy for F_{MSY} for small pelagics.

Early work on MSY (Gulland 1971) suggested that fishing mortality (F) equal to natural mortality (M) could provide a proxy for FMSY, although this approach did not account for biomass considerations. An alternative approach is the choice of a target value at F=0.667M (where M is the natural mortality) as an empirical target for management of small pelagic fish. This target was calculated by Patterson (1992), who analysed the historical behaviour of 27 exploited small pelagic fish stocks. Patterson (1992) defined an exploitation rate (E=F/Z, the ratio between fishing mortality and total mortality) of 0.4 as an appropriate upper limit to the exploitation rate for small pelagic stocks. STECF (2016c) has previously used the Patterson (1992) approach to estimate a proxy for FMSY for a number of such stocks. The relationship of E=0.4 translates directly to F=0.667M, the reduction from F=M of Gulland (1971) is applied in order to provide additional biomass protection.

STECF (STECF 2017) evaluated the Stock-Recruit and Exploitation rate methods and concluded that E=0.4 (equivalent to F=0.667M) is the best method for estimating FMSY for small pelagic stocks such as those in the Mediterranean. This EWG has continued with this practice and has provided estimates of catch/landings F based on F=0.667M (equivalent to E-0.4) as target values for stocks with age based assessments.

MSY Ranges

The EWG has been requested to provide MSY ranges for the stocks considered by the EWG. The usual procedure used by ICES, where MSY ranges were developed would be to establish S-R functions and to evaluate the ranges using simulations with recruitment dependent on the assumed S-R relationship, constraining the upper range interval to be precautionary. As discussed above it has not been possible to establish such relationships for most of these stocks, either because the data series are too short or because the data series show environmental effects which mask the SSB dependent aspects. Other approaches to this are to use a distribution of recruitment around a fixed value, typically geometric mean recruitment. Such an approach does not include any biomass related aspects and therefore ignores precautionary considerations and the results could mask some biomass related problems which are therefore not taken into account. The approach of Patterson (1992) explicitly includes precautionary considerations and E=0.4 is considered to be the upper bound on safe exploitation. This is why STECF recommends this method for exploitation targets for small pelagics.

To evaluate MSY ranges for stocks in this report the EWG uses the values of F associated with E=0.4 which are given in Table 2.2. These are the F_{MSY} values from the most updated assessments carried out on Mediterranean stocks assessment. These values are assumed to be analogous to values of $F_{0.1}$ and explicitly precautionary. Those values were then used in the formulas provided by STECF EWG 15-06 (STECF, 2015) to derive F_{MSY} range (F_{lower} and F_{upper}). The empirical relationships used to estimate F_{MSY} range are the following:

$F_{lower} = 0.00296635 + 0.66021447 \times F_{0.1}$

$F_{upper} = 0.007801555 + 1.349401721 \times F_{0.1}$

where $F_{0.1}$ is a proxy of F_{MSY}.

For one stock (Anchovy in GSA 7) with a production model, F_{MSY} is estimated within the model and the values of F_{lower} and F_{upper} can be estimated using the explicit surplus production relationships $F_{lower}= 0.78F_{MSY}$, and $F_{upper}=1.22\ F_{MSY}$. The derivation of these factors is provided in ICES (2014).

Neither of these two methods add information on the precautionary nature of the F_{MSY} ranges; the values of F_{upper} and F_{lower}. In the case of stock based on E=0.4 the F_{MSY} is considered to be precautionary, and because F_{low} is a lower exploitation rate it can be safely assumed that this will also be precautionary. As the WG is unable to parameterise stock recruit models and does not currently have B_{lim} reference values, it has not been possible to evaluate if the F_{upper} values are precautionary. In previous evaluations of pelagic stocks in then ICES region (ICES 2015) the EWG notes that in contrast to demersal stocks most small pelagic stocks evaluated (4 out of 5) F_{upper} was not found to be precautionary. Given this situation and without explicit evaluation the EWG considers the values of F_{upper} should not be used for exploitation.

Values of F_{msy} F_{upper} and F_{lower}

The table below (Table 4.3.1) shows the information for the stocks for which F_{MSY} values are available. and the estimated values of F_{MSY} range (F_{lower} and F_{upper}).The values of F_{low} and F_{MSY} are regarded as reasonable estimates that can be expected to be precautionary and thus may be used directly. The values for F_{upper} are indicative only; they have not been evaluated as precautionary and should not be used as such without further evaluation.

Table 4.3.1 FMSY ranges (F_{low} and F_{upp}) for small pelagic stocks from the Mediterranean. The values for F_{upp} are indicative only they have not been evaluated as precautionary and should not be used as such without further evaluation.

GSA	Species	Ref year	F_{curr}	F_{msy}	F_{upp}	F_{low}	F_{curr}/F_{MSY}	Report	Year of advice
GSA 6	Anchovy	2016	0.83	0.700	0.952	0.465	1.186	STECF EWG17-09	2017
GSA 7	Anchovy	2016							
GSA 6	Sardine	2016	1.35	0.526	0.718	0.350	2.567	STECF EWG17-09	2017
GSA 7	Sardine								
GSA 1-5-6-7	Atlantic horse mackerel								
GSA 9-10-11	Anchovy	2016	0.41	0.260	0.359	0.175	1.577	STECF EWG17-09	2017
GSA 9-10-11	Sardine								
GSA 9-10-11	Atlantic horse mackerel	2016	0.56	0.230	0.318	0.155	2.435	STECF EWG17-09	2017
GSA 17-18	Anchovy	2016	1.42	0.570	0.784	0.374	2.407	STECF EWG17-09	2017
GSA 17-18	Sardine	2016	1.30	0.440	0.602	0.293	2.955	STECF EWG17-09	2017
GSA 17-18-19-20	Atlantic horse mackerel								
GSA 22	Anchovy	2016	0.463	0.467	0.638	0.311	0.99	STECF EWG17-09	2017
GSA 22	Sardine	2016	0.534	0.502	0.686	0.335	1.06	STECF EWG17-09	2017

5 SUMMARY SHEETS BY STOCK

ToR 9. *To provide a synoptic overview of: (i) the fishery; (ii) the most recent state of the stock (spawning stock biomass, stock biomass, recruits, and exploitation level by fishing gear); (iii) the source of data and methods and; (iv) the management advice, including MSY value, range of values and conservation reference points.*

5.1 SUMMARY SHEET OF ANCHOVY IN GSA 5, 6 & 7

Due to data deficiencies and divergent signals among areas the combined area was not evaluated and analyses were carried out by GSA. There is insufficient data to evaluate anchovy in GSA 5, summaries for anchovy in GSA 6 and 7 are provided below in sections 5.1.2 and 5.1.3 respectively

5.1.1 SUMMARY SHEET OF ANCHOVY IN GSA 5

No analysis were carried out during the meeting

5.1.2 SUMMARY SHEET OF ANCHOVY IN GSA 6

Species common name: European anchovy

Species scientific name: *Engraulis encrasicolus*

Geographical Sub-area(s) GSA(s): 6

5.1.2.1 STOCK DEVELOPMENT OVER TIME

State of absolute and relative biomass

The assessment shows a fluctuating trend in terms of relative biomass (B/B_{MSY}), with estimations falling below B_{MSY} in the 80s (1979), reaching a historical low in 2006 (B = 2164 t, B/B_{MSY} = 0.085). Since 2007 a gradual increasing trend is observed towards B_{MSY} and the estimated biomass is approximated at 20.825 t in 2016 (B_{2016}/B_{MSY} = 0.82).

The stock is considered to be below B_{MSY}.

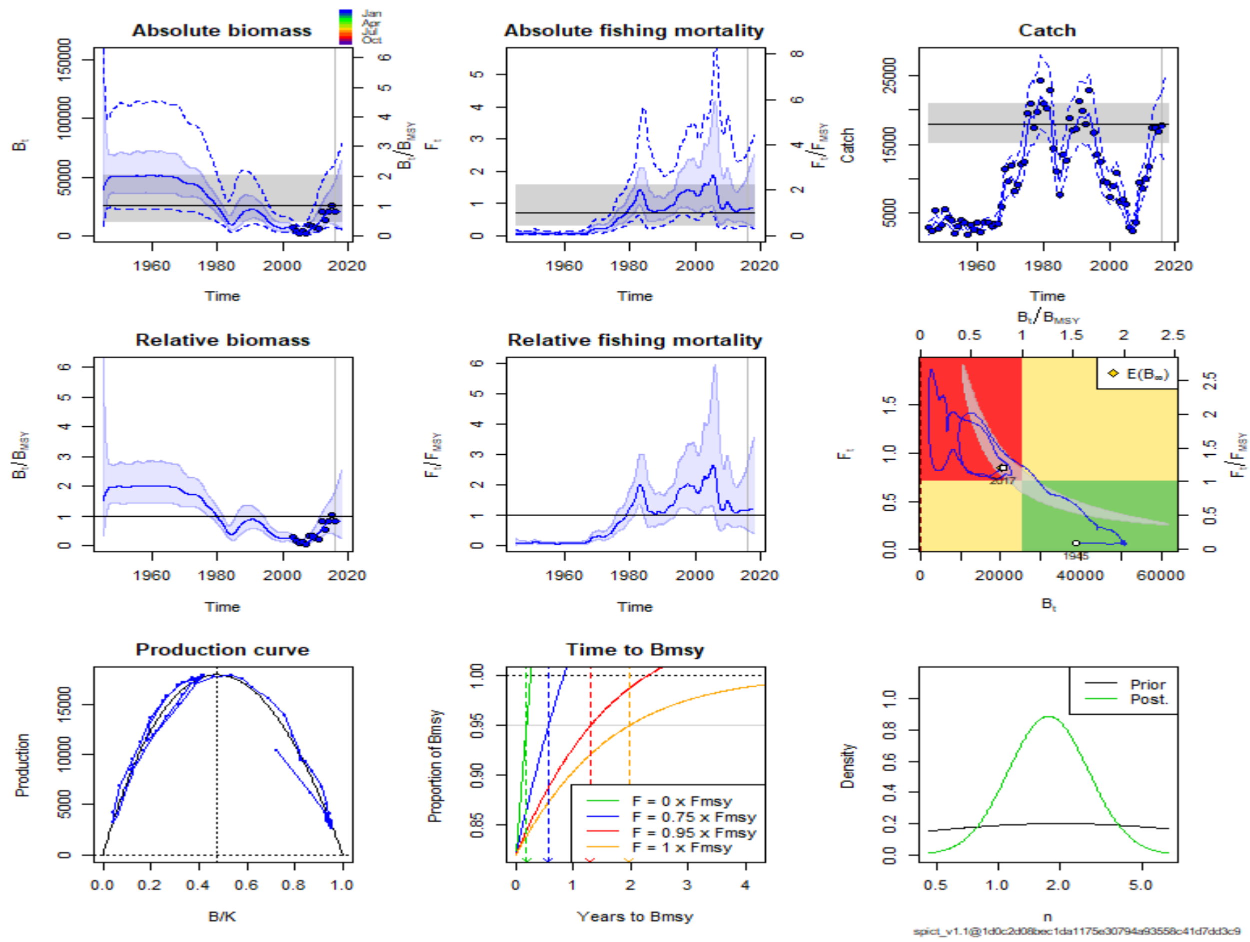


Figure 5.1.2.1.1. European anchovy in GSA 6. SPiCT model outputs. From left to right and descending: Absolute biomass and fishing mortality, landings, Relative biomass and fishing mortality, Kobe plot, Production curve, Short term predictions relating to F_{msyd} and Prior and posterior distribution of parameters that are estimated using informative priors.

Table 5.1.2.1.1. European anchovy in GSA 6. F/F_{msy}, B/B_{msy} and Landings estimates from the SPiCT model for Anchovy in GSA 6.

Year	F/F_{msy}	B/B_{msy}	Landings
1945	0.0877095	1.6955454	2654.967
1946	0.0863843	1.8998616	2934.355
1947	0.1048029	1.9792093	3706.581
1948	0.0940859	1.9785580	3326.095
1949	0.1016936	1.9901054	3616.433
1950	0.1253639	1.9938195	4465.794
1951	0.1201374	1.9786069	4247.314
1952	0.1002439	1.9786982	3544.033
1953	0.0780452	1.9840705	2766.528

1954	0.0848967	2.0091145	3047.957
1955	0.0951441	2.0159592	3427.080
1956	0.0863959	2.0081100	3100.269
1957	0.0683569	2.0026062	2445.860
1958	0.0755206	2.0236482	2730.745
1959	0.0780742	2.0209784	2819.234
1960	0.0816236	2.0204459	2946.689
1961	0.0761055	2.0095535	2732.656
1962	0.0885899	2.0180347	3194.305
1963	0.0944974	2.0083463	3390.956
1964	0.0921666	1.9965616	3287.901
1965	0.0966603	1.9899180	3436.602
1966	0.1138312	1.9774122	4021.228
1967	0.1719511	1.9576473	6010.098
1968	0.2623847	1.8969868	8883.356
1969	0.3055574	1.8147307	9904.856
1970	0.3277014	1.7638045	10327.616
1971	0.3037069	1.7387289	9435.214
1972	0.3189008	1.7390085	9908.229
1973	0.3827816	1.7108895	11695.740
1974	0.4675327	1.6466419	13742.500
1975	0.6293869	1.5436945	17323.352
1976	0.7668565	1.3962114	19111.229
1977	0.8248514	1.2800553	18856.905
1978	0.9495153	1.1901057	20162.627
1979	1.1669694	1.0569789	21987.718
1980	1.3334136	0.8996530	21400.655
1981	1.5482765	0.7563540	20856.188
1982	1.9149739	0.5821494	19830.553
1983	1.9422004	0.4263424	14824.012
1984	1.6136278	0.3808967	10973.743
1985	1.1951434	0.4530532	9624.938
1986	1.1106594	0.5966463	11834.741
1987	1.0496475	0.7287649	13663.194
1988	1.1052365	0.8239202	16275.695
1989	1.1017626	0.8591942	16912.484
1990	1.1084345	0.8849602	17527.830
1991	1.2236620	0.8713194	19041.417
1992	1.3117096	0.8117894	19019.725
1993	1.4105671	0.7485628	18847.148

1994	1.7093706	0.6431805	19576.223
1995	1.8791430	0.5014092	16822.072
1996	1.9344107	0.4030547	13922.930
1997	2.0192526	0.3324469	11989.763
1998	1.9839828	0.2823699	10012.635
1999	1.9357724	0.2572842	8901.289
2000	1.7724221	0.2558821	8101.008
2001	1.8521857	0.2691496	8907.325
2002	2.1885048	0.2421079	9445.763
2003	2.2304506	0.1917057	7641.189
2004	2.4110985	0.1539256	6611.972
2005	2.6096665	0.1094502	5105.797
2006	2.0968626	0.0852363	3195.430
2007	1.3622941	0.1123093	2694.569
2008	1.1882563	0.1964550	4182.722
2009	1.4143571	0.2965380	7519.147
2010	1.3550466	0.3709919	8954.308
2011	1.1575188	0.4857269	10014.554
2012	1.0822674	0.6331448	12243.256
2013	1.1410974	0.7461939	15221.960
2014	1.1681788	0.7946311	16585.915
2015	1.1720859	0.8152293	17072.838
2016	1.1927225	0.8196008	17466.309
2017	1.1992751	0.8145257	17453.602

State of the juveniles (recruits)

Not possible to evaluate juvenile abundance with the available model.

State of exploitation

The fishing mortality is observed to be fluctuating for the time period of 1979 to 2016 with F_{2016}/F_{MSYd} = 1.192. (Table 5.1.1.1.1.)

Based on the results, F_{2016}/F_{MSYd} = 1.192, anchovy stock is overexploited.

In a previous assessment (STECF 2016) the ratio F/F_{msy} was 0.8861, lower than in the current assessment.

5.1.2.2 Stock advice

STECF EWG 17-09 advises that when MSY considerations are applied the fishing mortality in 2018 should no more than F=0.70 this implies landings of no more than 15.38 tonnes.

5.1.2.3 Basis of the assessment

The assessment is based on SPiCT. Time series of Spanish landings made available by IEO for the period 1945 to 2001 and DCF landings from the 2016 DG MARE Data call for the period 2002 to 2016 comprise the input landings.

The tuning index is taken from the ECOMED biomass survey for the period 2003 to 2008 (carried out in autumn- November) and for the period 2009 to 2016 from the MEDIAS acoustic survey (carried out in summer), combined as one.

5.1.2.4 Catch options

Short-term predictions are based on landings and the results are shown in the following table. For the short-term predictions SPiCT uses the deterministic F_{msy} and B_{msy}.

Table 5.1.2.4.1. European anchovy in GSA 6. Short term forecasts of status quo for different fishing mortalities reductions.

Forecast scenario	Years	Landings	B (Biomass)	F (Fishing mortality)
1. Keep current catch	2018	17640.4	21146.1	0.836
	2019	17683.9	20907.3	0.846
	2020	17691.1	20594.9	0.858
2. Keep current F	2018	17453.6	20622.1	0.844
	2019	17375.8	20556.7	0.844
	2020	17333.7	20521.3	0.844
3. Fish at F_{MSY}	2018	15387.3	22928.8	0.704
	2019	16582.2	24147.8	0.704
	2020	17228.5	24784.4	0.704
4. No fishing	2018	24.6	38008.8	0.001
	2019	36.7	48232.2	0.001
	2020	42.5	52005.2	0.001
5. Reduce $F_{25\%}$	2018	14237.7	24173.7	0.633
	2019	15941.8	26114.7	0.633
	2020	16860.6	27105.5	0.633
6. Increase $F_{25\%}$	2018	20085.5	17528.8	1.055
	2019	17600.9	15903.5	1.055
	2020	16286.1	14997.5	1.055

5.1.2.5 Reference points

Table 5.1.2.5.1. European anchovy in GSA 6. Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not defined	
	F_{MSY}	0.70	SPiCT deterministic model estimates	This report
	B_{MSY}	25000 t	SPiCT deterministic model estimates	This report

5.1.2.6 Data deficiencies

No data on age structure in 2004. OTM fishing effort, the main fishing gear targeting small pelagics in the area, is reported only for 2015-2016.

5.1.3 SUMMARY SHEET OF ANCHOVY IN GSA 7

Species common name: European anchovy
Species scientific name: *Engraulis encrasicolus*
Geographical Sub-area(s) GSA(s): 7

5.1.3.1 STOCK DEVELOPMENT OVER TIME

Following the ICES approach on data limited stocks recent stock trends are inferred from an acoustic survey biomass index (Fig 5.1.3.1).

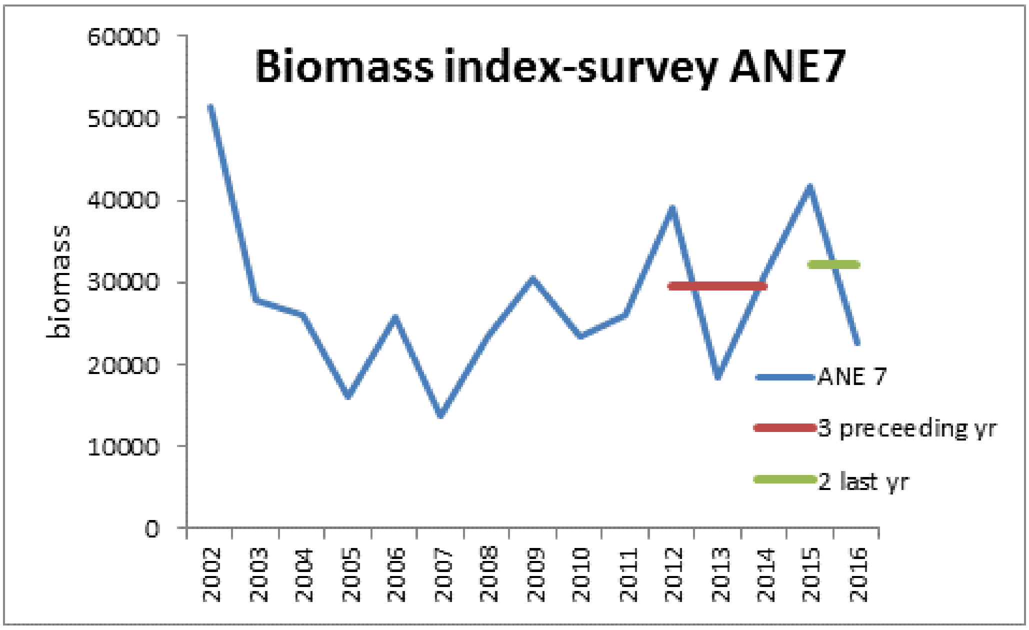


Figure 5.1.3.1.1 European anchovy in GSA 7. Biomass index estimated by direct acoustic method from PELMED survey. In green the mean of the last two years compared to the previous three years (red).

State of the adult abundance and biomass

Not known.

State of the juveniles (recruits)

Not known.

State of exploitation

Landings are given in Figure 5.1.3.1.2 but the exploitation rate implied by these Landings is not known.

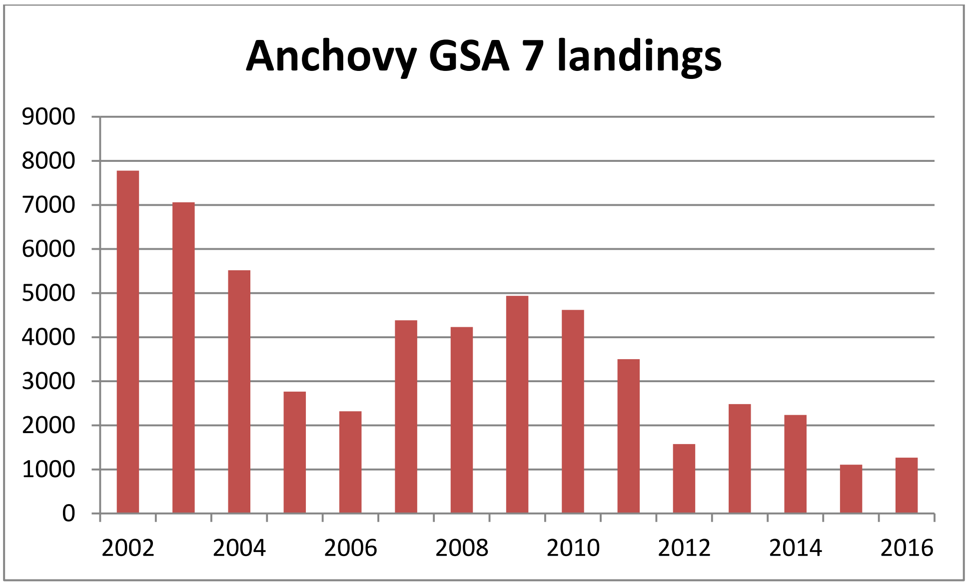


Figure 5.1.3.1.2 European anchovy in GSA 7. Landing by year

Table 5.1.3.1.1 European anchovy in GSA 7. Landing by year

year	landings
2002	7777.4
2003	7062.2
2004	5517.5
2005	2765.8
2006	2319.9
2007	4384.1
2008	4232.5
2009	4939.5
2010	4619.8
2011	3503.8
2012	1576.7
2013	2483.9
2014	2234.8
2015	1108.4
2016	1269.2

5.1.3.2 STOCK ADVICE

STECF EWG 17-09 advises that when precautionary considerations are applied landings should be no more than 1343 t in each of 2018 and 2019 implemented either through catch restrictions or effort reduction for the relevant fleets.

5.1.3.3 BASIS OF THE ASSESSMENT

Data from PELMED acoustic abundance indices for 2002-2016.

5.1.3.4 CATCH OPTIONS

Following the ICES procedures for data limited stocks the change in biomass over the last five years was used to provide an index for change (1.10, Figure 5.1.3.1). As this index is less than 1.2 and more than 0.8, the value is used to multiply the catch to provide an initial catch advice. The exploitation rate is unknown though indication from the length analysis suggest exploitation is above MSY and the state of the stock relative to B_{msy} is unknown therefore a precautionary buffer (0.8) is applied giving a factor of 0.9. The resulting landings advice referred to the average of the last three years (1530 t) is 1343.

5.1.3.5 REFERENCE POINTS

Reference points are not defined for this stock.

5.1.3.6 DATA DEFICIENCIES

No data on age structure in 2004. OTM fishing effort, the main fishing gear targeting small pelagics in the area, is reported only for 2015-2016.

Detailed information can be found in section 6.1.3.

5.2 SUMMARY SHEET OF SARDINE IN GSA 5, 6 & 7

Due to data deficiencies and divergent signals among areas the combined area was not evaluated and analyses were carried out by GSA. There is insufficient data to evaluate anchovy in GSA 5, summaries for anchovy in GSA 6 and 7 are provided below in sections 5.1.2 and 5.1.3 respectively

5.2.1 SUMMARY SHEET OF SARDINE IN GSA 5

No analysis were carried out

5.2.2 SUMMARY SHEET OF SARDINE IN GSA 6

Species common name: Sardine
Species scientific name: *Sardina pilchardus*
Geographical Sub-area(s) GSA(s): 6

5.2.2.1 STOCK DEVELOPMENT OVER TIME

State of the adult abundance and biomass
SSB displayed very marked changes in the period 2003-2016. SSB oscillated between 102.9*10^6 t in 2005 and 9.5*10^6 t in 2009. At present (2016), sardine SSB is at 24.2*10^6 t.

State of the juveniles (recruits)
The recruitment trend is similar to that of SSB (Fig.5.2.2.1), with a peak in 2005 (37.6*10^6 individuals) and a minimum in 2008 (7.2*10^6 individuals). Although fluctuating and at low level in comparison against the peak in 2004- 2005, in the last years recruitment seems to be increasing. The lowest recruitment in 2008 occurred the year before the lowest SSB in 2009.

State of exploitation
Fishing mortality (F_{0-3}) has displayed marked fluctuations in the analysed period 2002-2016. F has been rising over time and has been above Fmsy in 8 of the last 9 years. The highest value corresponded to 2014 (F_{0-3} =2.0), and the lowest values were observed at the beginning of the period (2002-2005). F is above F_{MSY}, the stock is considered over exploited

The highest observed SSB and recruitment in 2005 occurred at low F (F_{0-3}=0.3).

Table 5.2.2.1. Sardine in GSA 6. XSA summary results.

Year	Biomass	Landings	SSB	Recruits	Fbar
2002	641142.8	17167.6	56300.2	36552661.5	0.40
2003	846270.5	17523.4	66603.8	55690476.6	0.30
2004	797231.7	23171.5	88135.2	59091376.7	0.44
2005	667536.9	21229.3	102925.4	37640762.5	0.26
2006	374241.1	27799.7	94512.7	18648556.0	0.50
2007	224029.7	23552.2	55006.9	11268188.1	0.84
2008	135260.6	16670.6	26767.6	7232871.6	1.58
2009	178485.3	7506.8	9541.5	12067413.8	1.24
2010	140611.7	7627.2	14085.8	9732760.8	1.05
2011	321100.2	12568.3	14971.2	23548384.0	1.10
2012	241687.2	9395.3	26910.3	19525168.6	0.41
2013	198294.4	9928.8	23578.8	15883236.3	0.92
2014	152869.4	9877.3	18181.8	14965286.2	2.05
2015	343230.8	6449.6	15706.3	29774953.5	0.91
2016	225904.4	10042.4	24241.9	16805206.4	1.35

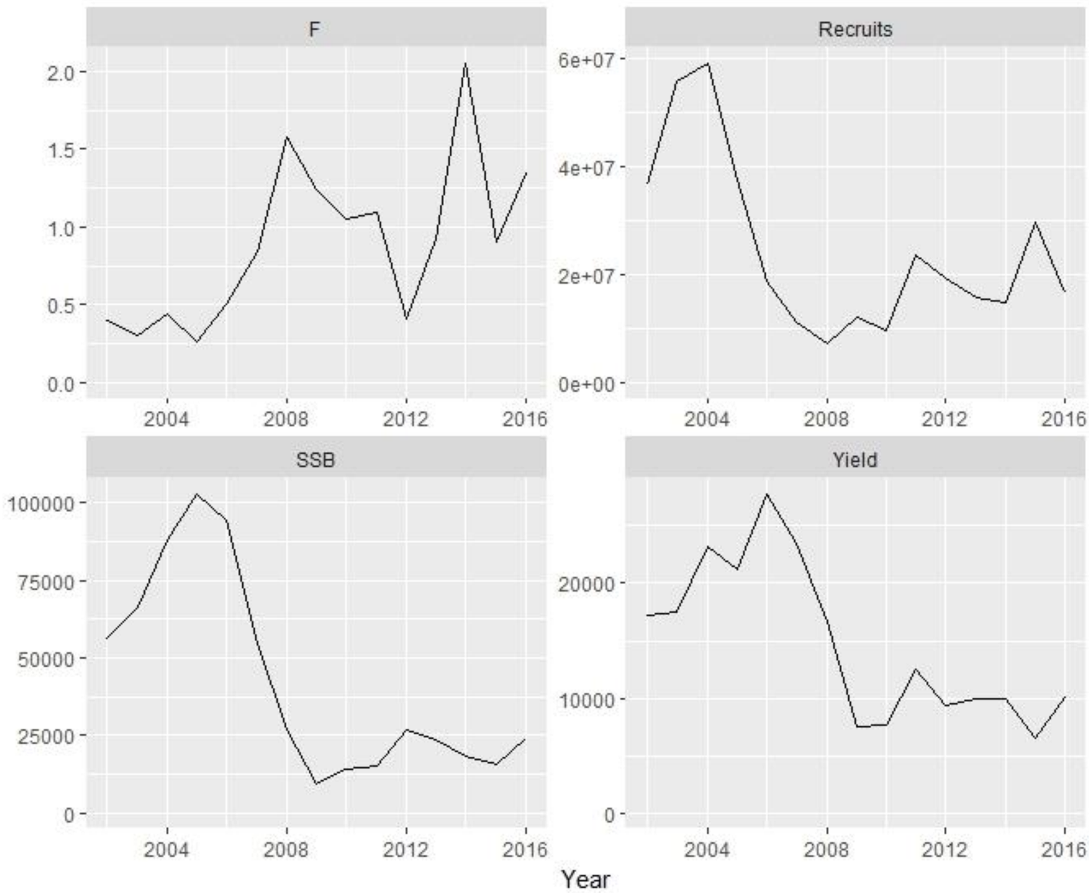


Figure 5.2.2.1. XSA summary results. SSB and yield (landings) in tonnes, recruits in millions.

5.2.2.2 Stock advice

STECF EWG 17-09 advises that when MSY considerations are applied the fishing mortality in 2018 should no more than F=0.53 this implies landings of no more than 5138 tons.

5.2.2.3 BASIS OF THE ASSESSMENT

The method applied is XSA. DCF data have been used as input: catch, purse seine catch at age; acoustic surveys ECOMED and MEDIAS; M vector estimated with the method proposed by Gislason *et al*. (2010) and used in previous assessments of this stock. For maturity at age it was assumed that age0 corresponds to immature individuals and age1 to mature individuals. The analysis considered ages 0 to 4+ and $F_{bar}=F_{0-3}$.

5.2.2.4 CATCH OPTIONS

Table 5.2.2.4.1. Sardine in GSA 6. Short-term forecast showing catch options at different F_{bar} scenarios, from no fishing (F factor=0) to F factor=2. $Landings_{2017}$ = 11662 tons and SSB_{2018} = 19558 tons, $Recruitment_{2017}$ geometric mean of last 3 years = 19562 thousands and F_{bar} (2017) = 1.36 (F geometric mean in the last three years).

Rationale	Ffactor	F_{bar}	Landings 2018	Landings 2019	SSB 2019	Change_SSB 2018-2019(%)	Change_Landings 2016-2018(%)
Zero catch	0	0	0	0	26917	37.63	-100.00
High long term yield (Fmsy)	1	1.360	10541	10811	19908	1.79	4.96
Status quo	0.39	0.526	5161	6743	23135	18.29	-48.60
Different scenario	0.1	0.136	1538	2461	25727	31.54	-84.68
	0.2	0.272	2919	4315	24702	26.30	-70.93
	0.3	0.408	4168	5746	23814	21.76	-58.50
	0.4	0.544	5306	6879	23038	17.79	-47.16
	0.5	0.680	6349	7801	22356	14.31	-36.78
	0.6	0.816	7311	8572	21752	11.22	-27.20
	0.7	0.952	8203	9234	21215	8.47	-18.32
	0.8	1.088	9034	9815	20733	6.01	-10.04
	0.9	1.224	9811	10336	20300	3.79	-2.30
	1.1	1.496	11229	11251	19553	-0.03	11.81
	1.2	1.632	11879	11662	19229	-1.68	18.29
	1.3	1.768	12496	12051	18933	-3.20	24.44
	1.4	1.904	13083	12422	18661	-4.59	30.28
	1.5	2.040	13642	12777	18411	-5.86	35.85

	1.6	2.176	14177	13119	18181	-7.04	41.17
	1.7	2.312	14689	13449	17967	-8.13	46.26
	1.8	2.448	15180	13768	17770	-9.14	51.15
	1.9	2.584	15652	14079	17586	-10.08	55.85
	2	2.720	16106	14381	17415	-10.96	60.38

5.2.2.5 REFERENCE POINTS

Table 5.2.2.5.1 Sardine GSA 6. Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not defined	
	F_{MSY}	0.53	F at E=0.4 MSY proxy	This report

5.2.2.6 DATA DEFICIENCIES

Growth parameters of sardine in GSA 6 should be revised (t_0 values are very negative). The procedure for transforming landings lengths into ages is not known. The availability of this procedure might help in the interpretation of the lengths and ages structures within a given area and among areas. ALK should be available from the acoustic surveys.

5.2.3 SUMMARY SHEET OF SARDINE IN GSA 7

Species common name: Sardine
Species scientific name: *Sardina pilchardus*
Geographical Sub-area(s) GSA(s): 7

5.2.3.1 STOCK DEVELOPMENT OVER TIME

Following the ICES approach on data limited stocks recent stock trends are inferred from an acoustic survey biomass index (Fig 5.1.2.1).

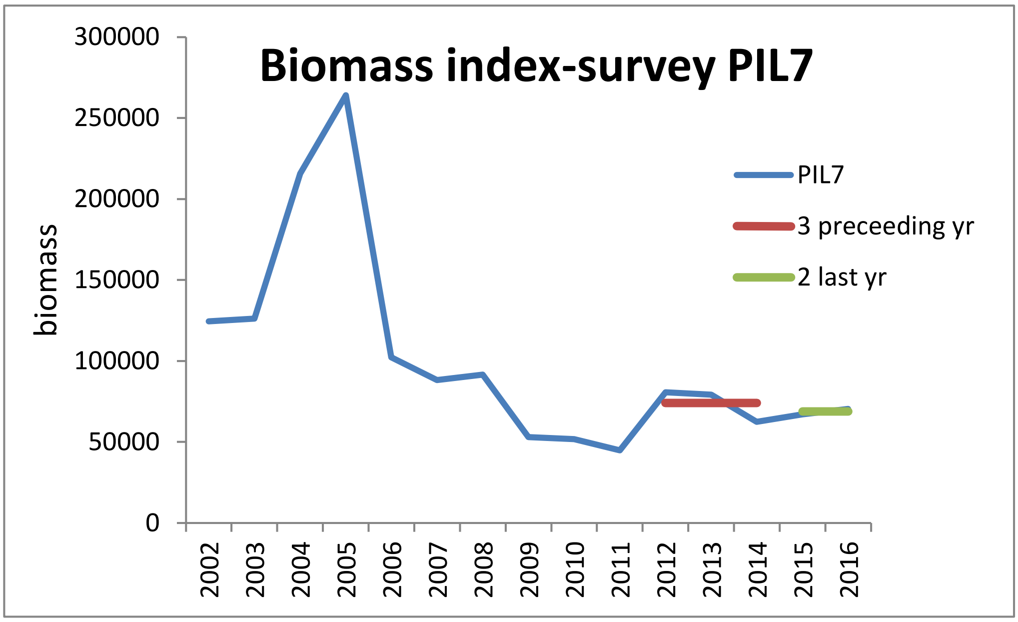


Figure 5.2.3.1. Sardine in GSA 7. Biomass index estimated by direct acoustic method from PELMED survey. In green the mean of the last two years compared to the previous three years (red).

State of the adult abundance and biomass
Not known.

State of the juveniles (recruits)
Not known

State of exploitation

Landings are given in Figure 5.2.3.1.2 but the exploitation rates implied by these Landings are not known.

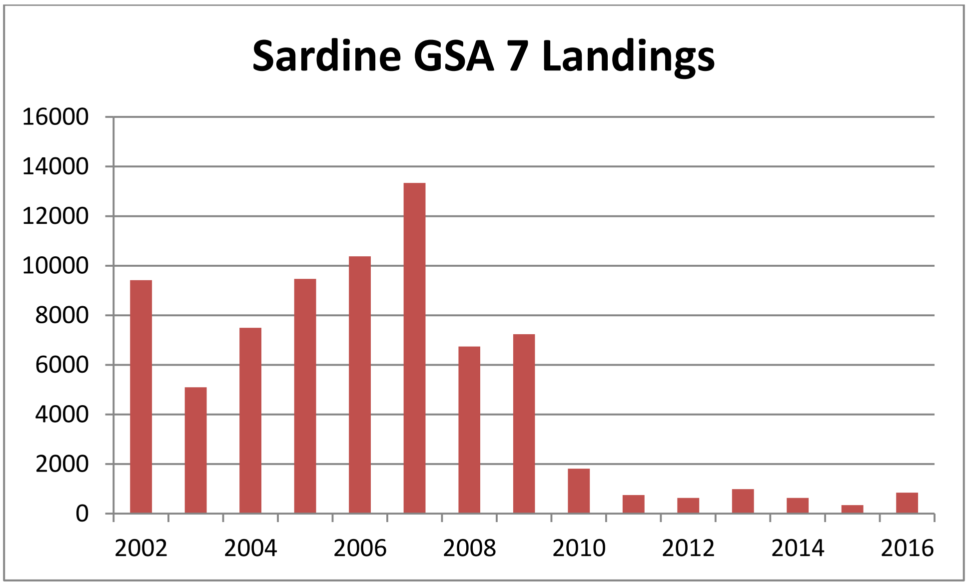


Figure 5.2.3.1.2 Sardine in GSA 7 Landings

Table 5.2.3.1.1 Sardine in GSA 7 Landings

2002	9416.4
2003	5095.2
2004	7493.4
2005	9472.2
2006	10381.1
2007	13339.6
2008	6740.5
2009	7240.6
2010	1813.7
2011	748.4
2012	635.4
2013	989.0
2014	632.1
2015	342.1
2016	845.6

5.2.3.2 Stock advice

STECF EWG 17-09 advises that when precautionary considerations are applied catches should be no more than 452.5 t in each of 2018 and 2019 implemented either through catch restrictions or effort reduction for the relevant fleets.

5.2.3.3 Basis of the assessment

Data from PELMED acoustic abundance indices for 2002-2016.

5.2.3.4 Catch options

Following the ICES procedures for data limited stocks the change in biomass over the last five years was used to provide an index for change (0.93, Figure 5.2.2.1). As this index is less than 1.2 and more than 0.8, the value is used to multiply the catch to provide an initial catch advice. The exploitation rate is unknown though indications from the length analysis suggest exploitation above MSY and the state of the stock relative to Bmsy is unknown therefore a precautionary buffer (0.8) is applied. The resulting landings advice taken from the average of the last three years (608.2 t) is 452.5 t.

5.2.3.5 REFERENCE POINTS

Reference points are not defined for this stock.

5.2.3.6 DATA DEFICIENCIES

No data on age structure for 2004, 2005 and 2011. Detailed information can be found in section 7.2.3

5.3 SUMMARY SHEET OF ATLANTIC HORSE MACKEREL IN GSA 1, 5, 6 & 7

Species common name: Atlantic Horse Mackerel
Species scientific name: *Trachurus Trachurus*
Geographical Sub-area(s) GSA(s): 1,5,6 & 7

5.3.1. Stock development over time

State of the adult abundance and biomass

It was not possible to provide an analytical assessment of the state of this stock due to the absence of some catch data over a number of years. An indicator of biomass is available from the MEDITS survey; this shows an increase in biomass from 2005 to 2007 followed by a decline to previous levels by 2014. Biomass in 2016 shows a significant rise in biomass.

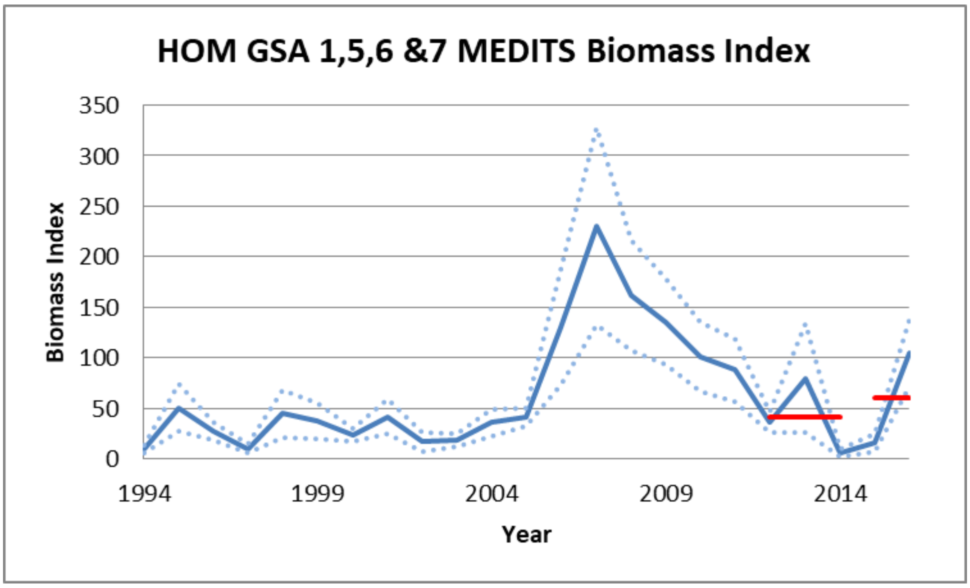


Figure 5.3.1.1. Atlantic horse mackerel in GSAs 1, 5, 6 & 7. Biomass index estimated by MEDITS trawl survey. Dotted lines show 5-95% confidence intervals on the survey index. Red lines show change in biomass over last 5 years, an increase of 1.47 times, derived from the mean of last two years (2015 and 2016) and mean of previous 3 years (2012 to 2014)

State of the juveniles (recruits)

Not known.

State of exploitation

Catches are given in Figure 5.3.1.2 but the exploitation rates implied by these Catches are not known.

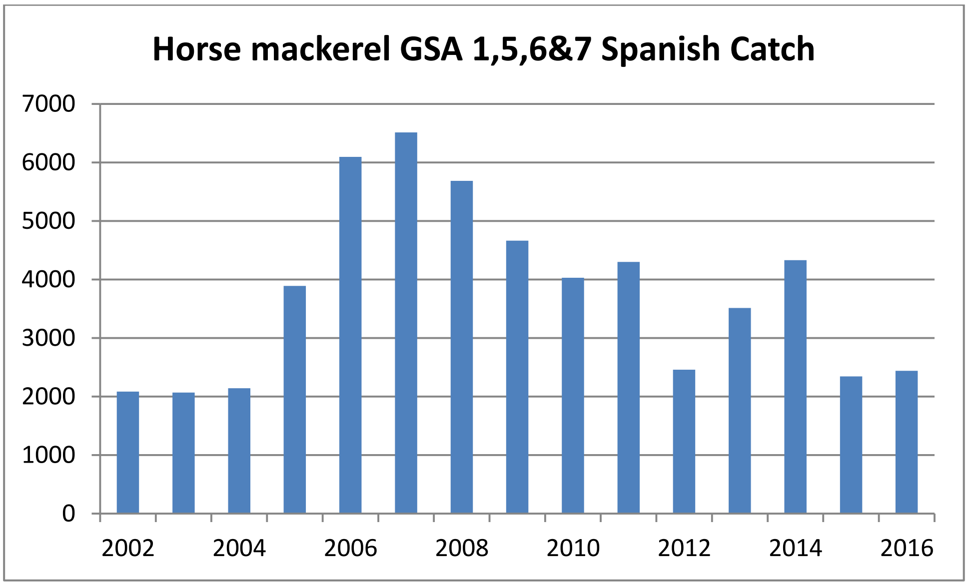


Figure 5.3.1.2. Atlantic horse mackerel in GSAs 1, 5, 6 & 7. Spanish catch by year, total catches (French catch or landings are not know).

Table 5.3.1.1. Atlantic horse mackerel in GSAs 1, 5, 6 & 7. Spanish catch by year, total catches (French catch or landings are not know).

2002	**2086**
2003	**2068**
2004	**2142**
2005	**3891**
2006	**6097**
2007	**6512**
2008	**5686**
2009	**4663**
2010	**4029**
2011	**4301**
2012	**2459**
2013	**3514**
2014	**4330**
2015	**2345**
2016	**2442**

5.3.2. Stock advice

STECF EWG 17-09 advises that when precautionary considerations are applied catches for each of 2018 and 2019 should be reduced to 96% of catches average 2014-2016.

5.3.3. Basis of the assessment

Data from MEDITS index for 1994-2016 (Figure 5.3.1.1).

5.3.4. Catch options

Following the ICES procedures for data limited stocks the change in biomass over the last five years was used to provide an index for change (1.14, Figure 5.3.1.1). As this index shows an increase greater than 1.2 this value is used to multiply the catch to provide an initial catch advice. The exploitation rate is unknown, though indications from length analysis suggest exploitation may be above MSY, and the state of the stock relative to B_{msy} is unknown therefore a precautionary buffer (0.8) is applied. As French catches are not reported the overall catch cannot be calculated, and only a factor can be advised.

5.3.5. Reference points

Reference points are not defined for this stock.

5.3.6. Data Deficiencies

There were a numbers of data deficiencies and errors in the data submitted through DCF. Detailed information can be found in section 6.3.
The most critical issues appear to be the missing French landings and/or catch data, only data foe 2016 was reported and that appears to be incorrect.

5.4 SUMMARY SHEET OF ANCHOVY IN GSA 9, 10, & 11

Species common name: European anchovy
Species scientific name: *Engraulis encrasicolus*
Geographical Sub-area(s) GSA(s): 9, 10 and 11

5.4.1 Stock development over time

State of the adult abundance and biomass

The SSB estimates show a stable trend, slightly increasing in the last three years from a value of 21339 tons (in 2013) to 39011 tons in 2016 (Figure 5.4.1.1).

State of the juveniles (recruits)

The assessment results show a slightly fluctuating pattern in the recruitment, with a peak in 2014 (7648 millions). (Figure 5.4.1.1).

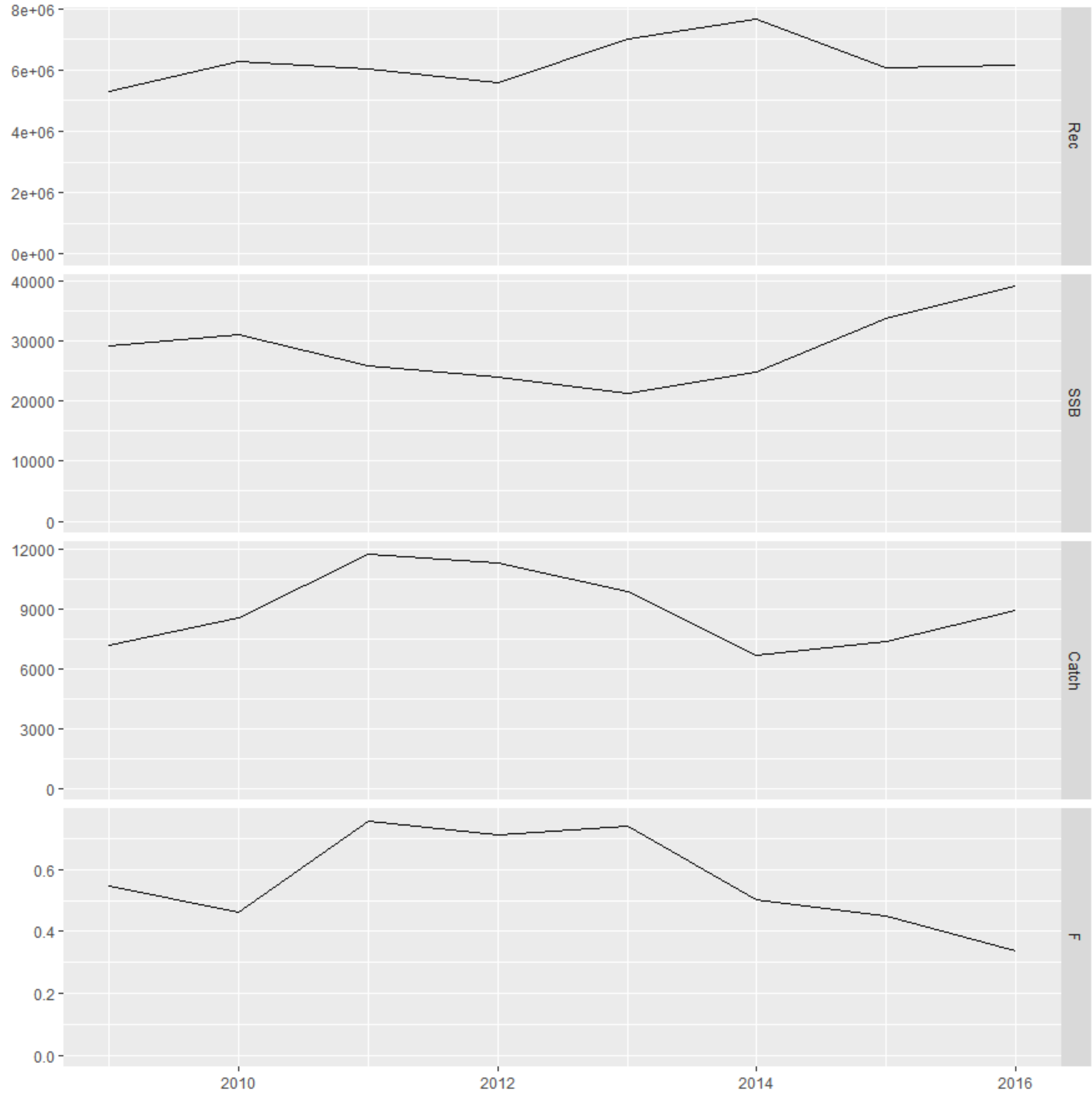


Figure 5.4.1.1. European anchovy in GSAs 9, 10 & 11. Model results recruitment, SSB (t), catch (t) and fishing mortality

State of exploitation

F reached the highest values in the central part of the time series (2011-2013). Thereafter, it has decreased until 2016, reaching the value of 0.34, above the reference point of F_{MSY}=0.22 this implies that the stock is overexploited (Figure 5.4.1.2).

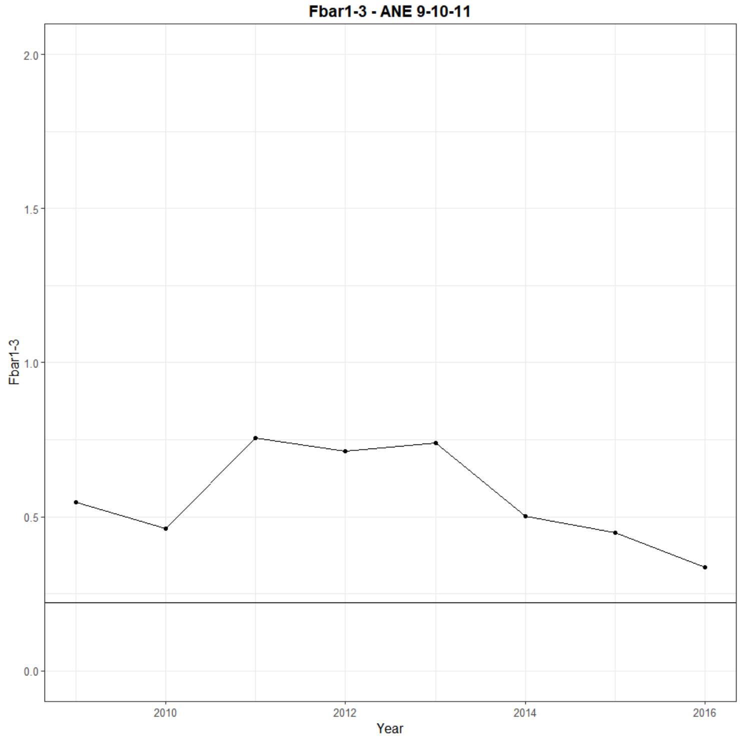


Figure 5.4.1.2. European anchovy in GSA 9, 10 & 11. F_{bar}(1-3) by year compared to F=0.22 (E=0.4).

Table 5.4.1.1. European anchovy in GSAs 9, 10 & 11. XSA assessment summary results.

	Fbar (1-3)	**Recruitment (thousands)**	**SSB (t)**	**Catch (t)**	**Total Biomass (t)**
2009	0.54689	5293672	29145	7154.9	61036
2010	0.46291	6254804	30925	8538	66679
2011	0.7561	6037315	25758	11756.7	64354
2012	0.71306	5587597	24051	11286.5	59137
2013	0.74009	6997280	21339	9879.5	57150
2014	0.50112	7648074	24851	6647.1	61076
2015	0.44866	6077207	33738	7332	70406
2016	0.33589	6150093	39011	8931.1	75750

5.4.2 Stock advice

STECF EWG 17-09 advises that, when MSY considerations are applied, the fishing mortality should be reduced to no more than F=0.22. This implies catches of no more than 6578 tons in 2018.

5.4.3 Basis of the assessment

An Extended Survivors Analysis (XSA) was performed using 2009-2016 DCF data (biomass landed and age composition of the catches), tuned with fishery independent abundance indices coming from the MEDITS trawl survey and the MEDIAS acoustic survey. The von Bertalanffy curve was re-estimated for sex combined, based on age readings data from GSA9 and 10. The maturity at age vector was obtained according to this new set of parameters. The natural mortality vector was obtained using the Gislason method.

The computation was made using the FLR libraries of the R-project software.

5.4.4 Catch options

Short-term prediction results are shown in the following Table (Table 5.4.4.1).

Table 5.4.4.1. European anchovy in GSAs 9, 10 & 11. Catch(2016) = 8931 tons. Catch (2017)= 9221 tons.

Rationale	Ffactor	F_{bar}	Catch 2018	Catch 2019	SSB 2018	SSB 2019	Change SSB 2018-2019 (%)	Change Catch 2016-2018 (%)
Zero catch	0	0	0	0	49742.06	65703.35	32.09	-100
High long term yield (Fmsy)	0.65	0.22	6577.8	7461.0	44087.3	49286.8	11.8	-26.3
Status quo	1.00	0.34	9447.6	9748.0	41417.1	42869.2	3.5	5.8
Different Scenarios	0.10	0.03	1113.6	1492.7	48825.5	62760.9	28.5	-87.5
	0.20	0.07	2185.0	2838.3	47928.7	59991.7	25.2	-75.5
	0.30	0.10	3216.3	4051.0	47051.4	57384.4	22.0	-64.0
	0.40	0.13	4209.1	5143.5	46193.1	54928.6	18.9	-52.9
	0.50	0.17	5165.1	6127.2	45353.2	52614.4	16.0	-42.2
	0.60	0.20	6086.0	7012.7	44531.5	50432.8	13.3	-31.9
	0.70	0.24	6973.3	7809.3	43727.4	48375.1	10.6	-21.9
	0.80	0.27	7828.4	8525.7	42940.6	46433.4	8.1	-12.3
	0.90	0.30	8652.7	9169.6	42170.6	44600.4	5.8	-3.1
	1.10	0.37	10214.3	10267.3	40679.7	41233.2	1.4	14.4
	1.20	0.40	10954.1	10733.1	39958.1	39686.6	-0.7	22.7
	1.30	0.44	11668.1	11150.8	39251.8	38223.7	-2.6	30.6
	1.40	0.47	12357.3	11525.0	38560.5	36839.2	-4.5	38.4

	1.50	0.50	13023.0	11859.9	37883.9	35528.4	-6.2	45.8
	1.60	0.54	13665.9	12159.6	37221.6	34286.6	-7.9	53.0
	1.70	0.57	14287.2	12427.3	36573.3	33109.5	-9.5	60.0
	1.80	0.60	14887.7	12666.4	35938.7	31993.4	-11.0	66.7
	1.90	0.64	15468.3	12879.7	35317.4	30934.3	-12.4	73.2
	2.00	0.67	16029.9	13069.6	34709.3	29928.9	-13.8	79.5

5.4.5 Reference points

Table 5.4.5.1. European anchovy in GSAs 9, 10 & 11. Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY Framework	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	F=0.22	E=0.4 MSY proxy	This Report

5.4.6 Data Deficiencies

The data used for the analyses come from the last DCF official data call (2017). Some deficiencies have been detected and the detailed list is reported in section 7 (Data quality and deficiencies by stock).

5.5 SUMMARY SHEET OF SARDINE IN GSAs 9, 10, & 11

Species common name: Sardine
Species scientific name: *Sardina pilchardus*
Geographical Sub-area(s) GSA(s): 9-10-11

5.5.1 Stock development over time

State of the adult abundance and biomass

The state of the stock is uncertain, preliminary assessments indicate a decline in biomass over the last 9 years, recent survey estimates show an increase in biomass over the last few years

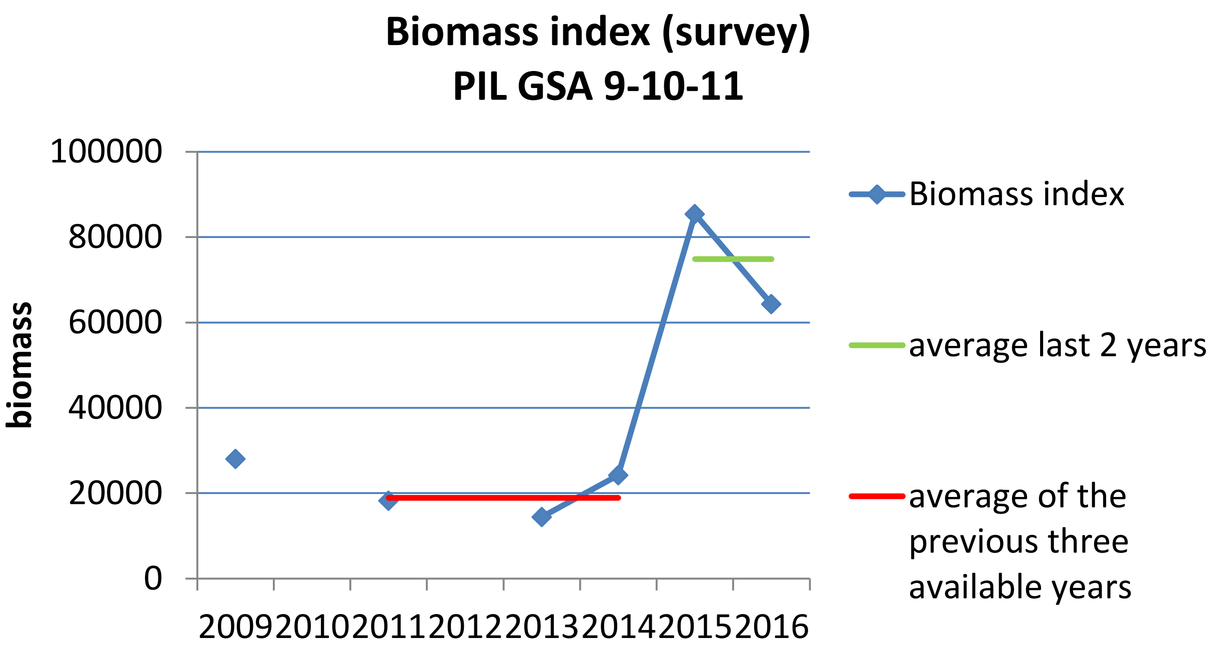


Figure 5.5.1.1 Sardine in GSA 9-10-11. Biomass index from MEDIAS survey: mean of the last two years (green) compared to the previous three years available (2014-2013-2011 in red).

State of the juveniles (recruits)

Not known

State of exploitation

State of exploitation is uncertain, based on size distribution in the landings, the length based analysis and indications from preliminary assessments the stock is not thought to be over exploited. Catch by year is given in Figure 5.5.1.2.

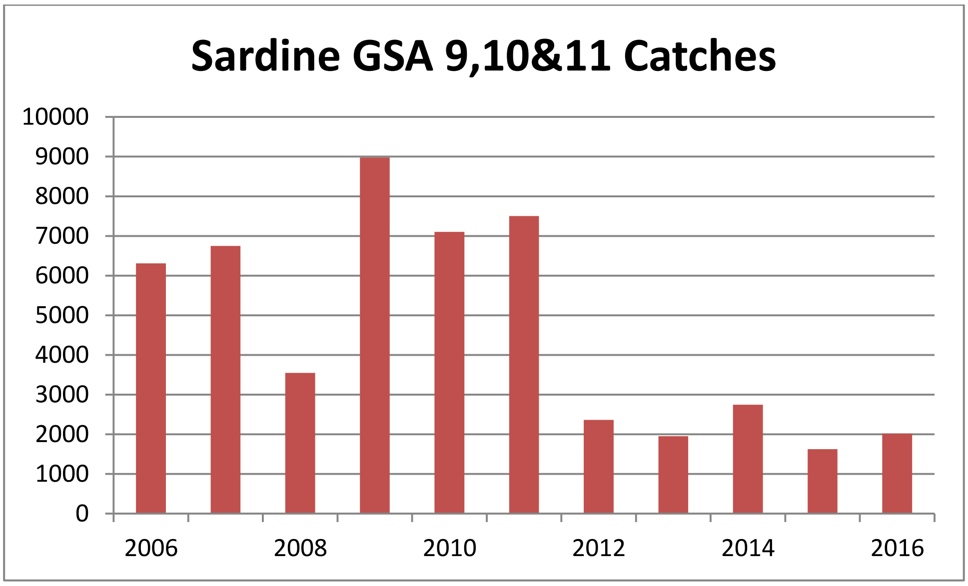


Figure 5.5.1.2 Sardine in GSA 9-10-11 Catches

Table 5.5.1.1 Sardine in GSA 9-10-11 Catches

2006	**6309**
2007	**6749**
2008	**3549**
2009	**8977**
2010	**7103**
2011	**7501**
2012	**2364**
2013	**1951**
2014	**2747**
2015	**1626**
2016	**2018**

5.5.2 Stock advice

STECF EWG 17-09 advises that when precautionary considerations are applied catches for each of 2018 and 2019 catches should not exceed 2556 t.

5.5.3 Basis of the assessment

Preliminary assessments based on an Extended Survivors Analysis (XSA) was performed using 2006-2016 DCF data (biomass landed and age composition of the catches), tuned with fishery independent abundance indices coming from the MEDITS trawl survey and the MEDIAS acoustic survey. Two runs were carried out: in the first the age matrices (commercial catch and survey) are derived by ALK and the secondo one by age slicing. The results were inconclusive and advice is based on data limited approach using acoustic survey biomass index

5.5.4 Catch options

Following the ICES procedures for data limited stocks the change in biomass over the last five years was used to provide an index for change (3.95, Figure 5.5.1.1). As this index is much higher than 1.2, this value is used to multiply the catch to provide an initial catch advice. The exploitation rate is inferred from length based analysis which supports the view the stock is not over exploited; no precautionary buffer is applied giving an overall factor of 1.2. The resulting catch advice referred to the average of the last three years (2130 t) is 2556.

5.5.5 Reference points

Reference points were not established for this stock.

5.5.6 Data Deficiencies

The data used for the analyses come from the last DCF official data call (2017). Some deficiencies have been detected and the detailed list is reported in section 7 (Data quality and deficiencies by stock).

5.6 SUMMARY SHEET OF ATLANTIC HORSE MACKEREL IN GSA 9, 10, & 11

Species common name: Atlantic horse mackerel

Species scientific name: *Trachurus trachurus*

Geographical Sub-area(s) GSA(s): 9, 10, and 11

5.6.1 STOCK DEVELOPMENT OVER TIME

State of the adult abundance and biomass

Summary results for Atlantic Horse Mackerel in GSAs 9, 10, 11 by year are shown in table 5.6.1.1. and figure 5.6.1.1. The SSB has fluctuated between 3529 and 664 t over the 8 years assessed and shows a decreasing trend. Stock size is currently estimated to be at 970 t.

State of the juveniles (recruits)

The XSA results show a variable trend in recruitment with a decrease from 2009 to 2014 and a peak in 2015 (Figure 5.6.1.1 and Table 5.6.1.1).

State of exploitation

F has increased from 2009, peak at around 1.8 in 2012 and decrease to the minimum of 0.56 in 2016. F in 2016 is estimated to be well above F_{MSY} and the stock is considered over exploited.

Table 5.6.1.1. Atlantic horse mackerel in GSAs 9, 10 & 11. Assessment summary result. SSB and catch are in tonnes, recruitment in 1000s individuals.

Year	SSB	Fbar	Rec	Catch
2009	2489.1	0.65	720023	5282.3
2010	3529.4	0.61	573254	7765.2
2011	2948.4	1.59	212087	4173
2012	1617.8	1.79	85719	1902
2013	741.9	1.41	79147	955
2014	633.8	1.3	76654	820.6
2015	908.2	0.87	764932	6857.2
2016	969.6	0.56	430635	3769

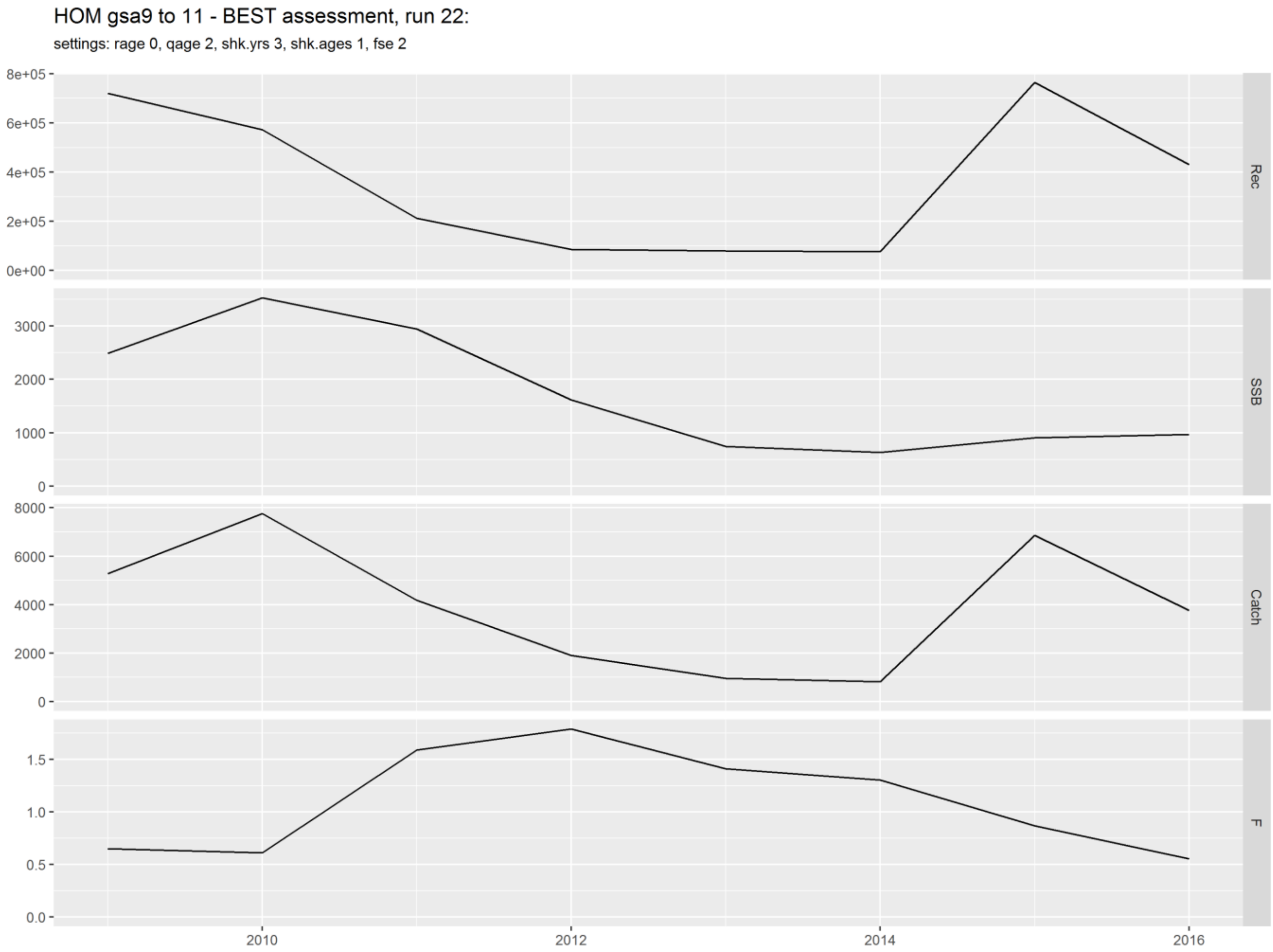


Figure 5.6.1.1. Atlantic horse mackerel in GSAs 9, 10 & 11. Assessment summary result. SSB and catch are in tonnes, recruitment in 1000s individuals.

5.6.2 STOCK ADVICE

STECF EWG 17-09 advises that when MSY considerations are applied fishing mortality should be reduced to no more than F=0.23 (corresponding to E = 0.4), equivalent a catch of 1183 t implemented either through catch restrictions or effort reduction for the relevant fleets.

5.6.3 BASIS OF THE ASSESSMENT

The stock of Atlantic horse mackerel in GSAs 9-11 was assessed using the Extended Survivors Analysis (XSA – Darby and Flatman, 1994). Data from DCF provided at EWG-17-09 containing information on horse mackerel landings and the respective age structure for 2009-2016 were used. A vector of natural mortality value by age was obtained from ICES WGHANSA (2013). Catch at age, weight at age, mortality at age and maturity at age data for the 2009-2016 period were compiled for age classes 0 to 7+ and used as input data for the assessment. The mean weight-at-age matrix was estimated using DCF data, and applied to the whole time series of data. Abundance indexes by age derived from MEDITS (otter trawl survey) from 2009 to 2016 were used as tuning data. Based on Von Bertalanffy growth parameters catch and tuning data by length were split by using a stochastic method to derive matrices by age.

The computation was made by R-project software and the FLR libraries.

5.6.4 Catch options

Catch options from a short-term forecast results are shown below in Table 5.6.4.1.

Table 5.6.4.1 Catch options from a short-term forecast based on F_{2017} = $F_{status\ quo}$ = 0.86, $Catch_{2016}$ = 3769t, $Catch_{2017}$ = 3342t SSB in 2018 = 1426t.

Rationale	Ffactor	Fbar	Catch_2018	Catch_2019	SSB_2018	SSB_2019	Change_SSB 2018-2019(%)	Change_Catch 2016-2018(%)
zero catch	0.0	0.00	0.0	0.0		3354.3	135	-100
E = 0.4	0.3	0.23	1183.0	1579.1		2632.6	85	-69
Status quo	1.0	0.86	3306.13	3259.66		3306.13	-3	-12
Different scenarios	0.1	0.09	483.0	701.0		3058.2	114	-87
	0.2	0.17	922.8	1271.7		2790.3	96	-76
	0.3	0.26	1323.4	1735.6		2547.8	79	-65
	0.4	0.34	1688.6	2112.2		2328.2	63	-55
	0.5	0.43	2022.0	2417.5		2129.4	49	-46
	0.6	0.51	2326.4	2664.6		1949.3	37	-38
	0.7	0.60	2604.6	2864.3		1786.1	25	-31
	0.8	0.69	2859.2	3025.4		1638.2	15	-24
	0.9	0.77	3092.4	3155.2		1504.1	5	-18
	1.0	0.86	3306.1	3259.7		1382.5	-3	-12
	1.1	0.94	3502.2	3343.6		1272.2	-11	-7
	1.2	1.03	3682.3	3411.0		1172.1	-18	-2
	1.3	1.11	3847.9	3465.2		1081.3	-24	2
	1.4	1.20	4000.4	3508.7		998.8	-30	6
	1.5	1.28	4140.8	3543.7		923.9	-35	10
	1.6	1.37	4270.3	3572.0		855.8	-40	13
	1.7	1.46	4389.9	3594.9		793.9	-44	16
	1.8	1.54	4500.5	3613.7		737.7	-48	19
	1.9	1.63	4602.8	3629.2		686.6	-52	22
	2.0	1.71	4697.6	3642.2		640.1	-55	25

5.6.5 Reference points

Table 5.6.5.1. Atlantic horse mackerel in GSAs 9, 10 & 11. Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY framework	F_{MSY}	0.23	E=0.4 MSY proxy	This report

5.6.6 DATA DEFICIENCIES

Data utilised for the analyses come from the last DCF official data call (2016). Some errors and deficiencies have been detected and the detailed list is reported in section 7.6 (Data quality). Total discards and discards at length are missing for 2009, 2014 and 2015 in GSA 10 and for 2010 and 2014 in GSA11, while reported for all other years in time frame (2009-2016). Total landings are reported from 2003 for GSA9, from 2006 for GSA10 and from 2009 for GSA11, while structures at length from 2007 for GSA9, 2009 for GSA10 and 2010 for GSA11 with differences on gears among years. In some years the difference among reported total catches and catches derived from the biological sampling of landing and discards can be explained taking in to account that this species is not an economically important and generally is poorly landed in the region.

A check and eventually an update on catch data and more appropriate sample procedures of landings would improve the assessment.

5.7 SUMMARY SHEET OF ANCHOVY IN GSA 17 & 18

Species common name: European anchovy
Species scientific name: *Engraulis encrasicolus*
Geographical Sub-area(s) GSA(s): 17 & 18

5.7.1 STOCK DEVELOPMENT OVER TIME

State of the adult abundance and biomass
The assessment indicates that the anchovy stock size fluctuated over the time period examined. Maximum values of SSB were obtained in 1978 (158000 t). After that, the stock started to decline reaching a minimum level in 1987 (around 19000 t). In the following years, the stock started recovering until 2006, when the biomass reached another maximum (SSB at 91000 tons). From 2005, the stock started to decline again, reaching in 2016 a SSB level of 28000 tons. SSB is currently at a low level, above and not far above the biomass of 1987 from which a slow stock recovery has been observed, the recovery occurred with F at about 50% of F_{MSY}.

State of the juveniles (recruits)
The assessment shows fluctuations in the number of recruits since the beginning of the time series, similar to those observed for the SSB. The recruitment (age 0) reached a maximum in 1977 (204 billion individuals) and a minimum value of 20 billion individuals in 1986. A second peak was registered in 2005, with a value of 117 billion individuals. Since then, recruitment decreased until 2016 (46 billion individuals).

State of exploitation
F has increased from the 1980s and is estimated to have peaked at around 1.3 in 2011. After a slight decrease, F increased again in the last years, being estimated at 1.42 in 2016. F has been above F_{MSY} since 2000 and now about 2.3* F_{MSY}, the stock is classed as overfished.

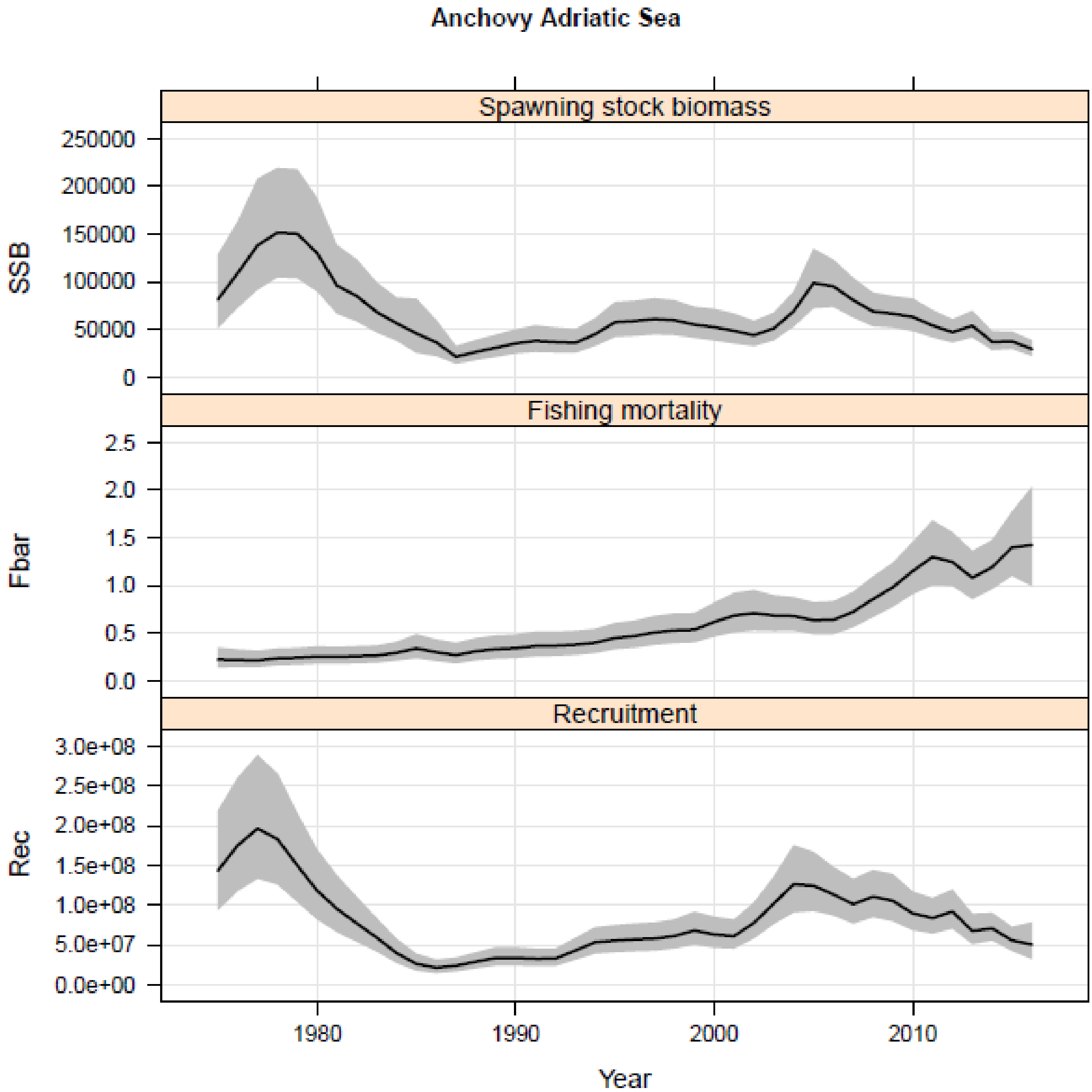


Figure 5.7.1. European anchovy in GSAs 17-18. SAM assessment main outputs.

Table 5.7.1. European anchovy in GSAs 17-18. SAM assessment summary results.

Year	Recruits Age 0 (Thousands)	Total biomass (tonnes)	Spawning biomass (tonnes)	Catch (tonnes)	Fbar ages 1-2	Year	Recruits Age 0 (Thousands)	Total biomass (tonnes)	Spawning biomass (tonnes)	Catch (tonnes)	Fbar ages 1-2
1975	151031654	755398	87204	21753	0.231	1997	58468576	461852	61883	34510	0.515
1976	182817693	1138247	114806	30001	0.225	1998	60611791	580126	59635	34752	0.536
1977	203871408	1160081	143774	38025	0.221	1999	66452635	587129	54285	31351	0.543
1978	190468998	1137109	157787	47667	0.241	2000	60430228	348015	51226	33190	0.620
1979	155942826	995500	156061	51021	0.247	2001	57540523	384231	46444	32209	0.687
1980	120721887	768350	137036	52733	0.264	2002	70915529	467428	41151	27834	0.716
1981	94773463	674684	98420	36171	0.260	2003	93455879	557936	46630	28254	0.690
1982	75075137	528607	84373	35596	0.265	2004	115872383	766814	62818	37309	0.666
1983	57139145	412091	66703	28854	0.270	2005	117506005	882929	91491	51124	0.636
1984	37693567	293902	55326	27038	0.298	2006	108254988	813418	91035	61084	0.643
1985	24471017	172301	44667	30761	0.342	2007	97757453	591845	77343	58689	0.729
1986	19855667	196614	32761	18354	0.298	2008	106856781	652131	65644	51380	0.854
1987	22953936	197008	19103	7832	0.266	2009	104636186	596002	64087	48923	0.974
1988	29680476	229349	24909	10124	0.301	2010	88631688	509915	62630	51124	1.146
1989	35962957	279288	31445	12965	0.331	2011	81981158	476870	53477	44400	1.317
1990	36143222	284646	37459	14802	0.344	2012	89254286	355045	45615	36827	1.254
1991	34795548	238948	40741	17518	0.370	2013	63974812	361132	51896	36425	1.081
1992	34414894	261974	38561	16806	0.372	2014	67120495	530725	34926	33157	1.186
1993	44812604	301040	37309	16732	0.383	2015	52064818	375120	35739	33996	1.419
1994	55118722	365492	46911	20925	0.407	2016	46085089	271577	27667	28681	1.428
1995	56911045	498321	59635	30485	0.452						
1996	57828946	498820	60174	32145	0.474						

Stock advice

STECF EWG 17-09 advises that when MSY considerations are applied fishing mortality should be reduced to no more than F=0.57 (corresponding to E = 0.4), equivalent a catch of 12195 t in 2018 implemented either through catch restrictions or effort reduction for the relevant fleets. As the current biomass is near the historic low, and previously recovery occurred only very slowly from this biomass and with Fs close to 50% of F_{MSY} even greater reductions should be considered.

5.7.2 Basis of the assessment

The stock of anchovy in GSAs 17-18 was assessed using the State-space Assessment Model (SAM) (Nielsen et al., 2014) in FLR environment with catch data from 1975 to 2016 (a short time series of data, 2000-2016, was also run). Three tuning fleets based on acoustic surveys covering the western and eastern GSA 18 and western GSA 17 (from 2004 to 2016), eastern GSA 17 (from 2013 to 2016), and a biomass index coming from the acoustic survey in eastern GSA 17 (from 2003 to 2012). Since the spawning takes place mostly in spring-summer (Zorica et al., 2013), previous assessments (STECF EWG 15-11) were carried out taking into account a conventional birth date on the first of June (split-year), as in Santojanni et al. (2003). Consequently, all data were shifted by 6 months in order to have each year compounded by the time interval ranging from the first of June, up to May 31st of the following year; the tuning indices were shifted as well.

Following the suggestions by STECF EWG 14-09, the present assessment was based on the calendar-year data. This approach is expected to simplify calculations, limiting the errors, and it will allow using the most recent survey index available. In addition a new mean weight-at-age matrix was estimated using DCF data, and applied to the whole time series of data.

Assessment was performed with FLSAM 1.02 within FLR environment (FLCore 2.6.5).

5.7.3 CATCH OPTIONS

Short-term prediction results are shown in the following table (Table 5.7.2).

Table 5.7.4.1 European anchovy in GSAs 17-18. Short-term forecasts showing catch options at different level of F. F_{2017} is the geometric mean of the last 3 years of the assessment (2014-2016) corresponding to $catch_{2017}$ of 23355 t. Recruitment 2017 and 2018 is 58332 million (computed as the geometric mean of recruitment in the last 3 years of the assessment 2014-2016).

Rationale	Ffactor	Fbar	Catch 2018	Catch 2019	SSB 2018	SSB 2019	Change SSB 2018-2019 (%)	Change Catch 2016-2018 (%)
Zero catch	0.00	0.00	0.0	0.0	39241.9	51676.7	31.7	-100.0
E = 0.4	0.43	0.57	12194.6	16382.2	33113.0	36744.8	11.0	-64.3
Status quo	1.00	1.33	22500.3	24060.6	27298.4	27784.2	1.8	-34.3
Different Scenarios	0.10	0.13	3442.6	5906.2	37613.2	46880.2	24.6	-89.9
	0.20	0.27	6478.5	10169.4	36109.9	43049.1	19.2	-81.1
	0.30	0.40	9181.8	13360.5	34718.8	39928.3	15.0	-73.2
	0.40	0.53	11611.1	15835.0	33428.3	37338.5	11.7	-66.1
	0.50	0.67	13813.2	17817.8	32228.2	35152.0	9.1	-59.7
	0.60	0.80	15825.7	19454.8	31109.4	33276.9	7.0	-53.8
	0.70	0.93	17678.6	20841.9	30063.8	31646.2	5.3	-48.4
	0.80	1.07	19396.1	22044.3	29084.2	30210.5	3.9	-43.4
	0.90	1.20	20998.0	23106.6	28164.3	28932.6	2.7	-38.7
	1.10	1.47	23915.9	24928.8	26481.5	26743.3	1.0	-30.2
	1.20	1.60	25255.8	25728.0	25709.1	25792.8	0.3	-26.3
	1.30	1.73	26528.7	26470.6	24977.3	24919.0	-0.2	-22.5
	1.40	1.87	27742.1	27166.2	24282.4	24110.7	-0.7	-19.0
	1.50	2.00	28902.1	27821.9	23621.2	23359.1	-1.1	-15.6
	1.60	2.14	30013.9	28443.6	22991.0	22656.7	-1.5	-12.4
	1.70	2.27	31081.9	29035.7	22389.2	21997.3	-1.8	-9.3
	1.80	2.40	32109.8	29601.8	21813.5	21375.8	-2.0	-6.3
	1.90	2.54	33100.9	30145.1	21261.8	20787.7	-2.2	-3.4
	2.00	2.67	34058.0	30667.8	20732.4	20229.5	-2.4	-0.6

5.7.4 REFERENCE POINTS

Table 5.7.5.1 European anchovy in GSA 17-18. Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY Framework	F_{MSY}	F = 0.57	E = 0.4 MSY proxy	This WG

5.7.5 *DATA DEFICIENCIES*

Data of the anchovy in GSA 17&18 have shown some deficiencies.

1) Some doubts about the historical data were underlined by the experts. For this reason, two assessments were carried out, one considering all the data available (years from 1975 to 2016) and one considering only the recent data (years from 2000 to 2016)
2) Different ALKs were used, resulting in quite important differences between age data coming from the surveys and age data coming from the commercial samples
3) The use of of two different codes for the same area (i.e. GSA 17 and SA 17) should be avoided. This issue can lead to an incomplete selection of data.

5.8 SUMMARY SHEET OF SARDINE IN GSA 17 & 18

Species common name: Sardine
Species scientific name: *Sardine pilchardus*
Geographical Sub-area(s) GSA(s): 17&18

5.8.1 STOCK DEVELOPMENT OVER TIME

State of the adult abundance and biomass
The assessment indicates that the sardine stock size has fluctuated over the time period examined (Figure 5.8.1.1). Maximum value of SSB was estimated to be in 1982 (763000 t). After that, the stock declined reaching a minimum level in 2001 (around 121000 t). In the following years the stock started increasing, reaching in 2016 a SSB biomass level of 161000 tons.

State of the juveniles (recruits)
The assessment estimates show fluctuations in the number of recruits since the beginning of the time series, similar to those observed for the SSB. The recruitment (age 0 – Figure 5.8.1.1, bottom) reached a maximum in 1981 (59.8 billion individuals) and a minimum value of 9.8 billion individuals in 1999. Since then, recruitment has been generally increasing until 2016 (24.8 billion individuals).

State of exploitation
Based on the assessment results F is estimated to have remained below 0.5 until 2010, F is estimated to have reached a peak of 1.7 in 2014 and has declined slightly so current F (Fbar ages 1-3, Figure 5.8.1.1) is estimated to be 1.30. F is well above F_{MSY} and the stock is considered to be being overfished.

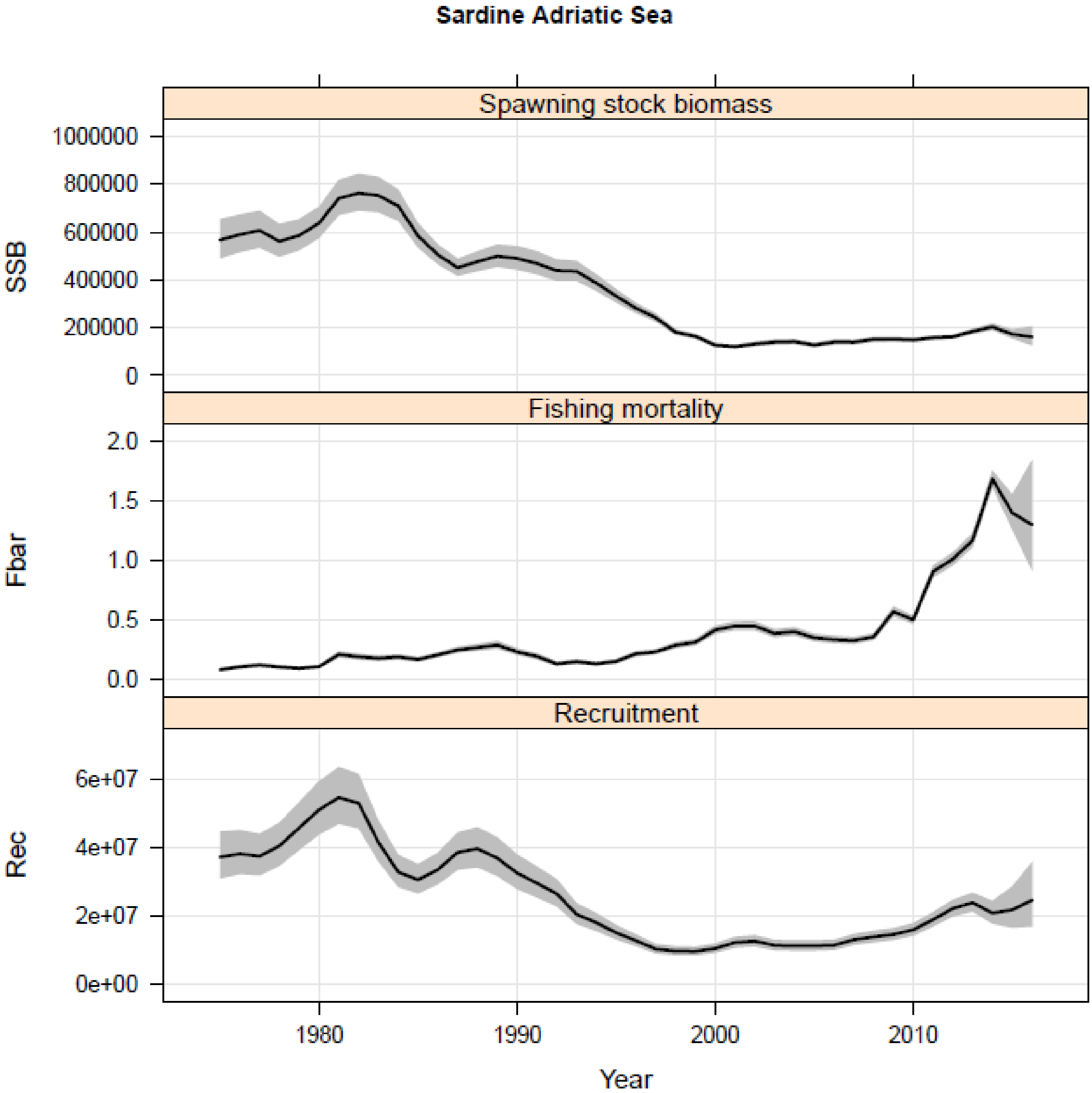


Figure 5.8.1.1 Sardine in GSAs 17 & 18. SAM assessment main outputs based on full time series of data long time series 1975-2016.

Table 5.8.1.1 Sardine in GSAs 17 & 18. SAM assessment summary results (long time series).

Year	Recruits Age 0 (Thousands)	Total biomass (tonnes)	Spawning biomass (tonnes)	Catch (tonnes)	Fbar ages 1-2	Year	Recruits Age 0 (Thousands)	Total biomass (tonnes)	Spawnin g biomass (tonnes)	Catch (tonnes)	Fbar ages 1-2
1975	37393221	829020	566935	34098	0.087	1997	10501199	320296	242316	38446	0.236
1976	38339835	869784	589482	46817	0.112	1998	9889657	250446	181317	35668	0.292
1977	37655892	882046	606828	54231	0.127	1999	9820671	250446	163898	28113	0.317
1978	40669948	861991	561294	44712	0.111	2000	10659904	196614	127389	26082	0.420
1979	45993011	908000	585956	41689	0.098	2001	12385042	226387	121176	24222	0.454
1980	51238410	1011556	637303	49119	0.114	2002	12800567	256273	132191	24029	0.454
1981	54843816	1141667	741181	92134	0.214	2003	11570855	226613	139804	21781	0.391
1982	53169740	1156606	762990	85136	0.195	2004	11398587	231886	141775	26609	0.407
1983	41741233	1053891	753135	83617	0.183	2005	11432835	197798	128027	20769	0.355
1984	32999402	949794	709276	92134	0.194	2006	11617231	264078	139804	20640	0.339
1985	30768439	799706	584201	75735	0.173	2007	13203599	292728	139665	22026	0.331
1986	33733434	795718	505347	79063	0.211	2008	14048132	350810	151297	27474	0.362
1987	38763902	738222	451351	72984	0.253	2009	14768395	279288	152207	33894	0.574
1988	39864629	759184	476394	68460	0.273	2010	16110793	314582	148747	34406	0.505
1989	37095269	759184	499319	70898	0.294	2011	19077115	371759	158103	54339	0.909
1990	32736460	718557	489921	61513	0.237	2012	22342472	405145	161781	58689	1.013
1991	29769651	677388	468832	54122	0.198	2013	24058526	441971	184610	71682	1.170
1992	26695351	625308	438888	40336	0.138	2014	20999307	438888	203414	82619	1.683
1993	20645336	580706	435827	45524	0.155	2015	21943905	480220	173165	78198	1.400
1994	18201235	514525	386930	39262	0.138	2016	24791217	495836	161297	78355	1.300
1995	15263883	439327	332369	41151	0.158						
1996	12942150	373622	281813	43871	0.220						

5.8.2 STOCK ADVICE

STECF EWG 17-09 advises that when MSY considerations are applied fishing mortality should be reduced to no more than F=0.44 (corresponding to E = 0.4 as proxy for Fmsy), equivalent a catch of 30679 t in 2018 implemented either through catch restrictions or effort reduction for the relevant fleets.

5.8.3 BASIS OF THE ASSESSMENT

The stock of sardine was assessed using the State-space Assessment Model (SAM) (Nielsen et al., 2014) in FLR environment with data from 1975 to 2016 as well as with short time series from 2000 to 2016. A three tuning indices (acoustic survey covering the western side in GSA 17 from 2009 to 2016 plus acoustic survey covering the whole GSA 18 from 2009 to 2015 as numbers at age; acoustic survey eastern side of GSA 17 from 2013 to 2016 number at age and acoustic east side GSA 17 survey from 2008 till 2012 as biomass index) were used in the assessment. All the analyses were performed with version 0.99-3 of FLSAM, together with version 2.5 of the FLR library (FLCore).

5.8.4 Catch options

Short term forecast was carried out by STECF EWG. Short-term prediction results are shown in the following table (Table 5.8.4.1).

Table 5.8.4.1 Sardine in GSAs 17 18. Short-term forecasts showing catch options at different level of F F_{2017} is the geometric mean of the last 3 years of the assessment (2014-2016), corresponding to a $catch_{2017}$ of 75916 t. Recruitment 2017 and 2018 is 21988 million (computed as the geometric mean of recruitment in the last 3 years of the assessment 2014-2016).

Rationale	Ffactor	Fbar	Catch 2018	Catch 2019	SSB 2018	SSB 2019	Change SSB 2018-2019 (%)	Change Catch 2016-2018 (%)
Zero catch	0.00	0.00	0.0	0.0	177927.0	238121.1	33.8	-100.0
E = 0.4	0.30	0.44	30679.0	41029.7	177927.0	212515.2	19.4	-61.4
Status quo	1.00	1.45	78493.7	77013.3	177927.0	175376.0	-1.4	-1.1
Different Scenarios	0.10	0.15	11071.6	17080.4	177927.0	228739.8	28.6	-86.1
	0.20	0.29	21168.8	30320.9	177927.0	220319.8	23.8	-73.3
	0.30	0.44	30414.7	40753.0	177927.0	212730.4	19.6	-61.7
	0.40	0.58	38914.6	49110.7	177927.0	205861.2	15.7	-51.0
	0.50	0.73	46758.5	55920.6	177927.0	199618.1	12.2	-41.1
	0.60	0.87	54023.6	61562.9	177927.0	193921.5	9.0	-32.0
	0.70	1.02	60776.3	66314.7	177927.0	188703.0	6.1	-23.5
	0.80	1.16	67073.7	70379.5	177927.0	183904.7	3.4	-15.5
	0.90	1.31	72965.2	73908.1	177927.0	179476.6	0.9	-8.1
	1.10	1.60	83696.2	79780.0	177927.0	171566.0	-3.6	5.4
	1.20	1.74	88605.2	82273.0	177927.0	168014.9	-5.6	11.6
	1.30	1.89	93248.9	84542.0	177927.0	164695.1	-7.4	17.4
	1.40	2.03	97652.0	86625.5	177927.0	161582.8	-9.2	23.0
	1.50	2.18	101836.3	88553.7	177927.0	158657.2	-10.8	28.2
	1.60	2.32	105820.9	90350.3	177927.0	155900.3	-12.4	33.3
	1.70	2.47	109622.7	92034.3	177927.0	153296.1	-13.8	38.1
	1.80	2.61	113256.7	93620.9	177927.0	150830.8	-15.2	42.6
	1.90	2.76	116736.2	95122.6	177927.0	148492.1	-16.5	47.0
	2.00	2.90	120073.0	96549.3	177927.0	146269.2	-17.8	51.2

5.8.5 Reference points

Exploitation rate (E=0.4) was agreed to be used as reference point.

Table 5.8.5.1 Sardine in GSAs 17 & 18. Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY Framework	F_{MSY}	F = 0.44	E = 0.4 MSY proxy	This report

5.8.6 Data Deficiencies

Data of the sardine from GSA 17&18 have shown some deficiencies.

- Catch and length data from the eastern side of GSA 18 are not available before 2007 and are reconstructed based on the GSA 17 eastern data.
- Eastern length data GSA 17&18 before 2000 are reconstructed as average of the 1998 to 2014 eastern GSA 17 data.
- Accuracy of catch data (eastern side GSA 17&18) for the period 1975 to 1998 is very doubtful, and should be revised if possible. These data do not contain any age indices of the catches
- Eastern acoustic survey GSA 17 data were used as tuning index in the period from 2003 to 2012 and as abundance at age matrix from 2013 to 2016, but model is not fitting abundance at age data very well.
- The use of of two different codes for the same area (i.e. GSA 17 and SA 17) should be avoided. This issue can lead to an incomplete selection of data.

5.9 SUMMARY SHEET OF ATLANTIC HORSE MACKEREL IN GSAs 17, 18, 19 & 20

Given data deficiencies and uncertainties in the fishery data no advice can be provided.

5.10 SUMMARY SHEET OF ANCHOVY IN GSA 22 & 23

Species common name: European anchovy

Species scientific name: *Engraulis encrasicolus*

Geographical Sub-area(s) GSA(s): 22

5.10.1 STOCK DEVELOPMENT OVER TIME

State of the adult abundance and biomass

Based on the selected assessment method the anchovy SSB fluctuated over the time period examined (2000-2016) from 23333 tons (in 2000) to 74802 tons in 2016. A drop in SSB was observed in the years 2009 to 2013. This is generally in accordance with the SAM results that estimate SSB at 67546 tons in 2016.

State of the juveniles (recruits)

The assessment shows an increasing trend in the number of recruits between 2001 and 2007. The recruitment (age 0) reached a maximum of 26.4 in 2016 (million individuals) and a minimum value of 9.4 million individuals in 2000. A second peak was registered in 2007, with a value of 25.6 million individuals.

State of exploitation

F_{bar} (1-3) shows a decreasing trend since 2000, presenting an average around 1.093 for the period 2007 to 2013. Since 2013 F is decreasing with a value at 0.46 in 2016.

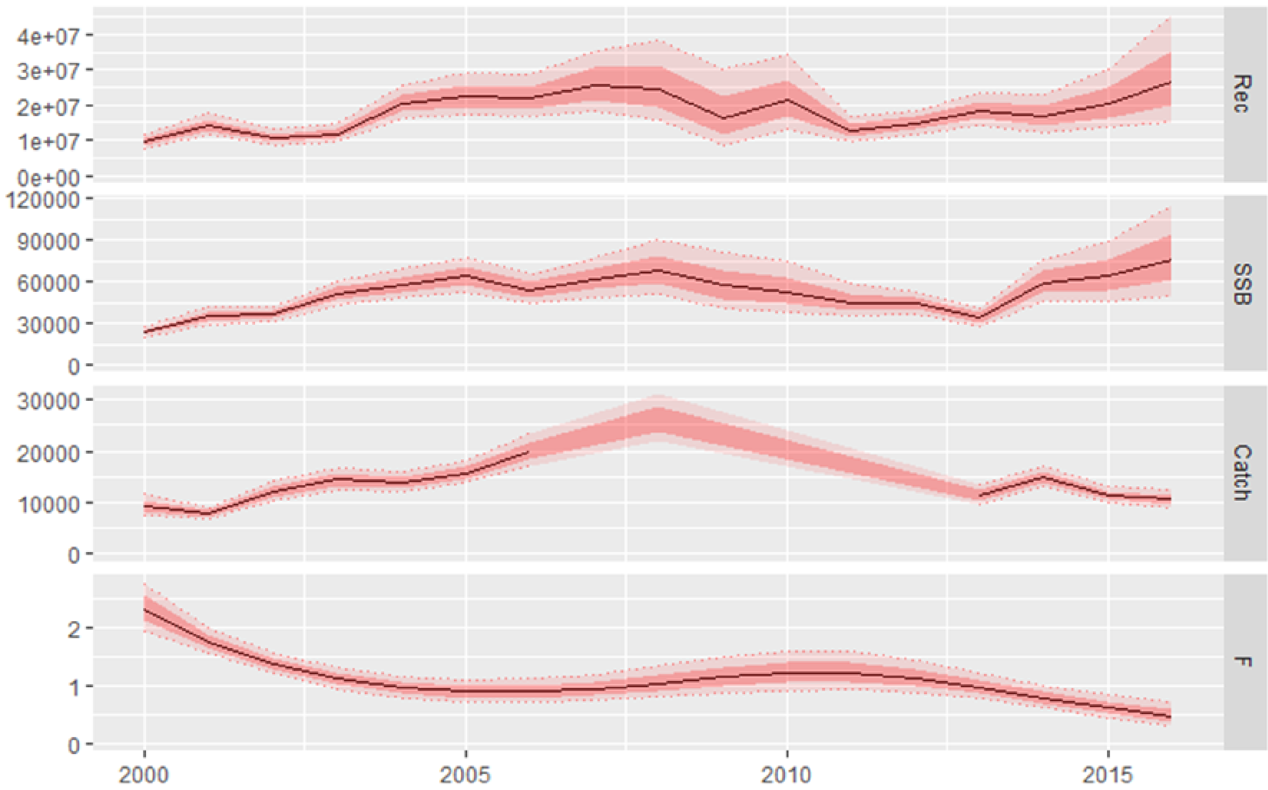


Figure 5.10.1.1 European anchovy in GSA 22. Assessment main outputs with confidence intervals.

Table 5.10.1.1 European anchovy in GSA 22. Assessment summary results. Catch refers to the model-estimated values.

Year	Fbar (1-3)	Recruitment (thousands)	SSB (t)	Catch (t)	Total biomass (t)
2000	2.32	9415.173	23333	9210.2	82956
2001	1.76	14244.784	34722	7771.6	122403
2002	1.37	10523.486	36508	12122.3	110432
2003	1.11	11838.247	50712	14329.8	163378
2004	0.95	20527.427	57162	13850.8	187674
2005	0.89	22372.351	63221	15672.1	199249
2006	0.89	21749.292	53445	19875.7	155770
2007	0.95	25633.405	60912	NA	192799
2008	1.04	24549.288	66521	25754	212953

2009	1.14	16238.424	54760	NA	161159
2010	1.21	21232.416	50374	NA	166171
2011	1.21	12714	43597	NA	128731
2012	1.13	14653.33	43290	NA	145598
2013	0.97	18221.445	33582	11330	108867
2014	0.79	16630.548	59054	1488	177540
2015	0.61	20191.875	63251	11384	194756
2016	0.46	26458.735	74802	10610	233460

5.10.2 STOCK ADVICE

While the assessment provided above is considered an acceptable estimate of stock status, the assessment is not considered suitable for catch advice; therefore EWG 17-09 is not able to provide catch advice for anchovy in GSA 22.

5.10.3 BASIS OF THE ASSESSMENT

Three different assessment methods were applied for this stock. The surplus model, SPICT for the period 1985-2016, including both the Greek and the Turkish GFCM landings data, and two analytical methods: the SAM and the a4a based on the catch at-age information for the Greek part of GSA 22for the period 2000-2016. All three assessment methods give a similar perception and showed a small increasing trend for the SSB of anchovy stock in GSA 22 for the last 5 years. The a4a method is selected as the primary source of stock status due to its more appropriate treatment of missing data.

The surplus model SPICT (Pedersen and Berg, 2017) in R environment was applied using the official reported landings from the entire Aegean Sea (GSA 22) as reported in the FishStat J from the GFCM Database from 1985 to 2016. Data prior to 1985 were excluded because they were considered unreliable due to the very low Turkish reported landings. As anchovy is fished predominantly from the purse seine fleet which presents negligible discards, landings records were considered as equal to catch records. The biomass from acoustics surveys that were conducted in the Greek part of the Aegean Sea was used as tuning index. Acoustics data were available in 1995 and 1996 and from 2003 onwards (with gaps in 2007, 2009-2012 and 2015).

The two analytical methods applied involved were a) the Assessment for All Initiative (a4a) (Jardim et al., 2015) and b) the State-space Assessment Model (SAM) (Nielsen et al., 2014) in FLR environment with the Greek anchovy catch data of GSA 22 from

2000 to 2016. A single tuning fleet was used in both methods based on the biomass at age estimates from summer acoustic surveys conducted in the Greek part of GSA 22 (2003 to 2016 with gaps in 2007, 2009-2013 and 2015). DCF catch data with gaps in the respective missing years for the catch at age information were used for the a4a method. As running the SAM model does not allow gaps in the catch at age information this was estimated based on the average length frequency for the missing years.

Assessment was performed with version 1.0.2 of FLSAM and 1.1.2 of FLa4a, together with version 2.6.4 of the FLR library (FLCore).

5.10.4 CATCH OPTIONS

No short-term prediction was carried out for this stock as the STECF EW-17 09 decided not to provide scientific advice based on the specific assessments.

5.10.5 REFERENCE POINTS

Table 5.10.5.1 Anchovy in GSA 22. Reference points, values, and their technical basis. F values refer to ages 1 to 3.

Framework	Reference point	Value	Technical basis	Source
MSY Framework	F_{MSY}	F = 0.467	E = 0.4 MSY proxy	This report

5.10.6 DATA DEFICIENCIES

Particular deficiencies were found in the DCF data provided. Specifically, no DCF catch / catch-at-length / catch-at-age data were provided for 2007, 2009, 2010, 2011, and 2012. No catch-at-age data were provided for 2016. Catch-at-age data were provided only for the last quarter for 2013 and 2015. No acoustic surveys took place in 2007, 2009-2012, 2015. The output of the acoustic survey in 2013 was used only as a total biomass index in the SPICT as the survey took place in a different period (September instead of June –July).

5.11 SUMMARY SHEET OF SARDINE IN GSAs 22 & 23

Species common name: European Sardine

Species scientific name: Sardina pilchardus

Geographical Sub-area(s) GSA(s): 22

5.11.1 STOCK DEVELOPMENT OVER TIME

State of the adult abundance and biomass

Based on the selected assessment method the sardine SSB fluctuated over the time period examined (2000-2016) from 18729 tons (in 2003) to 40084 in 2015 and 33851 tons in 2016. A drop in SSB was observed in the years 2009 to 2013 followed by an increase up to 2016.

State of the juveniles (recruits)

The assessment shows an increasing trend in the number of recruits since 2011. The recruitment (age 0) reached a maximum of 8.15 million individuals in 2015 and a minimum value of 2.9 million individuals in 2011. The recruitment in 2016 is considered as 6.18 million individuals.

State of exploitation

F_{bar} (1-3) shows a decreasing trend since 2011 reaching the value of 0.534 in 2016.

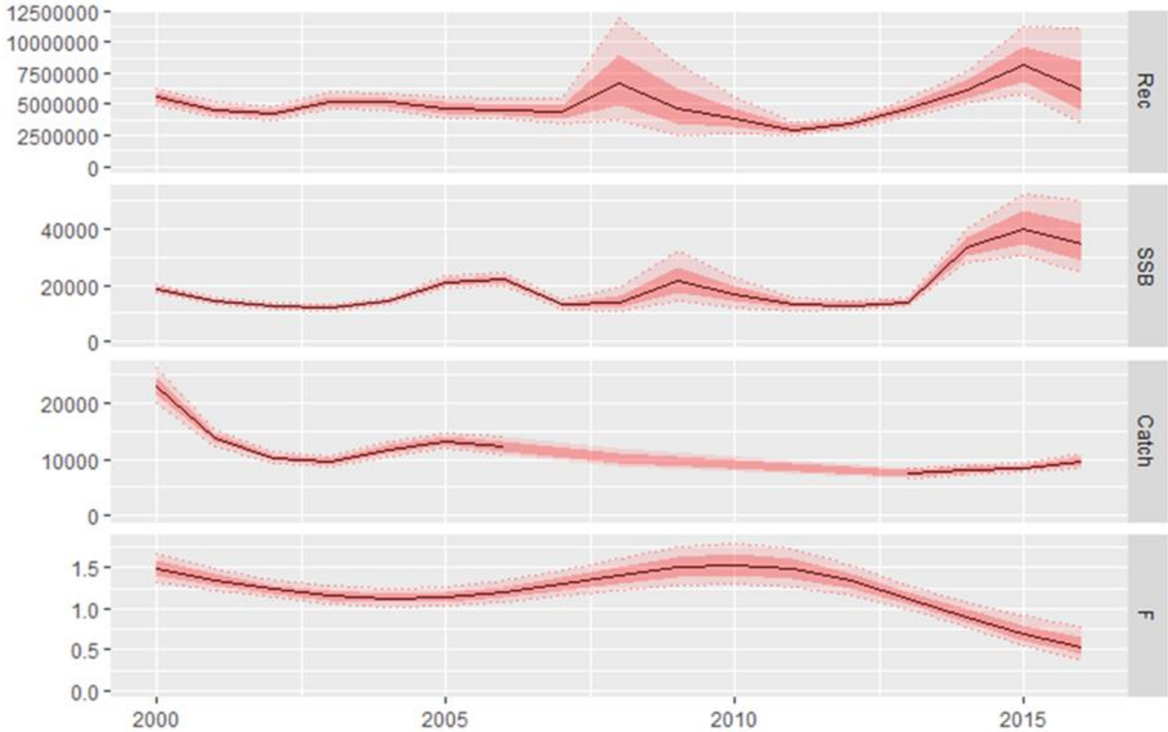


Figure 5.11.1.1 Sardine in GSA 22 & 23. A4A assessment main outputs with confidence intervals.

Table 5.11.1.1 Sardine in GSA 22 & 23. A4a assessment summary results. Catch refers to the model-estimated values.

Year	Fbar (1-3)	Recruitment (thousands)	SSB (t)	Catch (t)	Total biomass (t)
2000	1.49	5567.715	18729	22637	54563
2001	1.35	4535.463	14314	13652	41070
2002	1.24	4250.837	12363	10240	35284
2003	1.16	5245.865	11949	9522	38807
2004	1.13	5144.143	14295	11688	43717
2005	1.14	4673.725	20869	13099	63126
2006	1.20	4558.785	21896	1240	68377
2007	1.30	4334.579	13041	NA	37266
2008	1.41	6671.884	13741	10206	44224
2009	1.50	4629.739	20399	NA	68274
2010	1.53	3812.299	16086	NA	54990
2011	1.48	2953.659	12798	NA	43153
2012	1.34	3426.382	12726	NA	44421
2013	1.13	4667.09	13828	7447	49313
2014	0.91	6169.635	33723	8077	120911
2015	0.70	8154.626	40084	8480	136183
2016	0.53	6176.295	33851	9655	98339

5.11.2 STOCK ADVICE

While the assessment provided above is considered an acceptable estimate of stock status, the assessment is not considered suitable for catch advice; therefore EWG 17-09 is not able to provide catch advice for sardine in GSA 22.

5.11.3 BASIS OF THE ASSESSMENT

The stock of sardine in GSA 22 was assessed based on a) a data poor method and b) two analytical methods. The surplus model SPICT (Pedersen and Berg, 2017) in R environment was applied using the official reported landings from the entire Aegean Sea (GSA 22) as reported in the FishStat J from the GFCM Database from 1985 to 2016. Data prior to 1985 were excluded because they were considered unreliable due to the very low Turkish reported landings. As sardine is fished predominantly from the purse seine fleet which presents negligible discards, landings records were considered as equal to catch records. The biomass from acoustics surveys that were conducted in the Greek part of the Aegean Sea was used as tuning index. Acoustics data were available in 1995 and 1996 and from 2003 onwards (with gaps in 2007, 2009-2012 and 2015).

The two analytical methods applied involved were a) the Assessment for All Initiative (a4a) (Jardim et al., 2015) and b) the State-space Assessment Model (SAM) (Nielsen et al., 2014) in FLR environment with the Greek sardine catch data of GSA 22 from 2000 to 2016. A single tuning fleet was used in both methods based on the biomass at age estimates from summer acoustic surveys conducted in the Greek part of GSA 22 (2003 to 2016 with gaps in 2007, 2009-2013 and 2015). DCF catch data with gaps in the respective missing years for the catch at age information were used for the a4a method. As running the SAM model does not allow gaps in the catch at age information this was estimated based on the average length frequency for the missing years.

Assessment was performed with version 1.0.2 of FLSAM and 1.1.2 of FLa4a, together with version 2.6.4 of the FLR library (FLCore).

5.11.4 CATCH OPTIONS

No short-term prediction was carried out for this stock as the STECF EW-17 09 decided not to provide scientific advice based on the specific assessments.

5.11.5 REFERENCE POINTS

Table 5.11.5.1 Sardine in GSA 22. Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY Framework	F_{MSY}	$F_{1\text{-}3}$= 0.503	E = 0.4 MSY proxy	This report

5.11.6 DATA DEFICIENCIES

Particular deficiencies were found in the DCF data provided. Specifically, no DCF catch / catch-at-length / catch-at-age data were provided for 2007, 2009, 2010, 2011, and 2012. No catch-at-age data were provided for 2016. Catch-at-age data were provided only for last quarter for 2013 and 2015. No acoustic surveys took place in 2007, 2009-2012, 2015. The output of the acoustic survey in 2013 was used only in the SPICT as the survey took place in September instead of June –July.

6 ASSESSMENT BY STOCK

6.1 ANCHOVY IN GSAs 5, 6 & 7

The list of proposed stocks to be assessed by the EWG17-09 included a joint assessment of European anchovy in GSAs 5-6-7.

The purse seining activity in GSA 5 is much reduced. European anchovy landings in GSA 5 are very low (highest landings around 0.5 t) and information on the size structure of the landings is available only for 2016. In addition, GSA 5, the Balearic Islands, is not surveyed by the acoustic survey Medias. No biological information is collected in the frame of the DCF. The available information of European anchovy in GSA 5 is presented below in section 6.1.1, but this stock was not assessed.

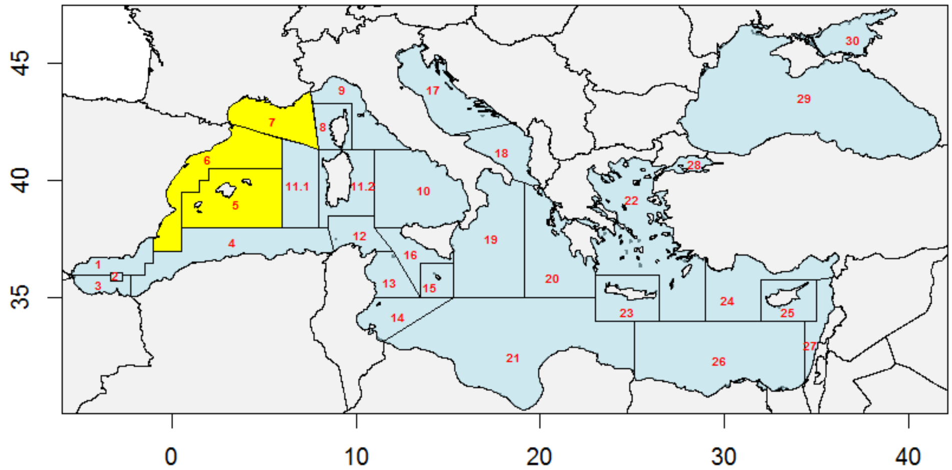


Figure 6.1.1. Geographical location of GSAs 5-6-7.

Table 6.1.1. European anchovy in GSAs 5, 6 & 7. Landings in GSAs 5-6-7 over the period 2002-2016 (tonnes).

	GSA 5	GSA 6	GSA 7
2002	6.2	10915.7	6941.3
2003	13.8	6509.5	6253.5
2004	13.3	6862.1	4497.1
2005	25.4	6166.1	2238.9
2006	22.6	2957.6	2124.8
2007	2.2	2262.2	4133.3
2008	0.9	3574.7	4003.0
2009	0.7	9366.9	4919.8
2010	6.1	8572.7	4613.0
2011	30.2	10021.4	3200.1
2012	204.0	11705.8	1537.5
2013	495.6	17398.2	2434.1
2014	370.1	17357.8	2232.8
2015	500.6	16945.3	1098.9
2016	476.9	17830.4	1257.3

The number of age classes in the European anchovy catch in GSA 6 and GSA 7 is basically limited to two age classes (0 and 1 in GSA 6; 1 and 2 in GSA 7). A joint assessment of European anchovy in GSAs 6-7 was performed with SPiCT (Stochastic Production model in Continuous Time), but the model did not converge and the data imply different stock trajectories in the two areas. Therefore, European anchovy was assessed separately in GSA 6 and GSA 7.

6.1.1 ANCHOVY IN GSA 5

No information is available on stock identification and boundaries of European anchovy in GSA 5. No biological information is collected in the frame of the DCF.

6.1.1.1 DATA

6.1.1.1.1 CATCH (LANDINGS AND DISCARDS)

There is no information on European anchovy discards in GSA 5.

Table 6.1.1.1.1.1 European anchovy in GSA 5. Landings in GSA 5 over the period 2002-2016, by fishing gear (tonnes; Otter Bottom Trawl (OTB), Purse Seine (PS)).

	GSA 5	
	OTB	PS
2002	0.1	6.1
2003	0.0	13.8
2004	0.1	13.2
2005	0.1	25.3
2006	0.1	22.5
2007	0.7	1.5
2008	0.0	0.9
2009	0.0	0.7
2010	0.0	6.1
2011		30.2
2012	0.0	204.0
2013		495.6
2014		370.1
2015		500.6
2016		476.9

Table 6.1.1.1.1.2 European anchovy in GSA 5. Landings size structure in 2016 (Purse seine).

LT (cm)	2016
0	0
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	5271.276
10	9911.907
11	4377.875
12	8156.042
13	8916.474
14	3622.919
15	669.492
16	136.38
17	0
18	0
19	0
20	0
21	0
22	0
23	0
24	0
25	0

6.1.1.1.2 EFFORT

Table 6.1.1.1.2.1 European anchovy in GSA 5. Fishing effort over the period 2002-2016 expressed as gt_days_at_sea and fishing days.

	gt_days_at_sea	days
	PS 5	PS 5
2004	21359	1704
2005	18273	1424
2006	17310	1323
2007	11710	1076
2008	10241	933
2009	9873	892
2010	11164	988
2011	7575	641
2012	14255	1177
2013	14840	1173
2014	11226	921
2015	9841	903
2016	84078	1092

6.1.1.1.3 SURVEY DATA

GSA 5 is not surveyed by the acoustic survey Medias.

6.1.1.2 STOCK ASSESSMENT

This stock was not assessed.

6.1.1.3 REFERENCE POINTS

6.1.1.4 SHORT TERM FORECAST AND CATCH OPTIONS

6.1.1.5 DATA DEFICIENCIES

The information of European anchovy in GSA 5 is very limited, which can be explained by the low amount of landings and the also limited fishing activity of purse seine in the area.

6.1.2 ANCHOVY IN GSA 6

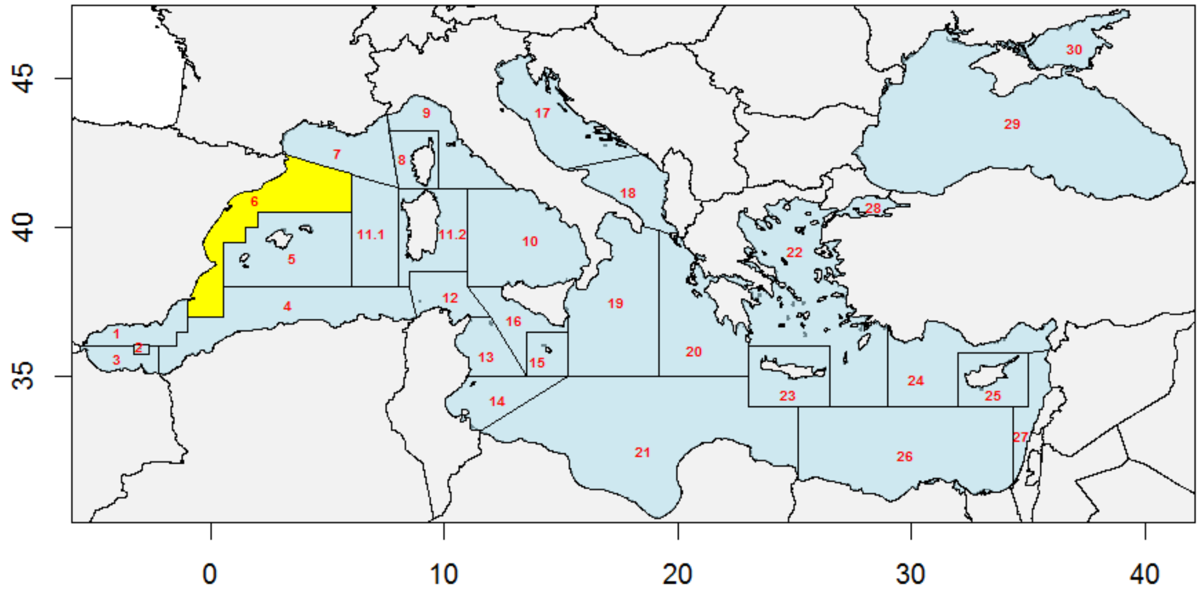


Figure 6.1.2.1 Geographical location of GSA 6.

No new information was available to the EWG 17-09 on stock identification and boundaries in relation to that reported by STECF (2016, 2017). A recent study on otolith growth (Ventero *et al*. 2017) suggests significant differences in the species growth between anchovy in the Alboran Sea (GSA 1) and in the Ebro Delta (located in GSA 6), which would be in agreement with the proposal about not merging GSA 1 with the other western Mediterranean GSAs.

Anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*) are the main target species of purse seining. Both species are very well adapted to the productivity mechanisms characteristic of their respective spawning seasons, that is, spreading of continental runoff at the surface in spring–summer and vertical mixing on the shelf in winter (Sabatés *et al.* 2007b). The Gulf of Lions is one of the main anchovy spawning areas in the NW Mediterranean, along with the shelf surrounding the Ebro river delta. During the spring, low-salinity surface water from the outflow of the Rhône is adverted by the shelf-slope current along the continental slope off the Catalan coast. Anchovy larvae from the Gulf of Lions spawning area have been demonstrated to be adverted southwards (i.e. towards GSA 6) in the low salinity waters (Sabatés *et al*. 2007a). The relative importance of this larval transport mechanism in relation to the larvae resulting from the local spawning in GSA 6 remains unknown (excerpt from STECF 2016).

Trophic studies of adult anchovy and larvae have shown that this species feeds on small zooplankton. The main prey of adults are copepods, and to a lesser extent, molluscs, cladocerans, other crustaceans and appendicularians while stomach contents of larvae consist mostly of copepod eggs, nauplii and copepodites (Plouvenez and Champalbert 2000; Tudela *et al*. 2002; Tudela and Palomera 1997). In the western Mediterranean spawning takes place during the warmest period, mainly from July to September (Sabatés et al. 2006). The species matures on completion of its first year of life, therefore, during the peak spawning season, most recruits are mature (Somarakis et al. 2004). Recruitment size to the fishery is 10 cm TL (Giráldez et al, 2015; excerpt from STECF 2016).

6.1.2.1 DATA

European anchovy landings in GSA 6 come from PS. PS discards are nil. A very small amount of anchovy landings is reported for OTB and GNS. Discards are reported only for OTB, and when reported are high in relation the landings of this gear, but not in the context of the PS fishery. Landings displayed an increasing trend in the last years, which can be explained by the high abundance of recruits (see Fig. 6.1.3.2.2).

6.1.2.1.1 CATCH (LANDINGS AND DISCARDS)

Table 6.1.2.1.1.1. European anchovy in GSA 6. Landings by fishing gear over the period 2002-2016 (tonnes; GNS-gillnet, OTB-otter bottom trawl, PS-purse seine).

	GSA 6		
	GNS	OTB	PS
2002		251.7	10664.0
2003		119.5	6390.0
2004		519.4	6342.6
2005		463.7	5702.5
2006		494.5	2463.2
2007		348.9	1913.3
2008		450.5	3124.2
2009		131.9	9235.0
2010		173.5	8399.2
2011	21.9	531.5	9468.0
2012	6.0	265.9	11433.9
2013	2.7	217.6	17177.9
2014	10.8	497.4	16849.6
2015	4.1	341.5	16599.7
2016		328.7	17501.7

Table 6.1.2.1.1.2 European anchovy in GSA 6. Discards by fishing gear over the period 2002-2016 (tonnes; GNS-gillnet, OTB-otter bottom trawl, PS-purse seine).

	GSA 6	
	OTB	PS
2005	0.31	
2006		0
2008	1.44	
2009	0.15	0
2010	0.04	0
2011	226.8	
2012	1506.23	
2013	281.11	
2014	157.95	
2015	441.51	
2016	695.65	

Table 6.1.2.1.1.3. European anchovy in GSA 6. PS landings length structure over 2002-2016 (thousands; TL in cm).

	2002	2003	2004	2005	2006	2007	2008	2009
0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
6	0	49.008	0	0	0	0	5.329	0
7	0	63.704	4.733	9.747	0	4.457	426.998	55.95
8	988.611	1831.611	1925.637	19.75	0	22.712	1688.235	1148.268
9	5362.528	5868.437	17558.807	320.648	0	170.088	8683.285	5688.09
10	19627.991	9689.182	24814.579	5003.342	1183.326	325.881	23898.124	18908.62
11	31194.636	21812.519	36786.454	14000.519	11712.647	311.555	38064.375	31429.496
12	34604.536	43421.644	83114.274	30092.013	21282.073	2974.778	42465.1	58478.423
13	81583.431	74892.357	121996.91	43827.779	30508.7	10046.671	47563.584	136129.842
14	154357.163	109776.614	80441.283	73339.787	28272.931	20641.339	37068.437	160568.97
15	110115.33	60172.175	24989.106	71363.033	20322.611	25618.894	16579.603	86262.573
16	31360.187	7629.786	3299.034	24756.236	9323.057	15111.796	2560.233	13889.152
17	20203.7	260.927	0.524	2831.06	2037.734	2201.413	94.62	388.678
18	6140.218	0	0	17.294	152.357	8.045	143.14	0
19	25.593	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0

cont. Table 6.1.2.1.1.3.

	2010	2011	2012	2013	2014	2015	2016
0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0
5	0	0	26.311	0	42.359	0	0
6	0	355.731	129.167	0	735.342	207.921	0
7	34.498	730.942	2386.314	494.441	3015.497	1192.552	689.099
8	285.013	17259.041	14435.721	9321.381	9899.927	7230.714	3368.1
9	3494.091	51015.429	68206.352	37840.709	49239.583	53156.126	20274.294
10	18745.431	63249.671	151042.21	136027.772	215312.196	242624.385	104609.176
11	44216.084	92070.581	168499.534	300374.076	337707.511	480129.39	224883.905
12	123188.479	134960.331	152358.454	402900.242	379360.929	424609.93	387998.637
13	185481.759	171980.593	158671.125	320810.045	301575.205	265198.81	307663.02
14	114544.3	131724.187	126113.385	148712.132	149858.193	73935.165	221862.412
15	35516.069	47682.391	65126.677	40830.839	32864.1	7920.372	61899.729
16	3513.508	4710.713	15279.241	3860.677	3423.083	53.839	5053.491
17	264.634	70.967	882.031	99.362	78.934	0	42.92
18	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0

Table 6.1.2.1.1.4. European anchovy in GSA 6. PS landings age structure over 2002-2016 (thousands).

	2002	2003	2004	2005	2006	2007	2008	2009
0	150286.8	125071.8	105024.7	37265.0	58753.6	11547.4	131615.9	215314.4
1	245371.7	199514.7	189298.1	74889.0	35321.8	41705.1	86122.6	291658.1
2	84556.1	10881.4	90491.2	129843.3	28661.5	23176.4	1359.4	5975.6
3	15349.3	0.0	10116.9	23574.2	2058.5	1008.7	143.1	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2010	2011	2012	2013	2014	2015	2016	
0	311114.2	541538.8	255971.4	984364.3	1209186.7	894764.2	631150.9	
1	200465.1	163611.7	266597.6	416907.4	273607.0	661495.0	690662.0	
2	17704.6	10659.7	217495.2	0.0	319.1	0.0	16531.7	
3	0.0	0.0	183092.2	0.0	0.0	0.0	0.0	
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

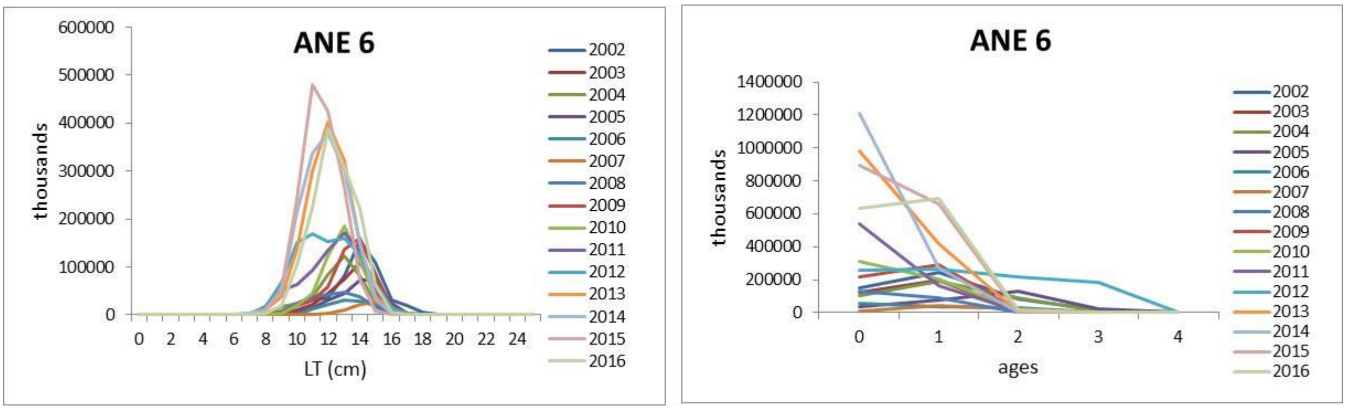


Figure 6.1.2.1.1.1 European anchovy in GSA 6. Length structure (left) and age structure of PS landings (thousands).

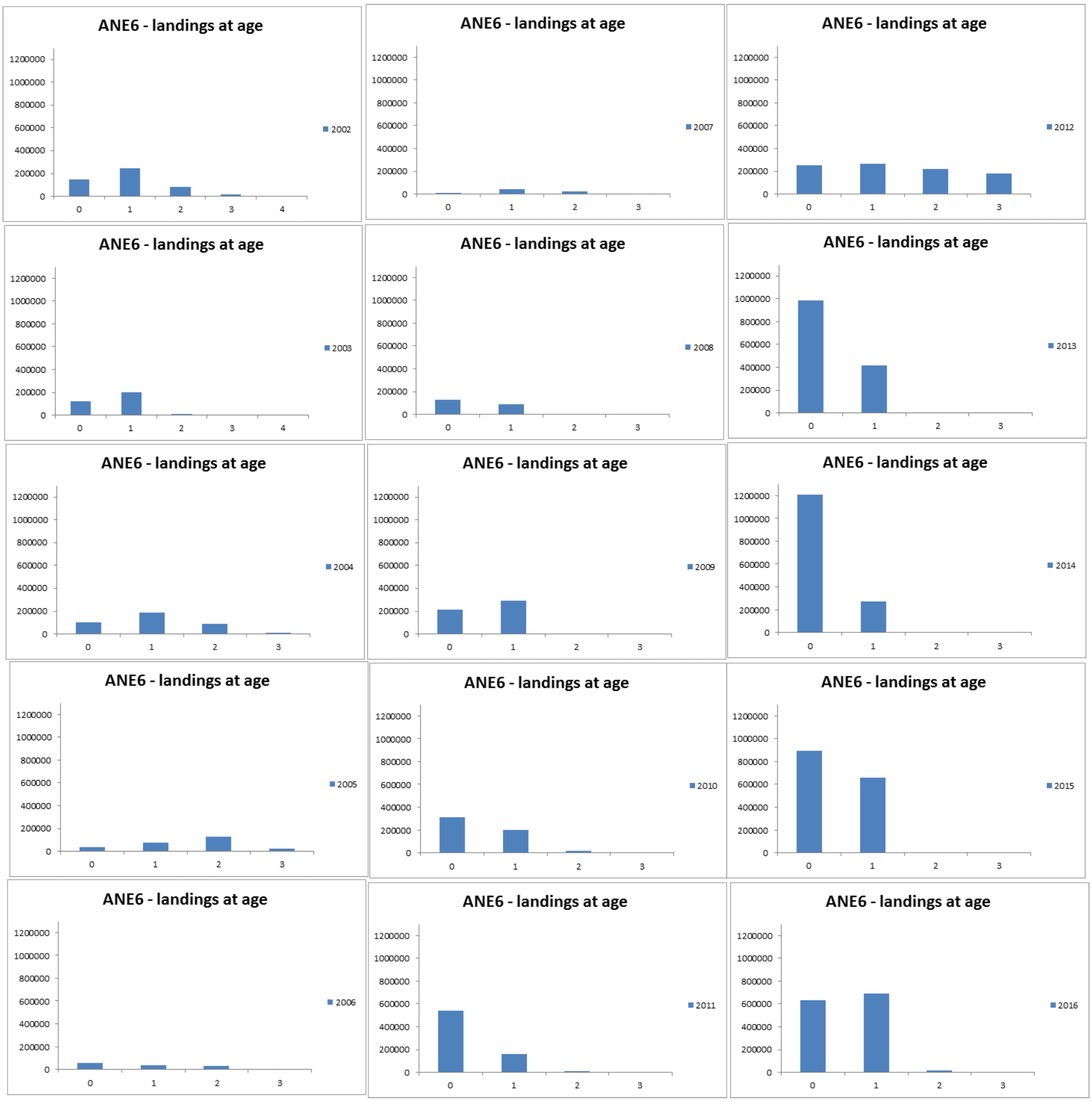


Figure 6.1.2.1.1.2. European anchovy in GSA 6. Age structure of PS landings (thousands). Note the absence of ages > 1 in the last years.

6.1.2.1.2 Effort

Table 6.1.2.1.2.1. European anchovy in GSA 6. PS fishing effort in GSA 6, expressed in gt_days_at_sea and fishing days.

	gt_days_at_sea	days
	PS 6	PS 6
2004	883666	20359
2005	762916	17345
2006	810575	17243
2007	445303	11031
2008	754749	16643
2009	813051	17563
2010	794731	16985
2011	830778	17832
2012	796035	17339
2013	846402	18968
2014	873989	19556
2015	808241	17589
2016	862467	19187

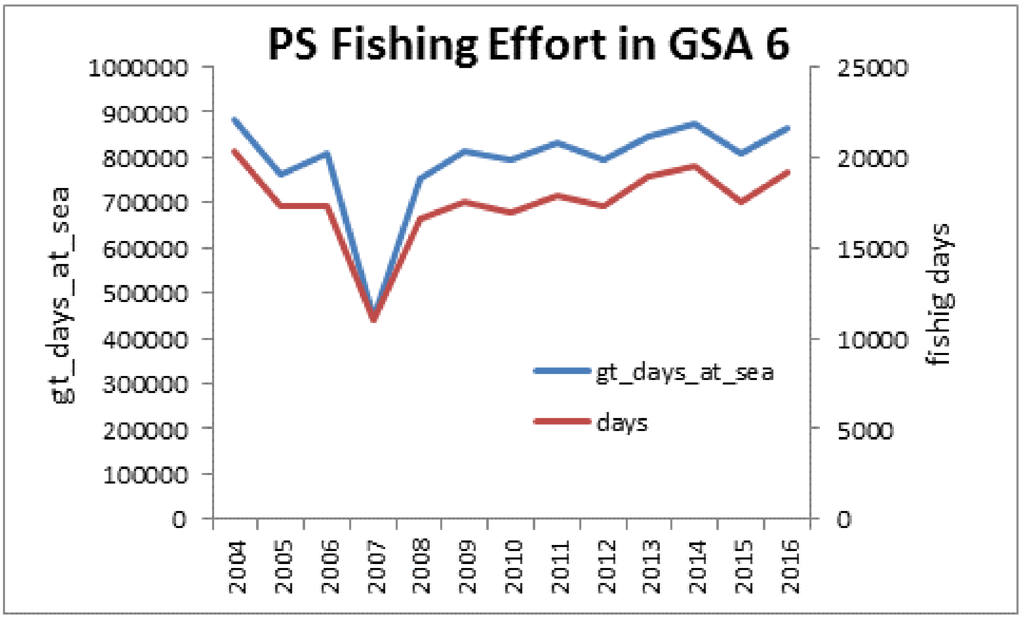


Figure 6.1.2.1.2.1. European anchovy in GSA 6. PS fishing effort in GSA 6 expressed as gt_days_at_sea (left axis) and fishing days (right axis).

6.1.2.1.3 SURVEY DATA

Two acoustic surveys data series are available for the period 2003-2016 in GSA 6. ECOMED surveys (2003-2008) were conducted in late autumn and MEDIAS surveys (2009-2016) in summer. The different timing of the surveys explains the differences in the distributions by size and age. Anchovy has a protracted spawning period. In the western Mediterranean spawning takes place during the warmest period, mainly from July to September (Sabatés *et al.* 2006). Thus, the ECOMED surveys in late autumn focused on recruitment and MEDIAS surveys in summer focused in the spawning stock biomass.

Table 6.1.2.1.3.1 European anchovy in GSA 6. Abundance index/year /size structure from the acoustic surveys ECOMED (2003-2008) and MEDIAS (2009-2016) (thousands; TL in cm).

ECOMED

	2003	2004	2005	2006	2007	2008
0	0	0	0	0	0	0
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	556.51	2107.417	0	0	2677.625	0
6	1855.194	14521.402	472.698	0	14199.938	9920.963
7	37523.095	93032.729	3753.154	746.304	88478.225	645793.257
8	632871.283	242909.322	20207.206	33581.427	269775.154	1467839.07
9	1197207.47	446395.122	172307.031	390665.732	326836.481	1749175.01
10	1155084.5	439593.192	157724.487	352740.219	174102.044	1536152.71
11	565626.095	287694.546	157543.835	423084.292	51887.664	440631.962
12	161813.421	141610.828	97453.324	182839.319	16761.11	90723.513
13	47486.919	74017.502	70135.845	50133.079	5318.906	31257.368
14	27370.567	80823.896	37845.464	22553.123	6868.131	0
15	9500.578	38216.53	15674.958	25249.459	11995.435	0
16	0	8315.169	7375.39	11375.758	1834.306	0
17	0	0	270.321	8130.148	0	0
18	0	0	0	337.688	0	0
19	0	0	0	0	0	0
20	0	0	0	0	0	0
21	0	0	0	0	0	0
22	0	0	0	0	0	0
23	0	0	0	0	0	0
24	0	0	0	0	0	0
25	0	0	0	0	0	0

(cont. Table 6.1.2.1.3.1). MEDIAS

	2009	2010	2011	2012	2013	2014	2015	2016
0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	1714.006	0	0	0	0	0
5	330.223	0	3436.254	0	0	5211.154	0	0
6	0	0	12984.531	0	55.543	10017.156	215.711	0
7	35349.491	0	8847.058	0	1826.46	31292.673	2479.546	0
8	225940.582	3009.383	11086.617	33243.942	333685.693	250415.523	70470.071	9755.594
9	264187.252	52680.837	155313.977	695757.566	1422757.21	905097.385	420673.823	58766.469
10	551060.782	297901.115	197446.98	3597638.61	1701813.67	2017288.69	2340105	778435.275
11	783514.82	450561.77	357057.602	3301866.69	1611856.17	2185707.97	4799645.03	2948971.65
12	563647.168	259758.486	318456.625	631879.568	691569.685	882899.043	2092745.06	1856529.3
13	312954.494	253074.173	255082.428	122000.339	159651.452	793303.584	526515.332	605979.125
14	94155.307	277235.323	194464.056	22779.031	13095.079	291788.526	56851.16	136199.048
15	17258.958	125522.563	67261.353	0	3549.828	49282.521	2815.874	17848.472
16	1026.464	18316.239	3419.861	0	0	5536.997	0	1592.067
17	73.892	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0

Table 6.1.2.1.3.2 European anchovy in GSA 6. Abundance index/year /age structure from the acoustic surveys ECOMED (2003-2008) and MEDIAS (2009-2016) (thousands). Note the presence of age class 2 in the last years.

ANE	GSA 6 Abundance by age						
	ECOMED	MEDIAS	ECOMED	MEDIAS	ECOMED	MEDIAS	Total nb
	age0-eco	age0-med	age1-eco	age1-med	age2-eco	age2-med	
2003	3778218.4		58677.3		0.0		3836895.6
2004	1750339.6		118898.1		0.0		1869237.7
2005	700729.7		40034.0		0.0		740763.7
2006	1463024.5		37765.7		646.4		1501436.6
2007	963350.7		7384.3		0.0		970735.0
2008	5966946.0		4547.8		0.0		5971493.8
2009		0.0		2844482.9		5016.5	2849499.4
2010		0.0		1670960.5		67099.4	1738059.9
2011		0.0		1586571.3		0.0	1586571.3
2012		551766.0		6863417.5		989982.2	8405165.7
2013		3353883.5		2459817.6		126159.7	5939860.8
2014		117630.6		6189779.4		1120431.3	7427841.2
2015		506438.2		8629914.6		1176163.8	10312516.6
2016		39363.5		4937547.3		1437166.2	6414077.0

Table 6.1.2.1.3.3 European anchovy in GSA 6. Biomass index/year /age structure from the acoustic surveys ECOMED (2003-2008) and MEDIAS (2009-2016) (tonnes).

ANE	GSA 6 biomass by age						
	ECOMED	MEDIAS	ECOMED	MEDIAS	ECOMED	MEDIAS	Total
	age0-eco	age0-med	age1-eco	age1-med	age2-eco	age2-med	biomass
2003	22352.7		739.5		0.0		23092.3
2004	11459.1		2102.9		0.0		13562.0
2005	5630.3		781.6		0.0		6411.9
2006	11290.8		856.3		12.3		12159.4
2007	4752.6		153.4		0.0		4906.0
2008	28703.9		63.6		0.0		28767.5
2009		0.0		27984.0		106.4	28090.4
2010		0.0		20765.4		1540.4	22305.7
2011		0.0		18416.0		0.0	18416.0
2012		4330.3		52459.6		10158.1	66948.1
2013		25179.7		18722.1		972.5	44874.3
2014		599.8		56099.6		10131.2	66830.6
2015		3804.8		70158.3		9791.0	83754.1
2016		349.3		52150.9		15410.0	67910.3

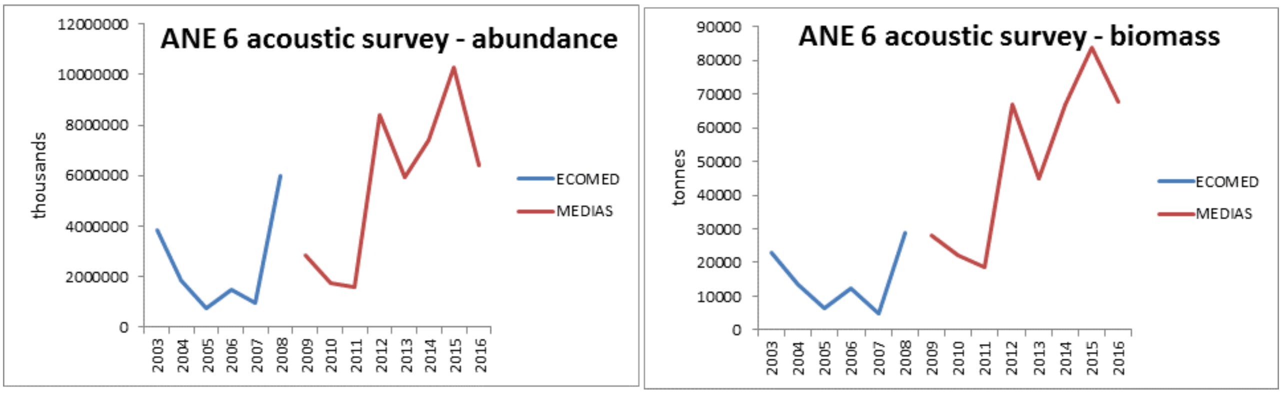


Figure 6.1.2.1.3.1 European anchovy in GSA 6. Abundance (thousands) and biomass (tonnes) as estimated from the acoustic surveys and the age structure.

6.1.2.2 STOCK ASSESSMENT

Methods: SPICT

Input data

Landings

Time series of landings where obtained for anchovy in GSA 6 through the following sources:

- For the period 1945 to 2001 the historical catch reconstruction performed and kindly made available to EWG by Pedro Torres and Ana Giraldez from IEO.
- For the period 2002 to 2016 from the DCF Data Call 2016.

Indices

- ECOMED biomass survey from 2003 to 2008 (conducted in autumn-winter, specifically in November).
- MEDIAS acoustic survey from 2009 to 2016 (conducted in summer).

The indices were combined as one biomass index. Input data can be seen in table 6.1.2.4.5.

Table 6.1.2.2.1. European anchovy in GSA 6. Landings and ECOMED and MEDIAS combined survey data used for this assessment for Anchovy in GSA 6.

Years	Landings GSA 6	ECOMED/MEDIAS
1945	2809.00	-1.000
1946	2253.00	-1.000
1947	5319.00	-1.000
1948	2677.00	-1.000
1949	3268.00	-1.000
1950	5607.00	-1.000
1951	4352.00	-1.000
1952	3974.00	-1.000
1953	2057.00	-1.000
1954	3114.00	-1.000

1955	3888.00	-1.000
1956	3617.00	-1.000
1957	1745.00	-1.000
1958	3199.00	-1.000
1959	2575.00	-1.000
1960	3496.00	-1.000
1961	2139.00	-1.000
1962	3593.00	-1.000
1963	3585.00	-1.000
1964	3077.00	-1.000
1965	3315.00	-1.000
1966	3345.00	-1.000
1967	5960.00	-1.000
1968	11304.00	-1.000
1969	9671.00	-1.000
1970	11986.00	-1.000
1971	8244.00	-1.000
1972	9081.00	-1.000
1973	12032.00	-1.000
1974	12480.00	-1.000
1975	19444.00	-1.000
1976	20898.00	-1.000
1977	17393.00	-1.000
1978	19696.00	-1.000
1979	24229.00	-1.000
1980	20932.00	-1.000
1981	20138.00	-1.000
1982	22802.00	-1.000
1983	14391.00	-1.000
1984	10947.00	-1.000
1985	7692.00	-1.000
1986	13498.00	-1.000
1987	12616.00	-1.000
1988	18843.00	-1.000
1989	17045.00	-1.000
1990	17204.00	-1.000

1991	21261.00	-1.000
1992	19793.00	-1.000
1993	18011.00	-1.000
1994	22876.00	-1.000
1995	16686.00	-1.000
1996	13430.00	-1.000
1997	12500.00	-1.000
1998	9558.00	-1.000
1999	9361.00	-1.000
2000	7315.00	-1.000
2001	8898.00	-1.000
2002	10915.67	-1.000
2003	6509.46	23092.268
2004	6862.07	13561.958
2005	6166.13	6411.887
2006	2957.60	12159.441
2007	2262.19	4905.990
2008	3574.70	28767.535
2009	9366.92	28090.401
2010	8572.71	22305.736
2011	10021.43	18416.027
2012	11705.78	66948.062
2013	17398.20	44874.289
2014	17357.83	66830.588
2015	16945.32	83754.095
2016	17830.40	67910.266

Input data as plotted by SPiCT can be seen in figure 6.1.2.5.1. One run was conducted for anchovy in GSA 6 providing coherent results in terms of diagnostics (residuals, autocorrelation and Shapiro p-value, figure 6.1.2.5.2). The default prior settings were used, therefore no informative priors were introduced as initial parameter estimates and the model converged in the first run.

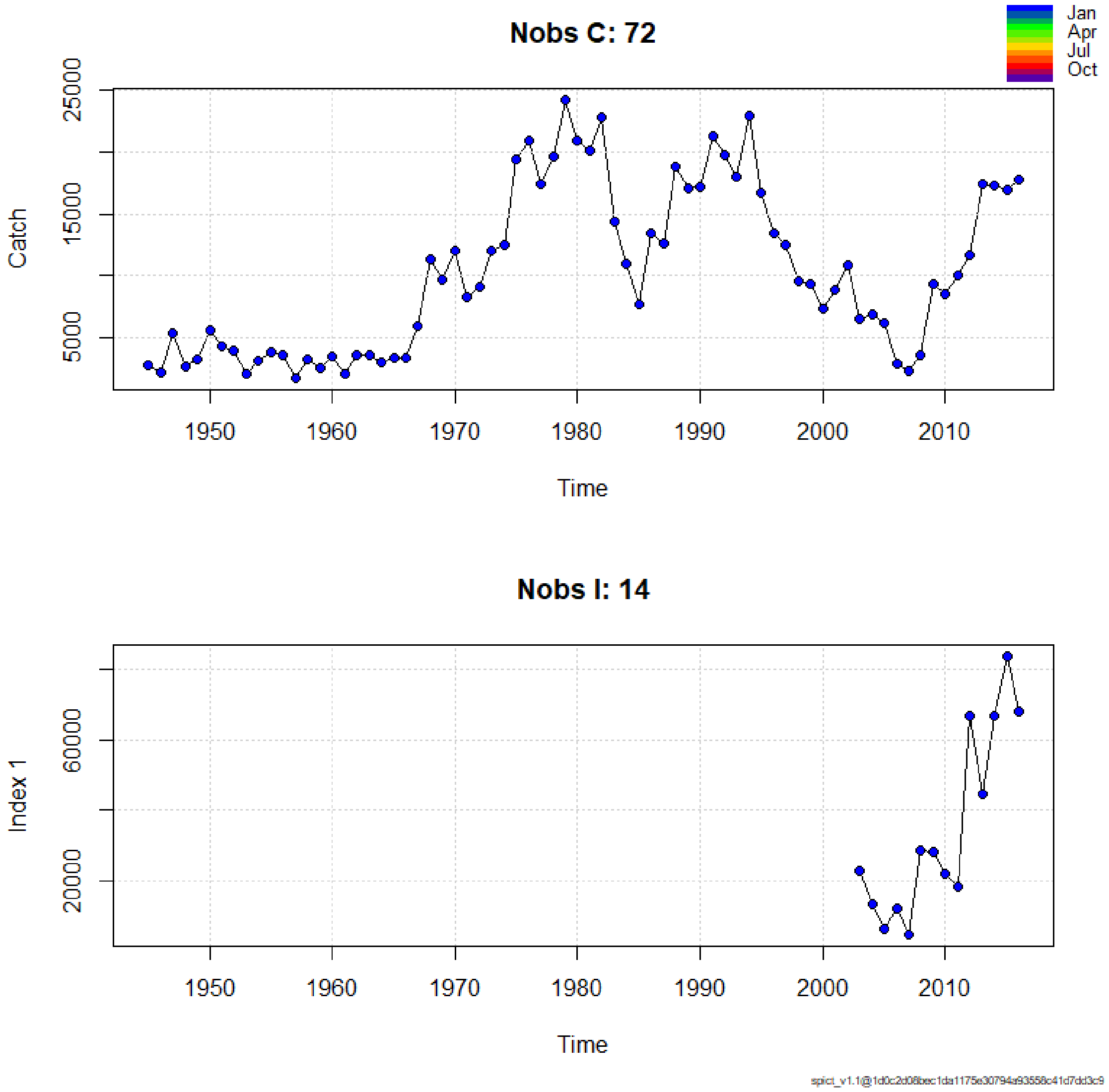


Figure 6.1.2.2.1. European anchovy in GSA6. Input Data. Landings time series: 1) 1945 to 2001 (made available by IEO) and 2) DCF data call from 2002 to 2016. Indices: ECOMED biomass survey from 2003 to 2008 and 2) MEDIAS acoustic survey from 2009 to 2016.

Assessment results

The assessment results based on a SPiCT model age given below

Table 6.1.2.2.1. European anchovy in GSA 6. F/Fmsy, B/Bmsy and Landings estimates from the SPiCT model for Anchovy in GSA 6.

Year	F/Fmsy	B/Bmsy	Landings
1945	0.0877095	1.6955454	2654.967
1946	0.0863843	1.8998616	2934.355
1947	0.1048029	1.9792093	3706.581
1948	0.0940859	1.9785580	3326.095

1949	0.1016936	1.9901054	3616.433
1950	0.1253639	1.9938195	4465.794
1951	0.1201374	1.9786069	4247.314
1952	0.1002439	1.9786982	3544.033
1953	0.0780452	1.9840705	2766.528
1954	0.0848967	2.0091145	3047.957
1955	0.0951441	2.0159592	3427.080
1956	0.0863959	2.0081100	3100.269
1957	0.0683569	2.0026062	2445.860
1958	0.0755206	2.0236482	2730.745
1959	0.0780742	2.0209784	2819.234
1960	0.0816236	2.0204459	2946.689
1961	0.0761055	2.0095535	2732.656
1962	0.0885899	2.0180347	3194.305
1963	0.0944974	2.0083463	3390.956
1964	0.0921666	1.9965616	3287.901
1965	0.0966603	1.9899180	3436.602
1966	0.1138312	1.9774122	4021.228
1967	0.1719511	1.9576473	6010.098
1968	0.2623847	1.8969868	8883.356
1969	0.3055574	1.8147307	9904.856
1970	0.3277014	1.7638045	10327.616
1971	0.3037069	1.7387289	9435.214
1972	0.3189008	1.7390085	9908.229
1973	0.3827816	1.7108895	11695.740
1974	0.4675327	1.6466419	13742.500
1975	0.6293869	1.5436945	17323.352
1976	0.7668565	1.3962114	19111.229
1977	0.8248514	1.2800553	18856.905
1978	0.9495153	1.1901057	20162.627
1979	1.1669694	1.0569789	21987.718
1980	1.3334136	0.8996530	21400.655
1981	1.5482765	0.7563540	20856.188
1982	1.9149739	0.5821494	19830.553
1983	1.9422004	0.4263424	14824.012
1984	1.6136278	0.3808967	10973.743
1985	1.1951434	0.4530532	9624.938
1986	1.1106594	0.5966463	11834.741
1987	1.0496475	0.7287649	13663.194
1988	1.1052365	0.8239202	16275.695

1989	1.1017626	0.8591942	16912.484
1990	1.1084345	0.8849602	17527.830
1991	1.2236620	0.8713194	19041.417
1992	1.3117096	0.8117894	19019.725
1993	1.4105671	0.7485628	18847.148
1994	1.7093706	0.6431805	19576.223
1995	1.8791430	0.5014092	16822.072
1996	1.9344107	0.4030547	13922.930
1997	2.0192526	0.3324469	11989.763
1998	1.9839828	0.2823699	10012.635
1999	1.9357724	0.2572842	8901.289
2000	1.7724221	0.2558821	8101.008
2001	1.8521857	0.2691496	8907.325
2002	2.1885048	0.2421079	9445.763
2003	2.2304506	0.1917057	7641.189
2004	2.4110985	0.1539256	6611.972
2005	2.6096665	0.1094502	5105.797
2006	2.0968626	0.0852363	3195.430
2007	1.3622941	0.1123093	2694.569
2008	1.1882563	0.1964550	4182.722
2009	1.4143571	0.2965380	7519.147
2010	1.3550466	0.3709919	8954.308
2011	1.1575188	0.4857269	10014.554
2012	1.0822674	0.6331448	12243.256
2013	1.1410974	0.7461939	15221.960
2014	1.1681788	0.7946311	16585.915
2015	1.1720859	0.8152293	17072.838
2016	1.1927225	0.8196008	17466.309
2017	1.1992751	0.8145257	17453.602

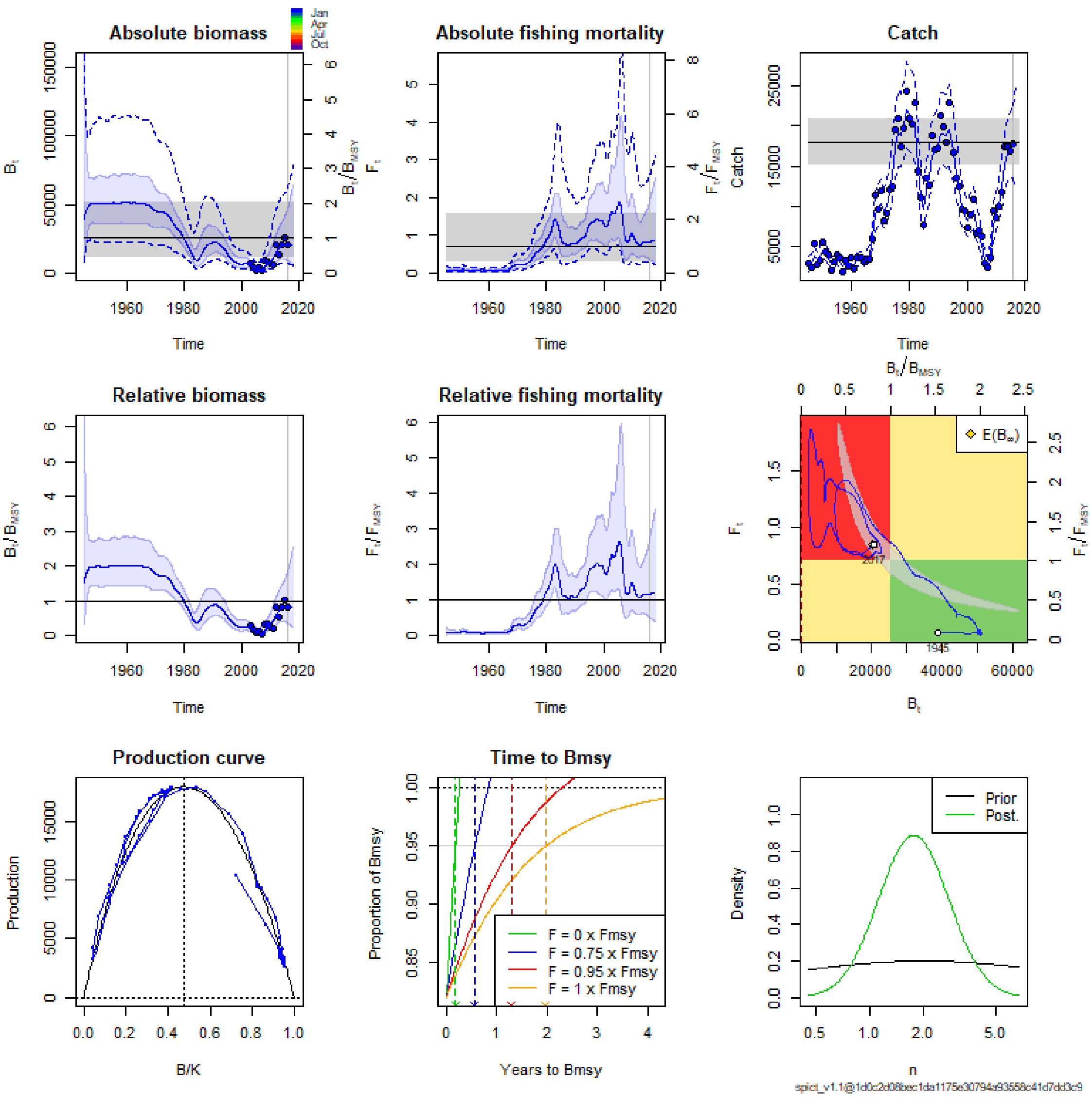


Figure 6.1.2.2.2. European anchovy in GSA6. SPiCT model results for Anchovy in GSA 6.

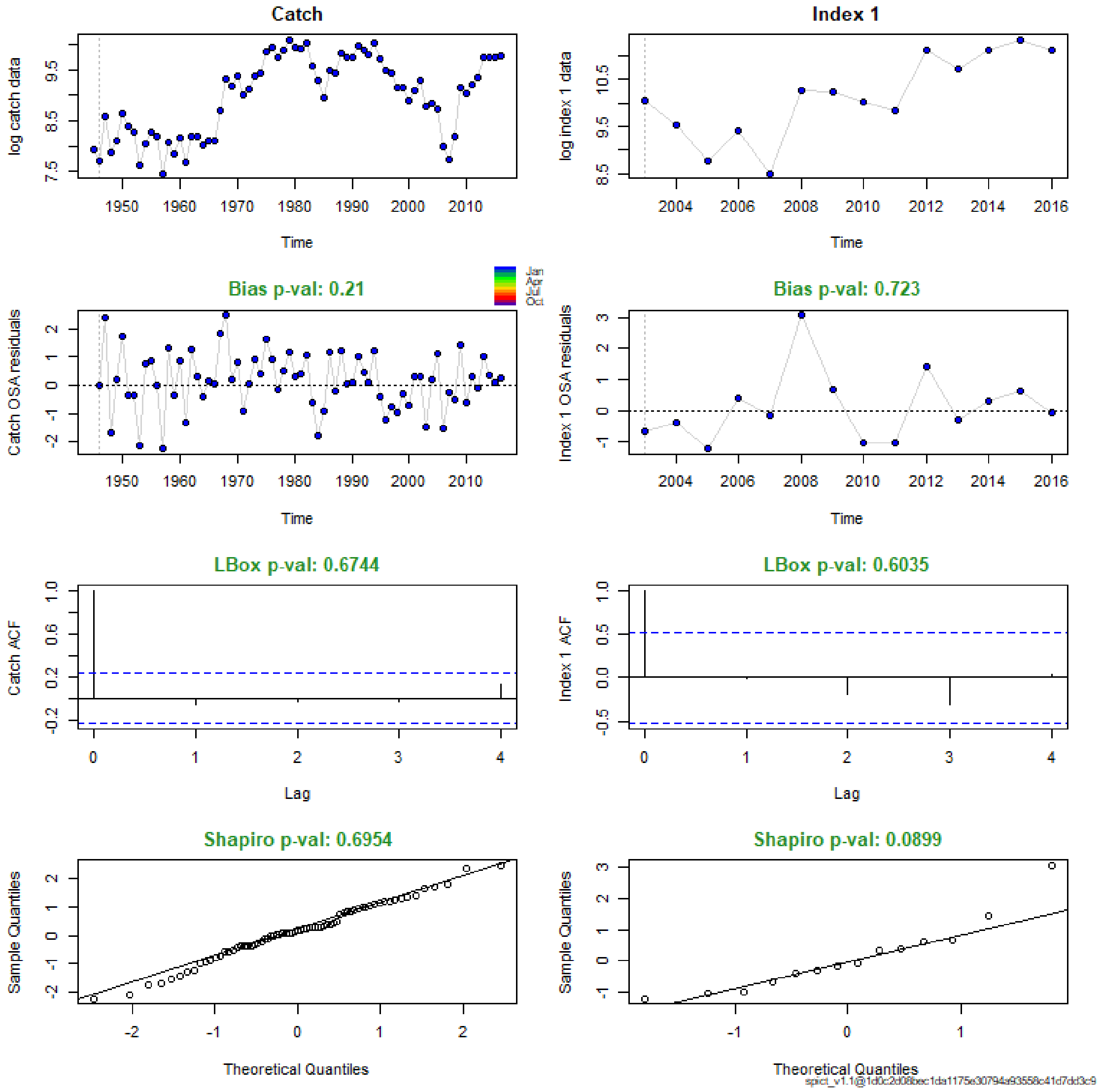


Figure 6.1.2.2.3. European anchovy in GSA6. Diagnostics of the SPiCT run for Anchovy in GSA 6.

The retrospective was run with the default value of the model (5 years) providing reliable estimates in terms of absolute and relative Biomass, especially for the last years of the assessment. F/F_{MSYd} is estimated as > 1 since 1979. There is consistency in the time series regarding the results, therefore the performance is acceptable (figure 6.1.2.2.4)

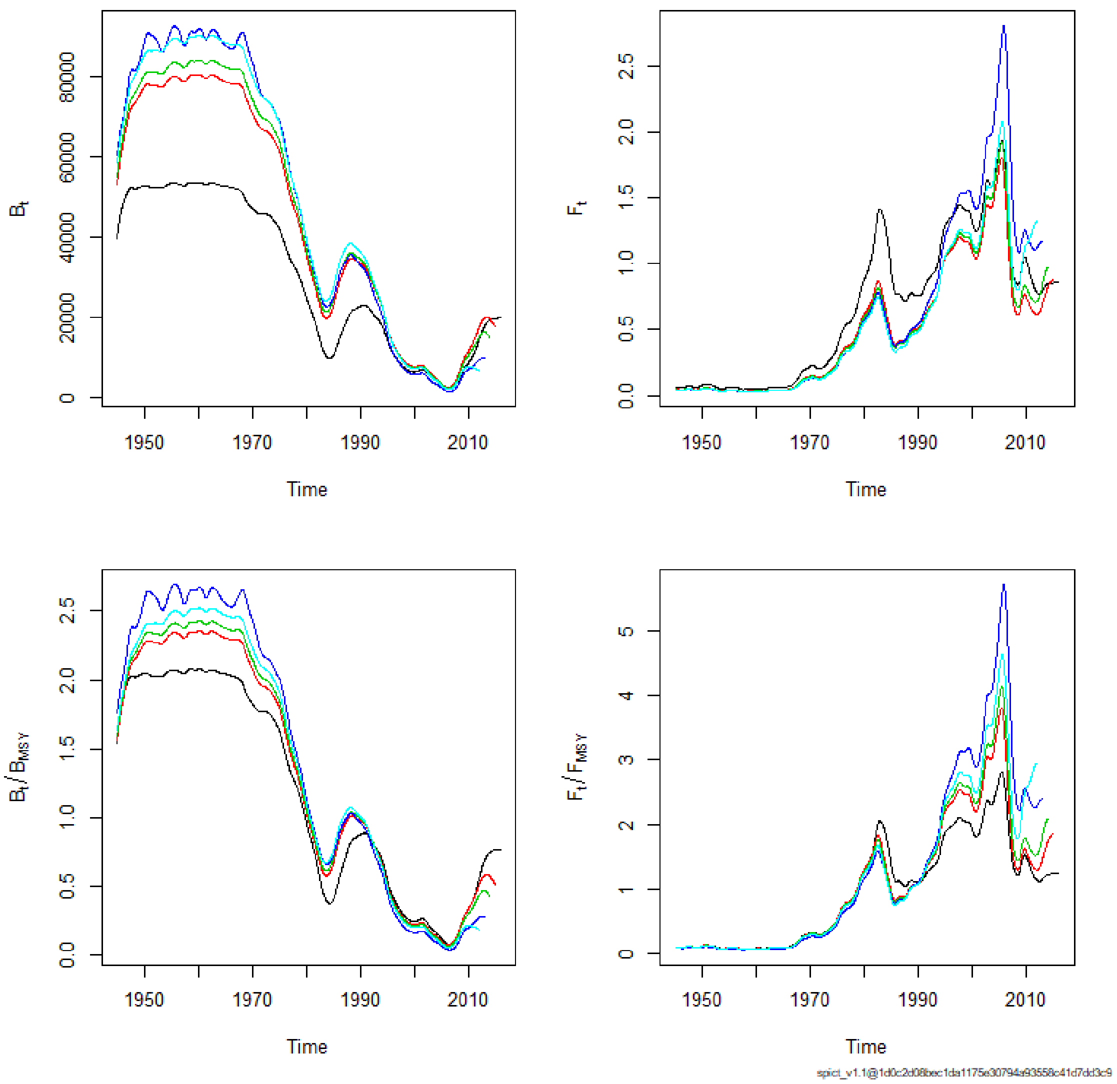


Figure 6.1.2.2.4. European anchovy in GSA6. Retrospective analysis for Anchovy in GSA 6.

Model estimates, reference points and summaries are reported below:

```
[1] "Convergence: 0  MSG: relative convergence (4)"
 [2] "Objective function at optimum: 46.8156635"
 [3] "Euler time step (years):  1/16 or 0.0625"
 [4] "Nobs C: 72,  Nobs I1: 14"
 [5] ""
 [6] "Priors"
 [7] "     logn  ~  dnorm[log(2), 2^2]"
 [8] " logalpha  ~  dnorm[log(1), 2^2]"
 [9] "  logbeta  ~  dnorm[log(1), 2^2]"
[10] ""
[11] "Model parameter estimates w 95% CI "
[12] "             estimate       cilow        ciupp     log.est  "
[13] " alpha  6.352267e+00 9.116330e-01 4.426266e+01  1.8488118  "
[14] " beta   7.217706e-01 3.979164e-01 1.309201e+00 -0.3260479  "
[15] " r      1.231909e+00 3.490506e-01 4.347790e+00  0.2085647  "
```

```
[16] " rc      1.408642e+00 6.320679e-01 3.139335e+00  0.3426263   "
[17] " rold    1.644579e+00 4.303802e-01 6.284303e+00  0.4974843   "
[18] " m       1.794384e+04 1.537430e+04 2.094284e+04  9.7950022   "
[19] " K       5.373897e+04 2.369446e+04 1.218798e+05 10.8918937   "
[20] " q       3.258479e+00 1.096033e+00 9.687380e+00  1.1812606   "
[21] " n       1.749072e+00 7.245925e-01 4.222034e+00  0.5590856   "
[22] " sdb     6.669390e-02 9.723800e-03 4.574447e-01 -2.7076415   "
[23] " sdf     2.559454e-01 1.740160e-01 3.764485e-01 -1.3627911   "
[24] " sdi     4.236576e-01 2.841108e-01 6.317457e-01 -0.8588297   "
[25] " sdc     1.847339e-01 1.353974e-01 2.520477e-01 -1.6888391   "
[26] " "
[27] "Deterministic reference points (Drp)"
[28] "           estimate        cilow        ciupp    log.est  "
[29] " Bmsyd 2.547679e+04 1.250147e+04 51919.237479 10.1455231  "
[30] " Fmsyd 7.043211e-01 3.160339e-01     1.569668 -0.3505209  "
[31] " MSYd  1.794384e+04 1.537430e+04 20942.842900  9.7950022  "
[32] "Stochastic reference points (Srp)"
[33] "           estimate        cilow       ciupp    log.est  rel.diff.Drp  "
[34] " Bmsys 2.538942e+04 1.243767e+04 51828.25570 10.1420878 -0.0034412728  "
[35] " Fmsys 7.037343e-01 3.154529e-01     1.56994 -0.3513544 -0.0008338617  "
[36] " MSYs  1.786735e+04 1.530401e+04 20860.03595  9.7907305 -0.0042809228  "
[37] ""
[38] "States w 95% CI (inp$msytype: s)"
[39] "                  estimate        cilow        ciupp    log.est  "
[40] " B_2016.00      2.082528e+04 6951.4763540 62388.491241  9.9439227  "
[41] " F_2016.00      8.317757e-01    0.2684761     2.576955 -0.1841925  "
[42] " B_2016.00/Bmsy 8.202345e-01    0.3714685     1.811148 -0.1981650  "
[43] " F_2016.00/Fmsy 1.181946e+00    0.5143512     2.716035  0.1671619  "
[44] ""
[45] "Predictions w 95% CI (inp$msytype: s)"
[46] "                prediction        cilow        ciupp    log.est  "
[47] " B_2017.00      2.074340e+04 6.201387e+03 69385.862382  9.9399833  "
[48] " F_2017.00      8.439709e-01 2.512226e-01     2.835282 -0.1696372  "
[49] " B_2017.00/Bmsy 8.170096e-01 3.117736e-01     2.140992 -0.2021045  "
[50] " F_2017.00/Fmsy 1.199275e+00 4.572977e-01     3.145129  0.1817172  "
[51] " Catch_2017.00  1.745360e+04 1.208991e+04 25196.898544  9.7673013  "
[52] " E(B_inf)       2.039791e+04           NA           NA  9.9231877  "
```

6.1.2.3 Reference Points

SPiCT provides estimates of reference points the MSY frame. The deterministic reference points are B_{MSYd} = 25.477 t, F_{MSYD} = 0.704 and the stochastic B_{MSYs} = 25. 390 t and F_{MSYs} = 0.70. Reference points are rounded to 2 significant figures are the same for stochastic and deterministic values giving B_{MSY} = 25 t, F_{MSY} = 0.70

The results of the assessment indicate that the stock is considered over-exploited since the 80's (F<Fmsyd).

6.1.2.4 Short term Forecast and Catch Options

The SPiCT model was used to carry out a short term forecast with the following condi tions:

```
Removing zero, negative, and NAs in  I  series  1
```

	prediction	cilow	ciupp	log.est
B_2017.00	2.074340e+04	6.201386e+03	69385.860442	9.9399833
F_2017.00	8.439710e-01	2.512226e-01	2.835282	-0.1696372
B_2017.00/Bmsy	8.170095e-01	3.117736e-01	2.140991	-0.2021045
F_2017.00/Fmsy	1.199275e+00	4.572978e-01	3.145129	0.1817172
Catch_2020.00	1.731095e+04	1.044177e+04	28699.039925	9.7590944
E(B_inf)	2.039789e+04	NA	NA	9.9231869

```
Observed interval, index:  2003.00 - 2016.00
Observed interval, catch:  1945.00 - 2017.00

Fishing mortality (F) prediction: 2018.00
Biomass (B) prediction:           2018.00
Catch (C) prediction interval:    2017.00 - 2018.00
```

Predictions

	C	B	F	B/Bmsy	F/Fmsy	perc.dB	perc.dF
1. Keep current catch	17640.4	21146.1	0.836	0.833	1.188	1.9	-1.0
2. Keep current F	17453.6	20622.1	0.844	0.812	1.199	-0.6	0.0
3. Fish at Fmsy	15387.3	22928.8	0.704	0.903	1.000	10.5	-16.6
4. No fishing	24.6	38008.8	0.001	1.497	0.001	83.2	-99.9
5. Reduce F 25%	14237.7	24173.7	0.633	0.952	0.899	16.5	-25.0
6. Increase F 25%	20085.5	17528.8	1.055	0.690	1.499	-15.5	25.0

95% CIs of absolute predictions

	C.lo	C.hi	B.lo	B.hi	F.lo	F.hi
1. Keep current catch	13559.6	22949.4	7946.9	56267.9	0.308	2.268
2. Keep current F	12089.9	25196.9	5431.4	78297.8	0.227	3.133
3. Fish at Fmsy	10565.2	22410.2	6889.1	76312.7	0.190	2.612
4. No fishing	13.8	43.7	20817.4	69396.9	0.000	0.003
5. Reduce F 25%	9687.7	20924.8	7753.5	75368.7	0.171	2.349
6. Increase F 25%	13788.2	29258.9	3767.5	81555.4	0.284	3.916

95% CIs of relative predictions

	B/Bmsy.lo	B/Bmsy.hi	F/Fmsy.lo	F/Fmsy.hi
1. Keep current catch	0.348	1.993	0.474	2.978
2. Keep current F	0.262	2.521	0.404	3.556
3. Fish at Fmsy	0.327	2.493	0.337	2.965
4. No fishing	0.875	2.560	0.000	0.004
5. Reduce F 25%	0.365	2.483	0.303	2.667
6. Increase F 25%	0.185	2.575	0.506	4.445

	C	B	F	B/Bmsy	F/Fmsy	perc.dB	perc.dF
1. Keep current catch	17640.4	21146.1	0.836	0.833	1.188	1.9	-1.0
2. Keep current F	17453.6	20622.1	0.844	0.812	1.199	-0.6	0.0
3. Fish at Fmsy	15387.3	22928.8	0.704	0.903	1.000	10.5	-16.6
4. No fishing	24.6	38008.8	0.001	1.497	0.001	83.2	-99.9
5. Reduce F 25%	14237.7	24173.7	0.633	0.952	0.899	16.5	-25.0
6. Increase F 25%	20085.5	17528.8	1.055	0.690	1.499	-15.5	25.0

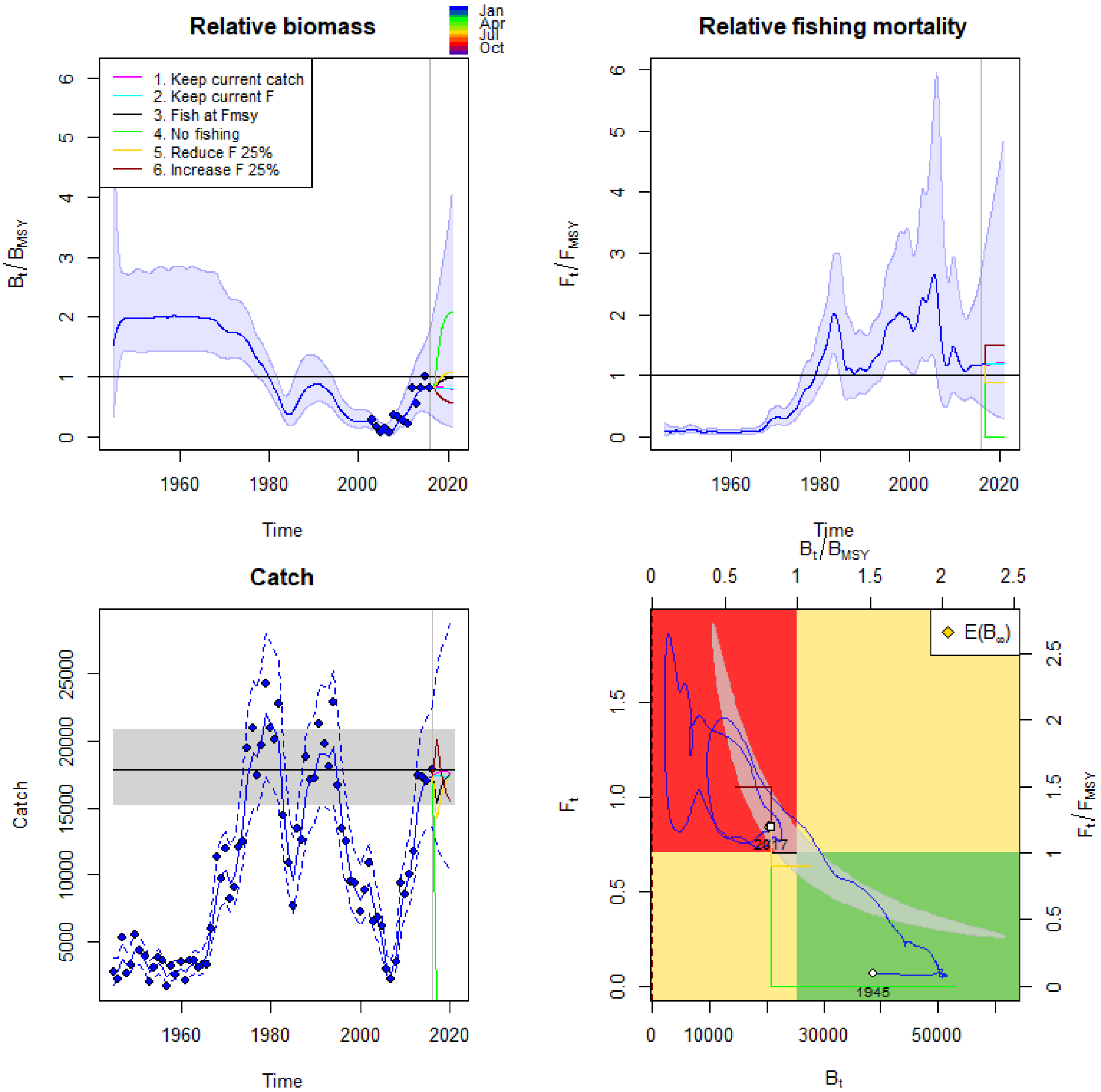


Figure 6.1.2.4.1. European anchovy in GSA 6. Short term forecast for the period 2018-2020

According to different scenarios: 1) keep current catch, 2) keep current F, 3) fishing at Fmsy, 4) no fishing, 5) reduce F by 25%, 6) increase F by 25%

Table 6.1.2.4.1. European anchovy in GSA 6. Short term forecasts of status quo and different fishing mortalities reductions.

Forecast scenario	Years	C (landings)	B (Biomass)	F (Fishing mortality)
1. Keep current catch	2018	17640.4	21146.1	0.836
	2019	17683.9	20907.3	0.846
	2020	17691.1	20594.9	0.858
2. Keep current F	2018	17453.6	20622.1	0.844
	2019	17375.8	20556.7	0.844
	2020	17333.7	20521.3	0.844
3. Fish at F_{MSY}	2018	15387.3	22928.8	0.704
	2019	16582.2	24147.8	0.704
	2020	17228.5	24784.4	0.704
4. No fishing	2018	24.6	38008.8	0.001
	2019	36.7	48232.2	0.001
	2020	42.5	52005.2	0.001
5. Reduce $F_{25\%}$	2018	14237.7	24173.7	0.633
	2019	15941.8	26114.7	0.633
	2020	16860.6	27105.5	0.633
6. Increase $F_{25\%}$	2018	20085.5	17528.8	1.055
	2019	17600.9	15903.5	1.055
	2020	16286.1	14997.5	1.055

6.1.2.5 DATA DEFICIENCIES

Growth parameters of anchovy in GSA 6 should be revised (t_0 values are very negative). The procedure for transforming landings lengths into ages is not known. The availability of this procedure might help in the interpretation of the lengths and ages structures within a given area and among areas. ALK should be available from the acoustic surveys.

6.1.3 ANCHOVY IN GSA 7

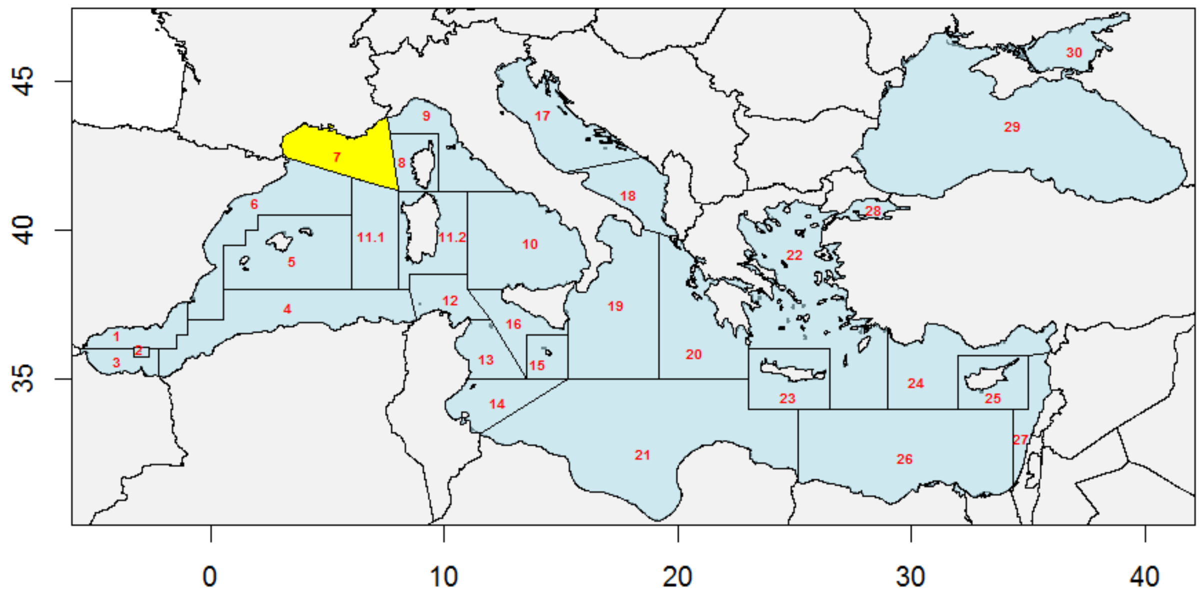


Figure 6.1.3.1 Geographical location of GSA 7

No new information was available to the EWG 17-09 on stock identification and boundaries in relation to that reported by STECF (2016, 2017). The Gulf of Lions may not correspond to a complete stock unit. A mechanism for the connectivity of anchovy larvae between the Gulf of Lions and the adjacent Catalan coast (northern GSA 6) has been described (see section 6.1.2; in this section information on the biology of the species is presented). According to GFCM (2015), large individuals would not move to the Catalan coast.

6.1.3.1 DATA

European anchovy landings come from OTM (Midwater Otter Trawl). Landings displayed a marked decreasing trend in the last years, against the observed increasing trend in GSA 6. There is no presence of large individuals in the landings. Spain reported small amount of anchovy landings from GSA 7. France reported very low OTB and OTM anchovy discards.

6.1.3.1.1 CATCH (LANDINGS AND DISCARDS)

Table 6.1.3.1.1.1 European anchovy in GSA 7. Landings by fishing gear over the period 2002-2016 reported by France and Spain (tonnes; OTB-otter bottom trawl, OTM- midwater otter trawl, PS-purse seine).

	GSA 7 France				GSA 7 Spain		GSA 7	GSA 7	GSA 7
	OTB	OTM	OTT	PS	OTB	PS	France	Spain	Total
2002		6941.3			82.1	754.1	6941.3	836.1	7777.4
2003		6253.5			94.3	714.4	6253.5	808.7	7062.2
2004		4497.1			69.6	950.8	4497.1	1020.4	5517.5
2005		2238.9			5.0	522.0	2238.9	527.0	2765.8
2006		2124.8			6.7	188.5	2124.8	195.1	2319.9
2007		4133.3			16.2	234.6	4133.3	250.8	4384.1
2008		4003.0			17.1	212.3	4003.0	229.5	4232.5
2009		4919.8			2.3	17.5	4919.8	19.7	4939.5
2010		4613.0			2.7	4.1	4613.0	6.8	4619.8
2011		3200.1			6.2	297.5	3200.1	303.8	3503.8
2012		1537.5			4.0	35.2	1537.5	39.2	1576.7
2013		2434.1			2.0	47.8	2434.1	49.8	2483.9
2014		2232.8			2.0		2232.8	2.0	2234.8
2015	305.6	793.3			9.5		1098.9	9.5	1108.4
2016	30.6	1225.7	0.4	0.7	0.4	11.5	1257.3	11.8	1269.2

Table 6.1.3.1.1.2 European anchovy in GSA 7. Discards by fishing gear over the period 2003-2016 (tonnes; OTB-otter bottom trawl, OTM- midwater otter trawl).

	OTB	OTM
2003	1.57	
2005	0.49	
2006	1.97	
2007	0.42	0.28
2008		0.23
2014		
2015		

Table 6.1.3.1.1.3 European anchovy in GSA 7. Landings length structure over 2002-2016 (thousands; TL in cm).

	2002	2003	2004	2005	2006	2007	2008	2009
0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	686.8	1707.6	0.0	0.0	0.0	71.4	115.4
8	571.6	1861.5	8185.1	93.8	0.0	871.7	619.3	6236.6
9	5661.8	17532.6	19632.3	534.9	524.8	5158.6	7822.4	15760.9
10	16875.2	35774.1	35339.1	5772.2	6015.0	10264.8	33313.0	36655.4
11	26858.0	83313.2	65683.5	9493.5	19456.2	20659.6	51960.2	77601.3
12	87290.4	98561.9	96502.7	16184.3	20020.6	32615.8	51419.7	122995.3
13	135564.8	95357.5	74856.8	35512.8	25433.2	46595.2	64202.0	86165.1
14	108617.0	81952.2	41311.6	33571.7	26124.6	64688.7	50556.3	41928.8
15	41864.0	28276.8	11093.4	16795.0	16664.4	42044.2	23103.0	11113.9
16	4666.0	8085.2	777.5	4197.6	5880.6	14399.3	5495.0	2261.9
17	407.0	192.1	0.0	283.5	1176.7	1808.3	685.8	105.9
18	0.0	0.0	0.0	0.0	16.8	387.8	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	49.1	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0

cont. Table 6.1.3.3

	2010	2011	2012	2013	2014	2015	2016
0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0
5	0.0	0.0	74.4	0.0	0.0	0.0	0.0
6	0.0	0.0	532.3	0.0	0.0	0.0	0.0
7	277.9	0.0	1738.5	0.0	0.0	74.0	247.9
8	13297.7	139.2	6328.2	0.0	0.0	222.0	665.3
9	26001.7	1799.4	6495.4	2506.3	429.7	814.1	2501.3
10	67098.2	23417.6	17274.1	13569.6	2894.2	3996.5	23680.5
11	123424.7	83978.3	31936.2	38126.2	25898.5	11397.3	64194.0
12	126438.9	109164.6	44953.0	66418.3	74390.7	11471.3	38832.6
13	62192.0	55935.5	29043.6	60498.7	63756.6	2516.3	8032.7
14	18592.4	13232.4	6224.5	20083.8	15607.5	666.1	591.0
15	2484.2	1273.3	532.1	3562.7	2657.2	74.0	0.0
16	120.1	88.8	42.8	0.0	86.5	0.0	0.0
17	0.0	178.8	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0

Table 6.1.3.1.1.4. European anchovy in GSA 7. Landings age structure over 2002-2016 (thousands).

	2002	2003	2004	2005	2006	2007	2008	2009
0	2510.2	9707.8	0.0	261.4	8284.6	58242.7	0.0	34092.6
1	36269.5	333785.9	0.0	52889.2	105236.5	91956.4	224712.8	262658.3
2	354902.7	97069.1	0.0	60191.1	7229.8	71827.3	55957.6	103390.3
3	33558.3	11031.1	0.0	8811.0	562.2	15213.8	8052.2	799.3
4	1134.9	0.0	0.0	0.0	0.0	2253.8	424.8	0.0
	2010	2011	2012	2013	2014	2015	2016	
0	47973.3	6358.6	0.0	5516.7	2536.2	15982.0	11132.5	
1	260187.3	179617.4	72770.9	78920.1	97122.3	55219.3	111565.5	
2	127650.4	90619.0	66779.2	105952.2	80471.8	42664.8	17172.7	
3	4117.0	5922.3	5625.1	14376.5	5572.7	5035.6	123.1	
4	0.0	0.0	0.0	0.0	17.9	0.0	0.0	

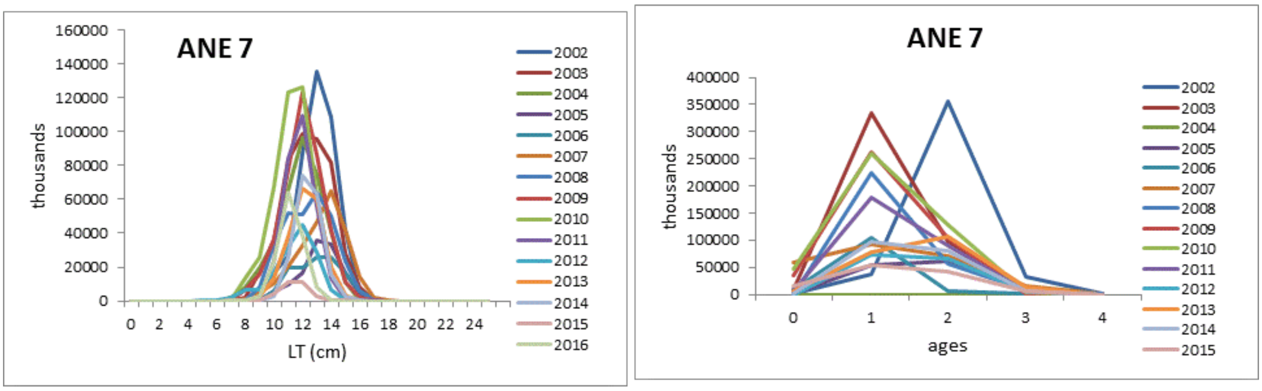


Figure 6.1.3.1.1.5 European anchovy in GSA 7. Length structure (left) and age structure of landings as reported by France (thousands).

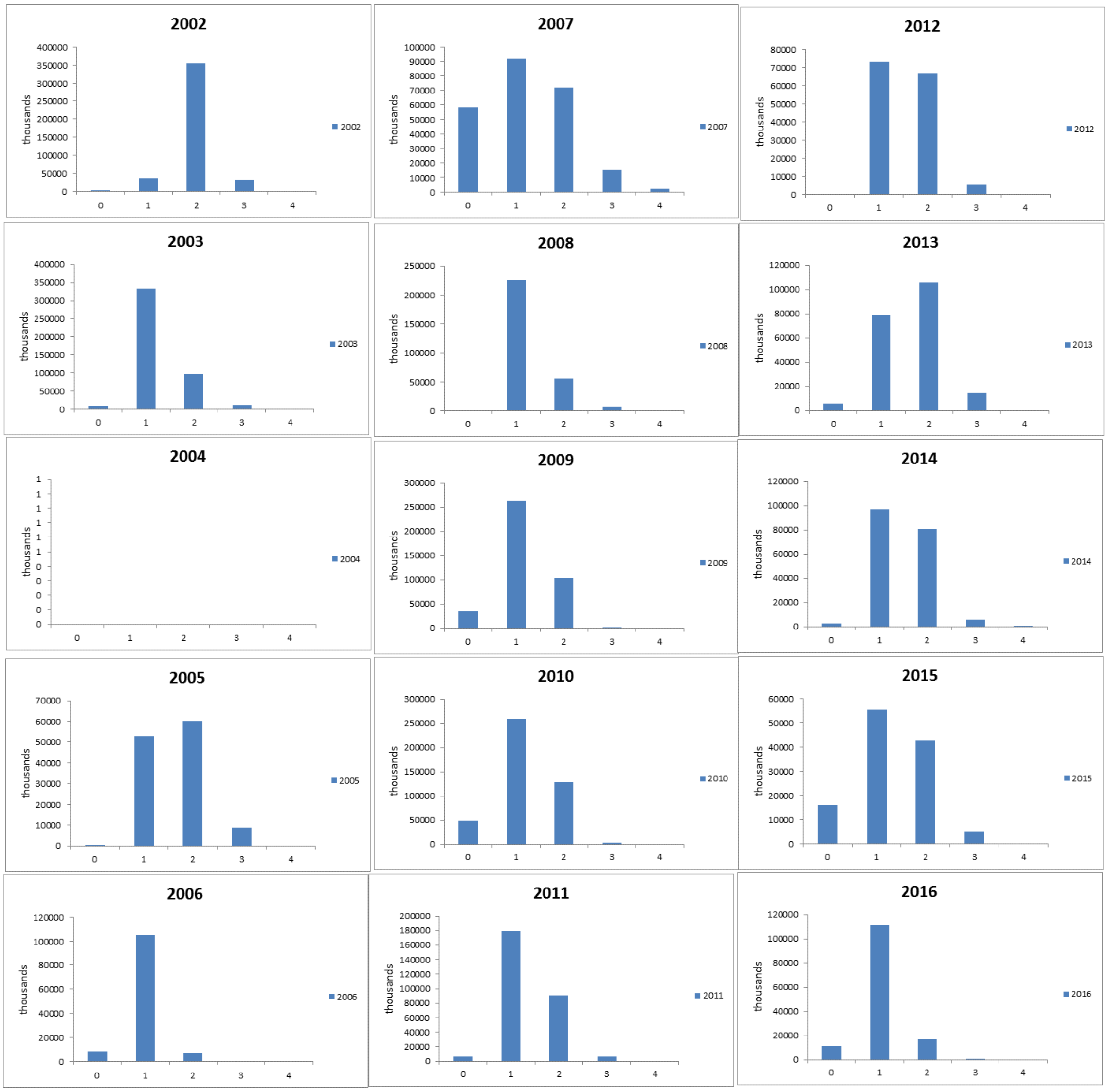


Figure 6.1.3.1.1.6 European anchovy in GSA 7. Age structure of landings (thousands). Landings consist basically of two age classes, 1 and 2. In 2016 age 2 is almost absent from the landings.

6.1.3.1.2 Effort

Table 6.1.3.1.2.1 Fishing effort in GSA 7, expressed in gt_days_at_sea and fishing days.

	gt_days_at_sea		days	
	OTM 7	PS 7	OTM 7	PS 7
2004		33436		755
2005		23559		515
2006		10879		247
2007		13247		293
2008		8174		184
2009		4069		94
2010		109		4
2011		7457		167
2012		652		15
2013		3418		52
2014				
2015	55063	105818	372	876
2016	64827	200366	456	1476

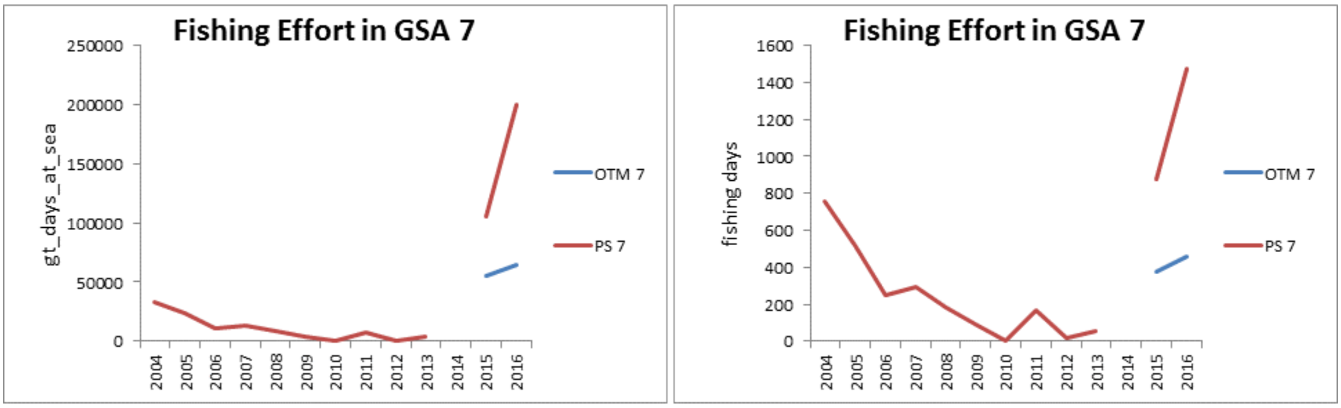


Figure 6.1.3.1.2.2 Fishing effort in GSA 7 expressed as gt_days_at_sea (left) and fishing days (right; OTB-midwater trawl; PS-purse seine).

6.1.3.1.3 Survey data

Table 6.1.3.1.3.1 European anchovy in GSA 7. Abundance index/year /size structure from the acoustic surveys PELMED, conducted in summer, over the period 2002-2016 (thousands; TL in cm).

	2002	2003	2004	2005	2006	2007	2008	2009
0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	348	0
3	0	0	0	0	0	0	813	0
4	0	0	0	0	0	0	1053	0
5	0	0	0	0	0	0	5100	8329
6	0	0	0	0	0	0	11197	9389
7	13	0	0	0	1384	0	2728	2339
8	6	2947	0	0	2101	0	0	0
9	1124	1251	25505	0	2070	0	0	30873
10	898	29018	256675	8167	3260	0	1134	486245
11	145082	757380	625102	0	18578	1221	48205	1029914
12	836698	1223423	736841	19988	243184	36625	493521	891049
13	1301320	454229	385078	268989	469294	139814	724030	479798
14	895272	63482	133315	274556	390477	233367	315713	71354
15	148275	7946	52075	131869	211334	233463	82912	23773
16	4768	0	11508	97385	78956	68795	6537	3219
17	0	0	0	20414	18689	0	1757	0
18	0	0	0	0	513	0	0	0
19	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0

(cont. Table 6.1.3.4.1)

	2010	2011	2012	2013	2014	2015	2016
0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0
5	0	0	0	0	0	802	0
6	0	0	0	0	51	0	119
7	0	0	0	0	0	1153	715
8	0	0	7780	8796	44465	1199	2742
9	29289	158042	452417	510128	539453	140849	4514
10	844998	1294897	2411640	1715868	1021944	1491269	197282
11	1263385	1080572	1681513	399095	1357819	2754053	969806
12	526651	632180	522661	44849	711068	703442	770297
13	123678	143638	55617	7126	138759	33343	242822
14	19123	10395	10326	0	15880	11789	45176
15	0	0	349	0	0	3032	6389
16	0	0	0	0	0	122	0
17	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0

Table 6.1.3.1.3.2 European anchovy in GSA 7. Abundance index/year /age structure from the acoustic surveys PELMED, conducted in summer, over the period 2002-2016 (thousands; TL in cm).

ANE GSA 7 Abundance by age					
	age0	age1	age2	age3	age4
2002	394	1441542	1744452	144374	2696
2003	3364	1422552	1096147	17469	144
2004		1898430	303758	23911	
2005	8167	555029	240111	18060	
2006	10503	1045081	358644	25520	91
2007	275	270803	388516	47650	6040
2008	24987	908593	728676	31126	1667
2009	72294	2263756	689546	10222	464
2010	109809	2482097	215218		
2011	135310	2942978	241435		
2012		4748833	389873	3596	
2013	53706	2585364	46792		
2014	74485	2303968	1305912	133734	11338
2015	72070	4495021	570282	3561	118
2016	27283	1794164	400790	17626	

Table 6.1.3.1.3.3 European anchovy in GSA 7. Biomass index/year /size structure from the acoustic surveys PELMED, conducted in summer, over the period 2002-2016 (tonnes; TL in cm).

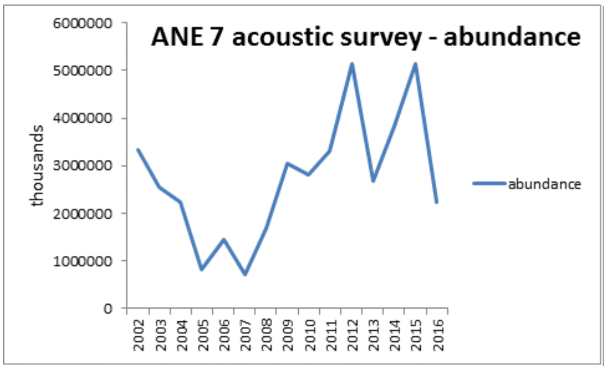
	2002	2003	2004	2005	2006	2007	2008	2009
0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	348	0
3	0	0	0	0	0	0	813	0
4	0	0	0	0	0	0	1053	0
5	0	0	0	0	0	0	5100	8329
6	0	0	0	0	0	0	11197	9389
7	13	0	0	0	1384	0	2728	2339
8	6	2947	0	0	2101	0	0	0
9	1124	1251	25505	0	2070	0	0	30873
10	898	29018	256675	8167	3260	0	1134	486245
11	145082	757380	625102	0	18578	1221	48205	1029914
12	836698	1223423	736841	19988	243184	36625	493521	891049
13	1301320	454229	385078	268989	469294	139814	724030	479798
14	895272	63482	133315	274556	390477	233367	315713	71354
15	148275	7946	52075	131869	211334	233463	82912	23773
16	4768	0	11508	97385	78956	68795	6537	3219
17	0	0	0	20414	18689	0	1757	0
18	0	0	0	0	513	0	0	0
19	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0

(cont. Table 6.1.3.4.3)

	2010	2011	2012	2013	2014	2015	2016
0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0
5	0	0	0	0	0	802	0
6	0	0	0	0	51	0	119
7	0	0	0	0	0	1153	715
8	0	0	7780	8796	44465	1199	2742
9	29289	158042	452417	510128	539453	140849	4514
10	844998	1294897	2411640	1715868	1021944	1491269	197282
11	1263385	1080572	1681513	399095	1357819	2754053	969806
12	526651	632180	522661	44849	711068	703442	770297
13	123678	143638	55617	7126	138759	33343	242822
14	19123	10395	10326	0	15880	11789	45176
15	0	0	349	0	0	3032	6389
16	0	0	0	0	0	122	0
17	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0

Table 6.1.3.1.3.4 European anchovy in GSA 7. Biomass index/year /age structure from the acoustic surveys PELMED, conducted in summer, over the period 2002-2016 (tonnes; TL in cm).

	ANE	GSA7 Abundance by age				
	age0	age1	age2	age3	age4	total
2002	2	20708	27762	2853	64	51389
2003	11	15121	12469	255	3	27860
2004	0	19986	5391	576	0	25953
2005	52	10396	5076	437	0	15962
2006	56	17815	7185	598	4	25658
2007	3	4845	7609	1051	145	13654
2008	62	11880	10827	585	40	23395
2009	323	21538	8365	188	11	30424
2010	807	20449	2259	0	0	23514
2011	931	22567	2408	0	0	25906
2012	0	34793	4164	58	0	39015
2013	223	17632	512	0	0	18366
2014	282	15963	12752	1770	173	30939
2015	501	35537	5746	68	3	41855
2016	189	17346	4952	254	0	22740



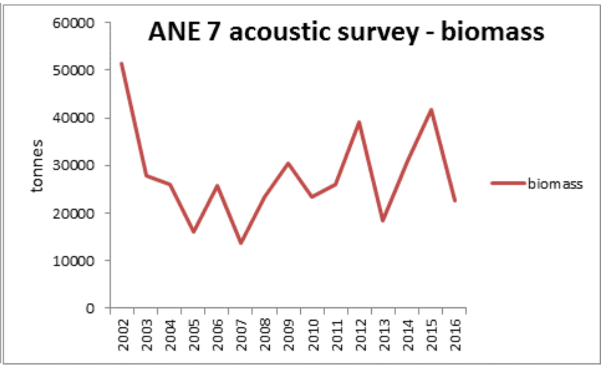


Figure 6.1.3.1.3.1 European anchovy in GSA 7. Abundance (thousands) and biomass (tonnes) as estimated from the acoustic surveys and the age structure. Note that biomass appears to be stabilized around 30.000 tonnes while landings displayed a decreasing trend.

6.1.3.2 STOCK ASSESSMENT

Ages 1 and 2 were the most abundant in the landings, the presence of other ages being very low (Fig. 6.1.3.2.2). In the last years, these two ages represented more than 90% of the total, with the exception of 2015, when age 0 represented 13% of the total. In 2016, age 1 represented, alone, 80% of the total landings. Because of the timing of the acoustic surveys, in summer, during the reproduction period, recruitment indices are not available. Because of the very limited number of age classes no analytical methodology was applied for the assessment of anchovy in GSA 7.

Different runs were performed with SPiCT, but none of the runs converged.

Methods 1: Biomass index

Biomass Index refers to the ICES data limited approach using a stock status indicator (ICES 2012). In the last years anchovy biomass has been fluctuating around 30000 tonnes. The change in biomass over the last five years was used to provide an index for change (1.10). Following the ICES approach, because this index is less than 1.2 and more than 0.8, the index value is used to multiply the catch (mean catch over 2014-2016). Because the exploitation rate is thought to be above MSY due to length indicator evaluation (See annex 1 and Figure 6.1.3.3.3) and the state of the stock relative to Bmsy is unknown a precautionary buffer (catch multiplier of 0.8) is applied. The catch advice which is applicable for two years is 1343 t.

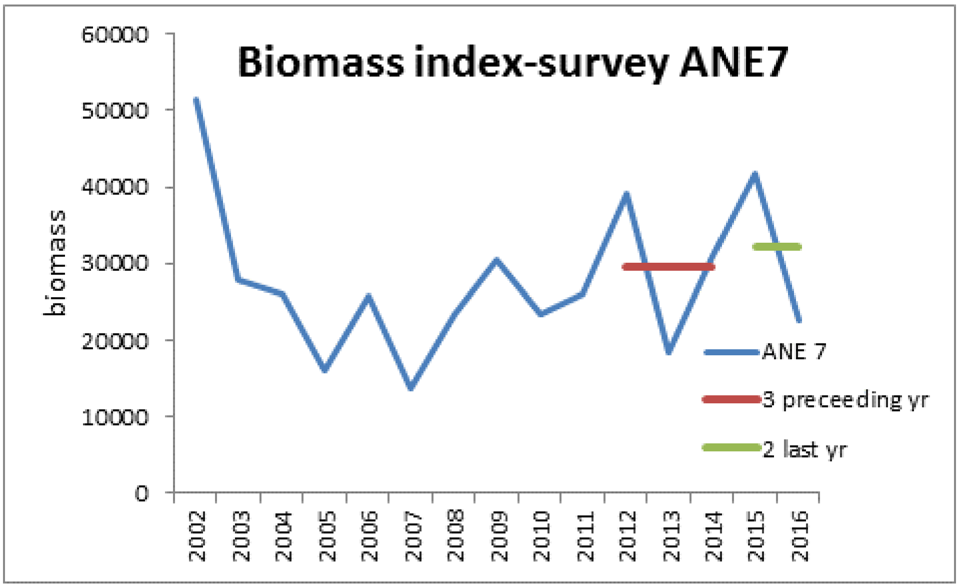


Figure 6.1.3.2.1 European anchovy in GSA 7. Biomass index estimated by direct acoustic method from PELMED survey. In green the mean of the last two years compared to the previous three years (red).

Methods 2: SPiCT

Different runs were done with SPiCT, but none of the runs converged.

Input data run #1

Landings

- Landings time series for the time period 2002 to 2016 from the DCF 2017 data call

Index

- Acoustic index for the period 1993 to 2016 (PELMED)

Input data run #2

Landings

- Landings time series for the time period 1950 to 2016 from FAO Global Capture Production

http://www.fao.org/fishery/statistics/global-capture-production/query/en and DCF.

Index

- Acoustic index for the period 2002 to 2016 (DCF)

Input data run #3

Landings

• Landings time series starting for the time period 1865 to 2014 from IFREMER (an additional source of data is the reconstructed time series of landings of anchovy in GSA 7 performed by IFREMER and kindly provided by C. Saraux.) and for 2015-2016 from the DCF 2017 data call

Index

• Acoustic index for the period 2002 to 2016 (DCF)

Input data run #4

Landings

• Landings time series starting for the time period 1865 to 2014 from IFREMER and for 2015-2016 from the DCF 2017 data call

Index

• Acoustic index for the period 1993 to 2016 (PELMED)

None of the runs converged.

Length Indicator Analysis

The length indicator analysis (See details in annex 1 to this report) was carried out for most stocks including anchovy in GSA 7 the results by year are given in Figure 6.1.3.2.2 and summarised over years in Figure 6.1.3.2.3. The exploitation rate indicator L_{fem}/L_{mean} is seen to be below 1.0 in the last three years, so the indicator suggests the stock is over exploited.

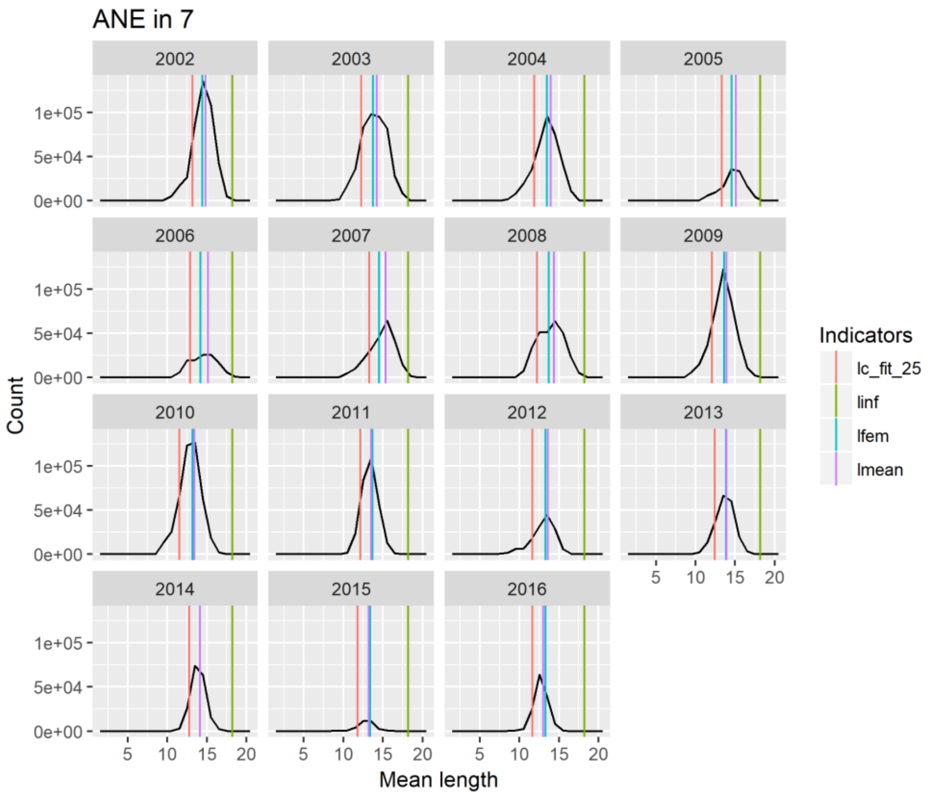


Figure 6.1.3.2.2, Results of year by year length indicator analysis showing distribution of length in the catch, and the L_{fem} and L_{mean} that are used to evaluate exploitation relative to MSY.

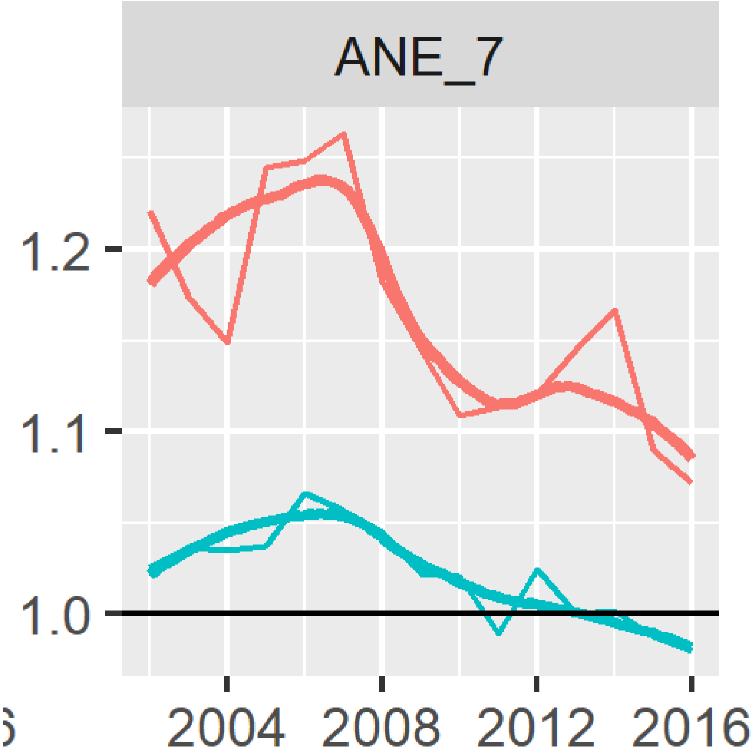


Figure 6.1.3.2.3, Summary of length indicator analysis showing distribution of length in the catch, and the L_{fem} and L_{mean} that are used to evaluate exploitation relative to MSY.

6.1.3.3 Reference Points

No reference points were estimated.

6.1.3.4 Short term Forecast and Catch Options

No short term predictions were performed.

Based on the biomass index, the catch advice which is applicable for two years is 1343 t.

6.1.3.5 Data Deficiencies

The use of two different codes for the same area, GSA 7 and SA 7 should be avoided. This issue can lead to an incomplete selection of data from the Gulf of Lions.

No data on age structure in 2004.

OTM fishing effort, the main fishing gear targeting small pelagics in the area, is reported for 2015-2016. No data on fishing effort in 2014.

As indicated in previous reports, the growth parameters should be revised (t_0 values are very negative). The procedure for transforming landings lengths into ages is not known. The availability of this procedure might help in the interpretation of the lengths and ages structures within a given area and among areas. ALK should be available from the acoustic surveys.

6.2 SARDINE IN GSAs 5, 6 & 7

The list of proposed stocks to be assessed by the EWG17-09 included a joint assessment of sardine in GSAs 5-6-7.

The purse seining activity in GSA 5 is much reduced. Sardine landings in GSA 5 are very low (highest landings < 0.5 t) and information on the size structure of the landings is available only for 2016. In addition, GSA 5, the Balearic Islands, is not surveyed by the acoustic survey Medias. No biological information is collected in the frame of the DCF. The available information of sardine in GSA 5 is presented below in section 6.2.1, but this stock was not assessed.

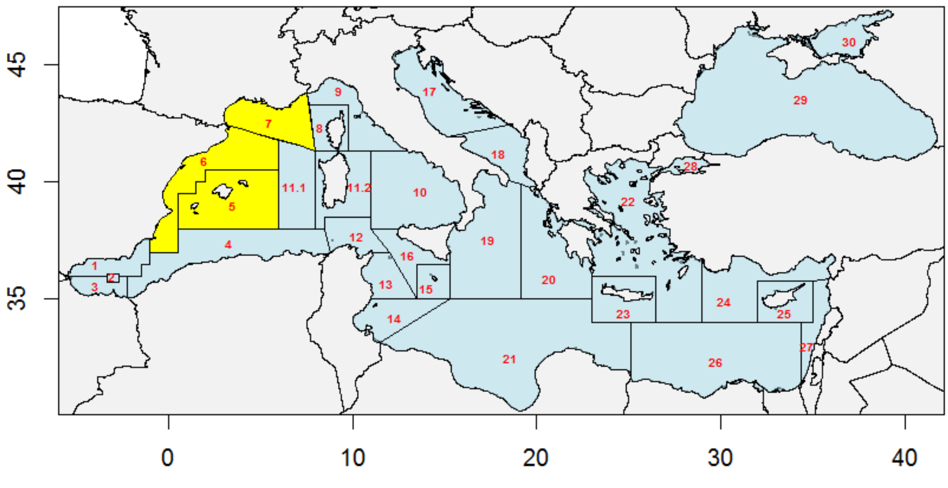


Figure 6.2.1. Geographical location of GSAs 5-6-7.

Table 6.2.1. Sardine in GSAs 5,6 & 7. Landings in GSAs 5-6-7 over the period 2002-2016 (tonnes).

	GSA 5	GSA 6	GSA 7
2002	488.0	17167.6	9416.4
2003	288.9	17523.4	5095.2
2004	154.9	23171.5	7493.4
2005	161.5	21229.3	9472.2
2006	140.2	27799.7	10381.1
2007	68.8	23552.2	13339.6
2008	125.8	16670.6	6740.5
2009	58.5	7506.8	7240.6
2010	42.1	7627.2	1813.7
2011	323.8	12568.3	748.4
2012	310.1	9395.3	635.4
2013	116.2	9928.8	989.0
2014	215.9	9877.3	632.1
2015	216.4	6449.6	342.1
2016	198.2	10042.4	845.6

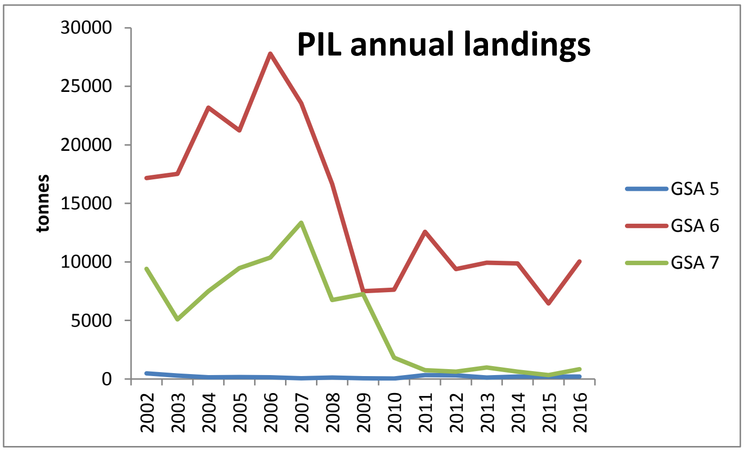


Figure 6.2.1 Sardine in GSAs 5,6 & 7. Landings (t) in GSAs 5-6-7.

The fishing activity in GSA 7 targeting small pelagics in GSA 7 is very limited. Acoustic surveys point to a marked increase of sardine biomass in GSA 6 since 2011, while sardine biomass in GSA 7 has fluctuated around 60000 t since 2009, after several years of decrease since the biomass peak in 2004. Sardine landings in GSA 7 since 2010 have remained at very low level, while those in GSA 6 in the same period have fluctuated around 9000 t. Because of the different behaviour of sardine in GSA 6 and 7, these stocks were assessed separately.

6.2.1 SARDINE IN GSA 5

No information is available on stock identification and boundaries of sardine in GSA 5. No biological information is collected in the frame of the DCF.

6.2.1.1 DATA

6.2.1.1.1 CATCH (LANDINGS AND DISCARDS)

There is no information on sardine discards in GSA 5.

Table 6.2.1.1.1.1 Sardine in GSA 5. Landings in GSAs 5 over the period 2002-2016, by fishing gear (tonnes; Otter Bottom Trawl (OTB), Purse Seine (PS)).

	GSA 5		
	OTB	PS	Total GSA 5
2002	11.2	476.9	488.0
2003	8.7	280.2	288.9
2004	8.8	146.1	154.9
2005	3.8	157.8	161.5
2006	1.1	139.1	140.2
2007	1.2	67.6	68.8
2008	1.1	124.7	125.8
2009	0.1	58.4	58.5
2010	0.2	42.0	42.1
2011	0.1	323.7	323.8
2012	0.1	310.0	310.1
2013	0.2	116.0	116.2
2014	0.1	215.8	215.9
2015	0.1	216.3	216.4
2016		198.2	198.2

Table 6.2.1.1.1.2 Sardine in GSA 5. Landings size structure in 2016 (Purse seine; thousands).

	2016
0	0.0
1	0.0
2	0.0
3	0.0
4	0.0
5	0.0
6	0.0
7	0.0
8	0.0
9	0.0
10	0.0
11	0.0
12	212.6
13	1319.1
14	1525.0
15	1375.0
16	1024.1
17	513.7
18	152.5
19	25.8
20	0.0
21	0.0
22	0.0
23	0.0
24	0.0
25	0.0

6.2.1.1.2 EFFORT

Table 6.2.1.1.2.1 Sardine in GSA 5. Fishing effort over the period 2002-2016 expressed as gt_days_at_sea and fishing days.

	gt_days_at_sea	days
	PS 5	PS 5
2004	21359	1704
2005	18273	1424
2006	17310	1323
2007	11710	1076
2008	10241	933
2009	9873	892
2010	11164	988
2011	7575	641
2012	14255	1177
2013	14840	1173
2014	11226	921
2015	9841	903
2016	84078	1092

6.2.1.1.3 SURVEY DATA

GSA 5 is not surveyed by the acoustic survey Medias.

6.2.1.2 STOCK ASSESSMENT

GSA 5 is not surveyed by the acoustic survey Medias.

6.2.1.3 REFERENCE POINTS

6.2.1.4 SHORT TERM FORECAST AND CATCH OPTIONS

6.2.1.5 DATA DEFICIENCIES

The information of sardine in GSA 5 is very limited, which can be explained by the low amount of landings and the also limited fishing activity of purse seine in the area.

6.2.2 SARDINE IN GSA 6

No new information was available to the EWG 17-09 on stock identification and boundaries in relation to that reported by STECF (2016, 2017). This stock was assumed to be confined within the GSA boundaries.

Maturity

Sardine has a protracted spawning period, from autumn to winter (Olivar *et al.*, 2003). It was assumed that age0 corresponds to juveniles and at age 1 all individuals will spawn, that is, are mature.

Natural mortality vector

The same that was used in the last approved assessment (STECF 2016).

M was estimated by STECF (2015) with the method proposed by Gislasson *et al.* (2010) using as input the following growth parameters: L_{inf}= 23.9; k=0.40; t_0=-0.4.

Ages	0	1	2	3	4	5+
M	2.8	1.14	0.78	0.6	0.53	0.48

6.2.2.1 DATA

Sardine landings in GSA 6 come predominantly from PS; a small amount is reported for OTB. Discards, low, are reported for OTB. Since 2010 landings have fluctuated around 9000 t.

6.2.2.1.1 CATCH (LANDINGS AND DISCARDS)

Table 6.2.2.1.1.1 Sardine in GSA 6. Landings by fishing gear over the period 2002-2016 (tonnes; GNS-gillnet, OTB-otter bottom trawl, PS-purse seine).

	GSA 6			
	GNS	OTB	PS	Total GSA 6
2002		169.6	16998.0	17167.6
2003		163.1	17360.2	17523.4
2004		338.1	22833.5	23171.5
2005		246.6	20982.7	21229.3
2006		654.6	27145.1	27799.7
2007		641.1	22911.1	23552.2
2008		485.2	16185.4	16670.6
2009		100.6	7406.1	7506.8
2010	26.3	125.6	7475.3	7627.2
2011	31.4	402.3	12134.7	12568.3
2012	10.0	191.8	9193.5	9395.3
2013	27.5	167.6	9733.7	9928.8
2014	8.7	209.1	9659.5	9877.3
2015	2.3	138.3	6309.1	6449.6
2016		108.2	9934.2	10042.4

Table 6.2.2.1.1.2 Sardine in GSA 6. Discards reported in the period 2005-2016 (OTB-otter bottom trawl; tonnes).

	GSA 6
	OTB
2005	0.31
2006	
2008	1.44
2009	0.15
2010	0.04
2011	226.8
2012	1506.23
2013	281.11
2014	157.95
2015	441.51
2016	695.65

No data available on the discards length structure.

Table 6.2.2.1.1.3 Sardine in GSA 6. PS landings length structure over 2002-2016 (thousands; TL in cm).

	2002	2003	2004	2005	2006	2007	2008	2009
0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
6	0	12.552	88.767	0	0	0	0	0
7	0	0	532.596	0	0	0	0	0
8	230.139	202.961	5274.173	0	0	0	0	0
9	693.119	2358.036	11297.801	2610.563	1053.228	141.337	189.383	300.84
10	5701.761	23773.78	26049.324	35722.996	16254.736	910.15	4616.309	6397.808
11	7712.993	71147.946	80655.725	61953.854	29927.677	9927.089	23288.274	33642.634
12	16076.181	69806.372	151618.569	71219.994	35522.872	44188.257	55099.916	77031.301
13	85174.922	99688.238	133188.461	107428.035	44994.674	50175.15	63339.152	102779.229
14	174290.15	132373.889	135380.826	152290.786	111365.477	59704.755	63702.524	75720.834
15	157214.522	139656.052	152029.802	151873.986	206860.541	115738.093	83927.874	34503.231
16	94640.496	88168.503	105432.764	111888.461	188213.025	118418.684	89956.739	17653.348
17	38704.539	35065.147	51694.297	59791.338	108739.011	87369.536	78124.467	9514.305
18	8543.494	10831.624	21253.43	17135.091	48567.145	80124.456	45571.014	5717.998
19	751.997	2785.756	11269.247	5230.967	17336.87	40573.494	21034.517	2955.85
20	10.966	654.095	4412.952	1403.489	4996.319	9982.029	5688.641	1674.377
21	0	69.087	1133.929	337.595	795.83	803.931	294.548	449.929
22	0	6.725	130.711	78.669	134.116	144.136	3.314	40.356
23	0	0	0.173	0	0	0	0	0
24	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0

	2010	2011	2012	2013	2014	2015	2016
0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0
5	0	0	40.282	0	0	0	0
6	0	0	132.399	0	0	0	0
7	0	404.569	104.174	0	0	0	0
8	66.465	2359.622	195.343	25.761969	157.572	281.547	1302.711
9	988.285	1315.747	2959.443	1339.25794	4170.455	3525.81	7497.594
10	8835.652	19163.367	18846.638	14824.1942	18257.585	19758.986	37114.9
11	27018.084	85318.816	56600.03	57629.5629	49190.254	45341.723	92779.66
12	53032.741	106652.491	94492.886	100496.206	112930.728	98952.495	184849.53
13	71207.435	132774.405	99445.535	130701.366	148003.041	114884.95	156766.41
14	68602.847	140437.92	79322.992	99828.5725	111728.583	66078.175	94862.42
15	58124.121	77623.483	59231.033	63050.5539	58949.188	23693.013	38589.76
16	34592.089	33160.623	37012.108	30629.5096	17933.826	8540.3	9815.721
17	13919.703	16670.271	15635.288	8538.69752	6416.456	2307.711	1745.977
18	3768.327	6082.192	3818.141	2157.93409	1454.479	929.201	381.686
19	682.341	1144.501	594.446	556.885882	892.408	375.911	215.288
20	1110.556	277.24	63.831	108.839871	125.934	81.848	46.111
21	310.692	32.528	24.414	4.371	138.061	4.238	3.187
22	29.753	3.085	0.089	0	0	0	0.091
23	2.05	0	0	0	0	0	0
24	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0

Table 6.2.2.1.1.4 Sardine in GSA 6. PS landings age structure over 2002-2016 (thousands).

	2002	2003	2004	2005	2006	2007	2008	2009
0	110356.9	215131.1	306081.2	338375.5	129262.0	109821.3	133899.2	183806.1
1	399539.2	384115.0	470161.9	287682.5	355650.9	198231.8	255377.6	160658.4
2	65009.4	59921.7	77496.6	127139.3	241042.1	165098.8	106594.2	17613.6
3	12519.3	12987.0	21870.8	21524.8	73699.4	100083.7	35972.3	5423.2
4	1989.3	3775.1	13625.2	3084.0	14065.2	38696.9	2951.4	816.5
5+	331.2	670.9	2207.9	1159.7	1041.9	6268.5	42.1	64.3
	2010	2011	2012	2013	2014	2015	2016	
0	100226.3	404484.3	170241.2	97253.1	94438.7	147792.5	116611.8	
1	229452.4	191607.1	286246.8	297512.3	336380.3	202153.6	428883.8	
2	9751.9	25598.6	10387.5	108475.6	90416.5	34109.2	77621.7	
3	1675.9	1436.3	1364.4	5844.1	8988.4	700.6	2782.5	
4	982.1	137.2	266.4	793.5	124.6	0.0	71.3	
5+	200.5	157.0	12.8	0.0	0.0	0.0	0.0	

SoP corrections were applied to catch numbers at age, corrections range from 1.14 to 1.31 with an average of 1.23.

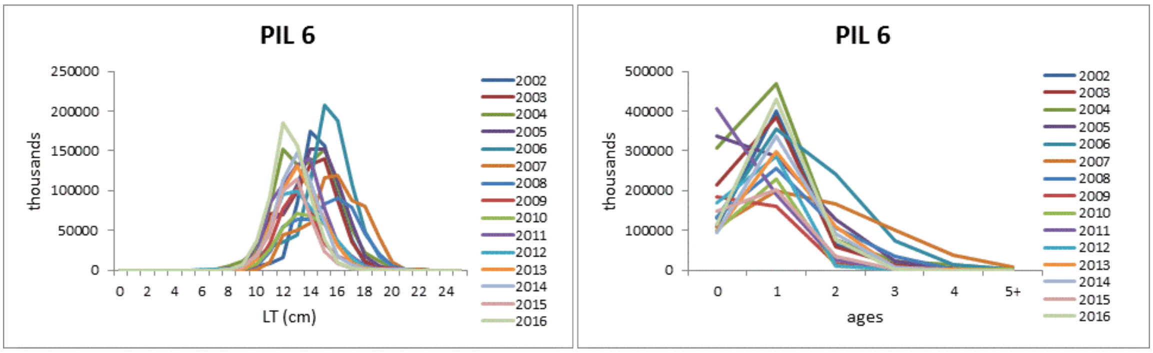


Figure 6.2.2.1.1.1 Sardine in GSA 6. Length structure (left) and age structure of PS landings (thousands).

6.2.2.1.2 Effort

Table 6.2.2.1.2.1 Sardine in GSA6. PS fishing effort in GSA 6, expressed in gt_days_at_sea and fishing days.

	gt_days_at_sea PS 6	days PS 6
2004	883666	20359
2005	762916	17345
2006	810575	17243
2007	445303	11031
2008	754749	16643
2009	813051	17563
2010	794731	16985
2011	830778	17832
2012	796035	17339
2013	846402	18968
2014	873989	19556
2015	808241	17589
2016	862467	19187

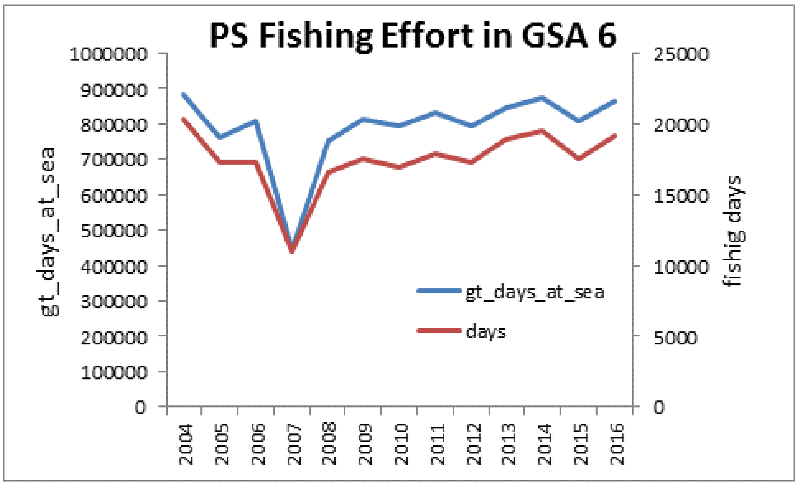


Figure 6.2.2.1.2.1 Sardine in GSA6. PS fishing effort in GSA 6 expressed as gt_days_at_sea (left axis) and fishing days (right axis).

6.2.2.1.3 SURVEY DATA

Table 6.2.2.1.3.1 Sardine in GSA 6. Abundance index/year /size structure from the acoustic surveys from the acoustic surveys ECOMED (2003-2008) and MEDIAS (2009-2016) (thousands; TL in cm).

	2003	2004	2005	2006	2007	2008
0	0	0	0	0	0	0
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	2451	0	0	0	0
8	53434	21885	1041	19167	0	0
9	218184	61651	33386	65230	0	0
10	686319	314770	148947	192938	1279	48693
11	869863	610092	329984	283547	92824	198659
12	707340	526785	538215	240327	190402	119561
13	424031	231409	354906	164432	171617	34345
14	338100	189606	211149	112852	53494	6873
15	240104	133237	142034	153689	65281	6331
16	214732	48483	109231	201779	62507	9987
17	173489	19669	84633	235850	55669	10675
18	111682	8129	36816	197934	37960	13083
19	54733	5254	12445	95123	15268	7871
20	17571	2879	2883	21779	3423	2712
21	1721	804	1351	7489	735	301
22	765	68	1570	2844	0	0
23	0	0	0	393	0	88
24	0	0	0	0	0	0
25	0	0	0	0	0	0

cont. Table 6.2.2.1.3.1

	2009	2010	2011	2012	2013	2014	2015	2016
0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	306	0
6	7680	0	494	2697	128862	1987	23267	55
7	29661	1208	6786	142201	683453	60534	254410	462135
8	606018	134884	431789	1165569	1905313	203431	872774	1408386
9	1382838	772056	1326066	2486069	2027153	220281	786380	528519
10	1093790	710612	1360105	1243213	1119648	74393	825913	496227
11	440960	293762	486810	438861	427683	22915	471140	431683
12	60631	53526	179260	249646	96726	100206	144671	342179
13	14006	53932	138380	110329	156979	72057	176868	197791
14	26048	85252	154052	59367	62461	23397	66102	106258
15	19400	52052	110672	29316	32180	9739	27995	54596
16	10370	18050	98579	13064	8651	354	6020	6084
17	4016	3340	27691	3362	1729	0	875	1230
18	664	1142	2021	612	0	0	1692	547
19	238	0	249	0	0	0	0	0
20	38	0	58	293	61	0	0	0
21	0	348	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0

Table 6.2.2.1.3.2 Sardine in GSA 6. Abundance index/year /age structure from the acoustic surveys ECOMED (2003-2008) and MEDIAS (2009-2016) (thousands). Note the presence of age class 2 in the last years.

PIL	GSA 6 Abundance by age															
	ECO	MED	ECO	MED	ECO	MED	ECO	MED	ECO	MED	ECO	MED	ECO	MED	ECO	MED
	age0	age0	age1	age1	age2	age2	age3	age3	age4	age4	age5	age5	age6	age6	age7	age7
2003	2489245		1259398		206650		79375		64396		13003		0		0	
2004	1452950		665679		41285		7767		7812		1677		0		0	
2005	1276577		533431		152533		34723		7415		3912		0		0	
2006	1162345		674689		106773		34419		9700		2139		3672		1635	
2007	508217		155257		62100		15067		6626		2001		489		702	
2008	411195		37240		7071		2422		734		135		194		189	
2009		3622843		67341		5614		516		40		0		0		0
2010		1925819		238062		14919		903		114		348		0		0
2011		3817869		452391		49658		2972		120		0		0		0
2012		5136729		729875		72323		5672		0		0		0		0
2013		6237760		313753		79291		19121		975		0		0		0
2014		510166		260377		17873		879		0		0		0		0
2015		3089951		275404		266153		24207		2697		0		0		0
2016		2849869		1021141		156799		7881		0		0		0		0

Table 6.2.2.1.3.3 Sardine in GSA 6. Biomass index/year /age structure from the acoustic surveys ECOMED (2003-2008) and MEDIAS (2009-2016) (tonnes).

PIL	GSA 6 Biomass by age															
	ECO	MED	ECO	MED	ECO	MED	ECO	MED	ECO	MED	ECO	MED	ECO	MED	ECO	MED
	age0	age0	age1	age1	age2	age2	age3	age3	age4	age4	age5	age5	age6	age6	age7	age7
2003	24829		26125		7341		3267		3427		690		0		0	
2004	15927		12831		1334		330		466		109		0		0	
2005	16851		10892		5287		1532		393		323		0		0	
2006	15030		24715		4718		1649		511		148		239		104	
2007	7425		4448		2430		613		259		75		15		33	
2008	4556		1439		330		121		40		9		12		12	
2009		24654		1726		235		23		2		0		0		0
2010		13539		4984		434		34		4		27		0		0
2011		22037		8447		1171		85		5		0		0		0
2012		31294		9957		1819		226		0		0		0		0
2013		34858		5115		1514		365		19		0		0		0
2014		3200		2694		307		15		0		0		0		0
2015		17644		3878		3714		354		38		0		0		0
2016		15647		13569		2594		137		0		0		0		0

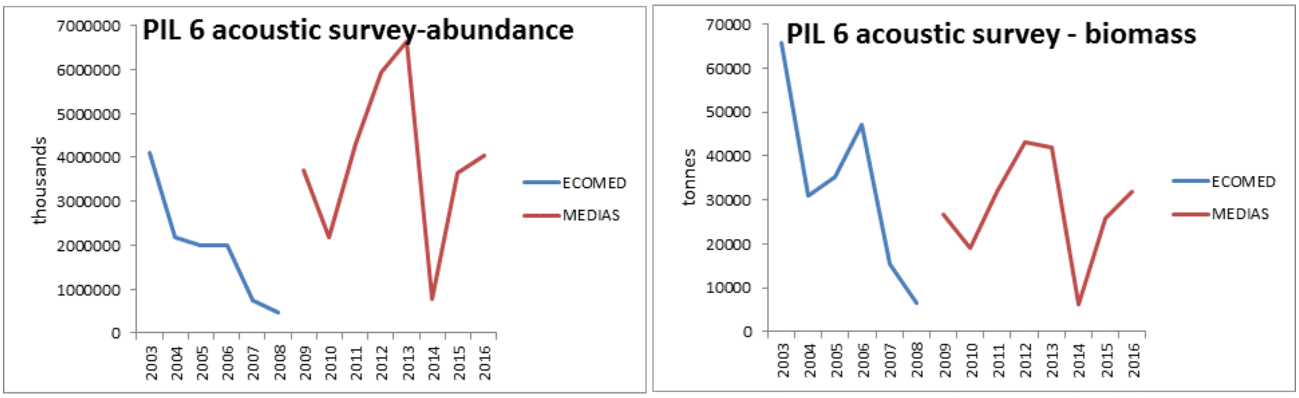


Figure 6.2.2.1.3.1 Sardine in GSA 6. Abundance (thousands) and biomass (tonnes) as estimated from the acoustic surveys and the age structure. In the last two years 2015-2016 sardine biomass appears to be increasing, which would be reflected in the increased landings in 2016.

6.2.2.2 STOCK ASSESSMENT

Sardine in GSA 6 was assessed with XSA using DCF data as input and the data from the purse seine fishery. Sardine catches, numbers at age in the catch, natural mortality and maturity at age are presented in previous sections. Weight at age is presented in Table 6.2.2.2.1. The final run considered ages classes 0-4+ and Fbar(0-3). Data from the acoustic surveys ECOMED and MEDIAS were used for tuning. Numbers at age in the acoustic surveys are presented in the previous section.

Table 6.2.2.2.1. Sardine in GSA 6. Weight at age (kg; DCF).

age	2002	2003	2004	2005	2006
0	0.016	0.014	0.012	0.015	0.015
1	0.022	0.022	0.021	0.021	0.025
2	0.030	0.031	0.031	0.032	0.032
3	0.037	0.039	0.041	0.042	0.041
4	0.045	0.052	0.056	0.051	0.051
age	2012	2013	2014	2015	2016
0	0.011	0.011	0.009	0.011	0.012
1	0.019	0.016	0.015	0.016	0.012
2	0.032	0.022	0.022	0.022	0.019
3	0.046	0.029	0.031	0.039	0.024
4	0.055	0.031	0.051	0.053	0.049

Different sensitivity analyses were performed before selecting the final XSA run, considering different combinations for shrinkage.

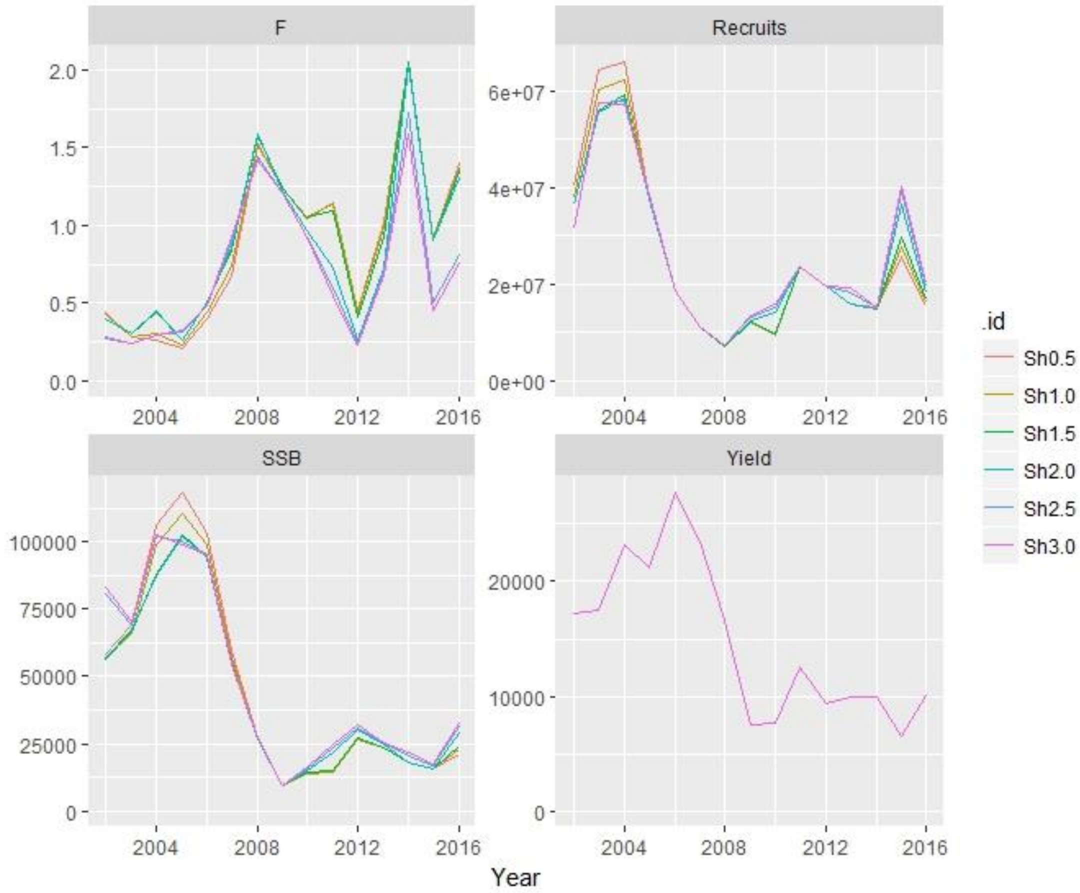


Figure 6.2.2.2.1. Sardine in GSA 6. Sensitivity analysis considering different combinations for shrinkage.

For the final run the following settings were selected based on the retrospective performance (Figure 6.2.2.2.3.):

fse=1.5, rage=-1, qage=2, shk.n=TRUE, shk.f=TRUE, shk.yrs=3, shk.ages=2.

Table 6.2.2.2.2. Sardine in GSA 6. Residuals table.

	shrinkage	minimum_MEDIAS	maximum_MEDIAS	average_MEDIAS	minimum_ECOMED	maximum_ECOMED	average_ECOMED
1	Sh0.5	-1.642670	1.726947	0.5630307	-1.3294168	1.603641	0.4872591
2	Sh1.0	-1.634121	1.721716	0.5568839	-1.2169781	1.269004	0.4335836
3	Sh1.5	-1.611750	1.729140	0.5465181	-0.8039734	1.478775	0.3316519
4	Sh2.0	-1.488631	1.915467	0.5411052	-0.8074011	1.502944	0.3186932
5	Sh2.5	-1.452790	1.292086	0.4668805	-2.2426291	1.289623	0.4249971
6	Sh3.0	-1.435629	1.281447	0.4521978	-2.2794916	1.298338	0.4288236

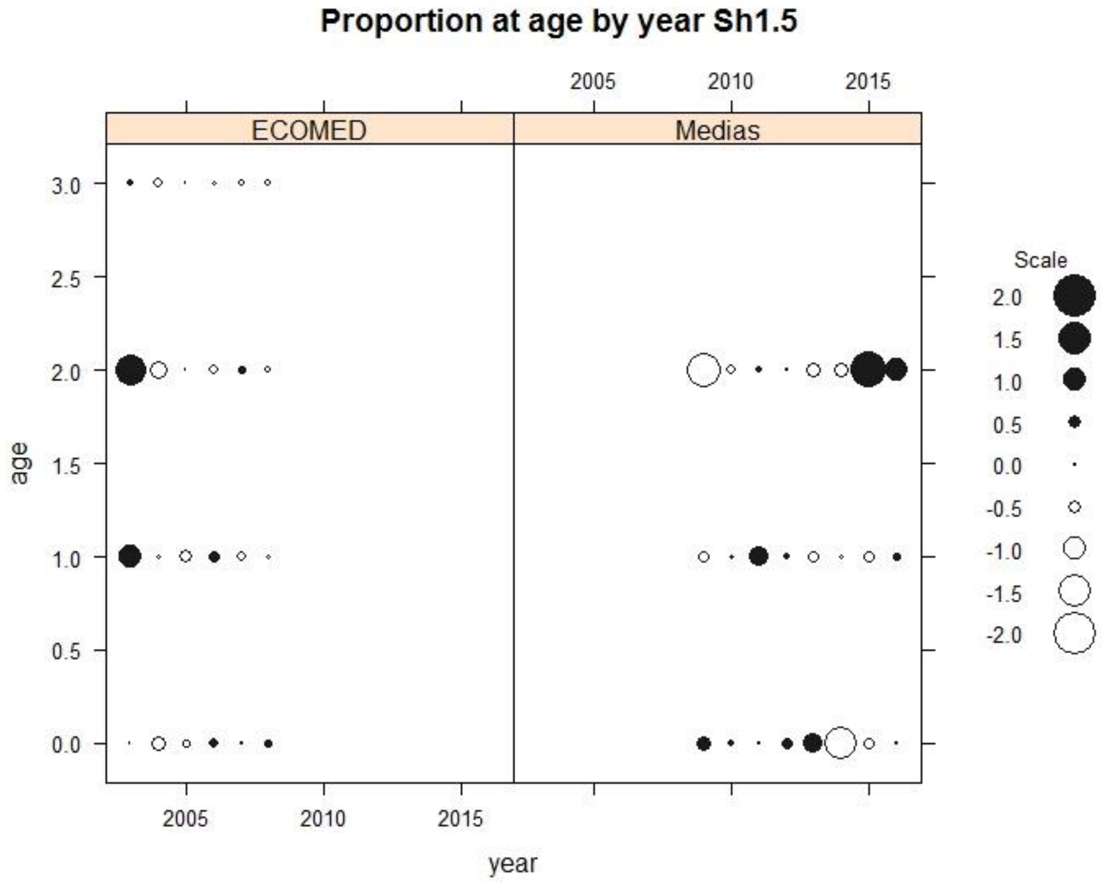


Figure 6.2.2.2.2 Sardine in GSA 6. Residuals pattern of the acoustic surveys ECOMED and MEDIAS.

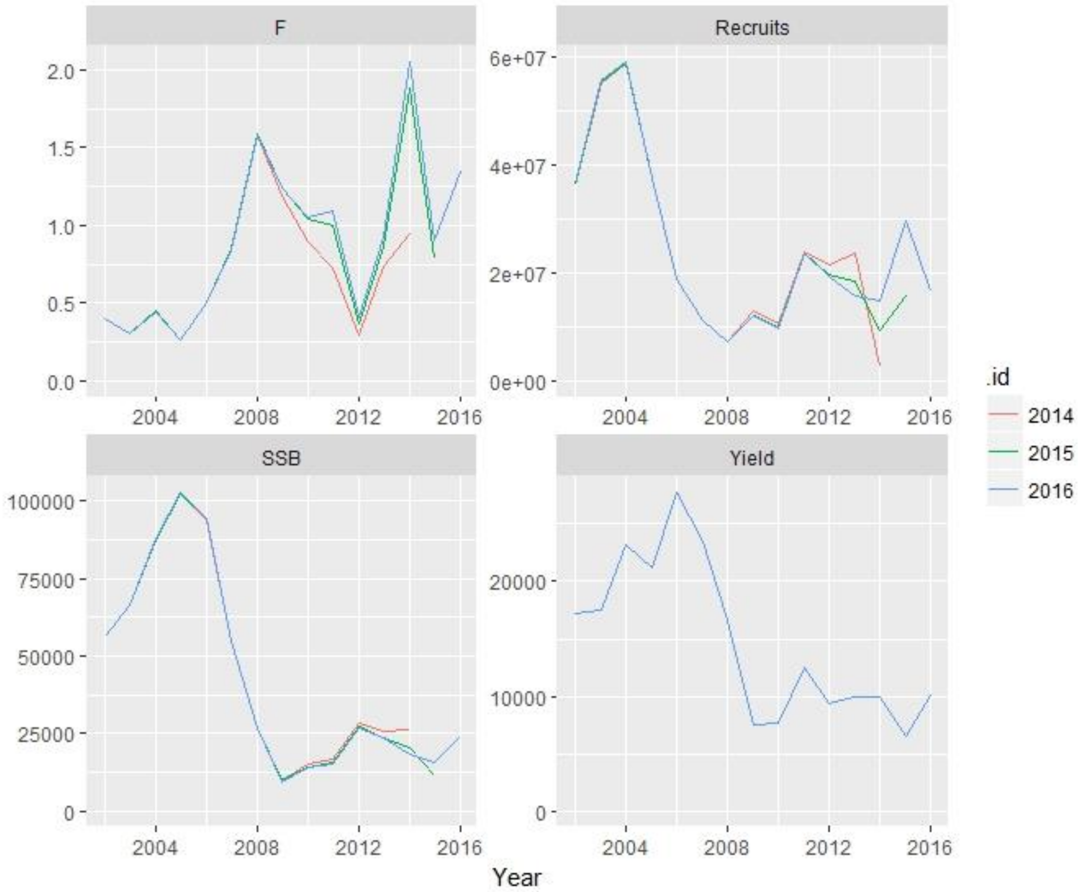


Figure 6.2.2.2.3. Sardine in GSA 6. XSA retrospective analysis.

The XSA assessment results are shown in Fig. 6.2.2.2.4 and Table 6.2.2.2.3.

Sardine SSB, Recruits and Yield displayed a very marked decreasing trend from 2005 to 2008. Since then, SSB seems to be stabilized around 23000 t and catch around 10000 t. Although fluctuating and at low level in comparison against the peak in 2004- 2005, in the last years recruitment seems to be increasing.

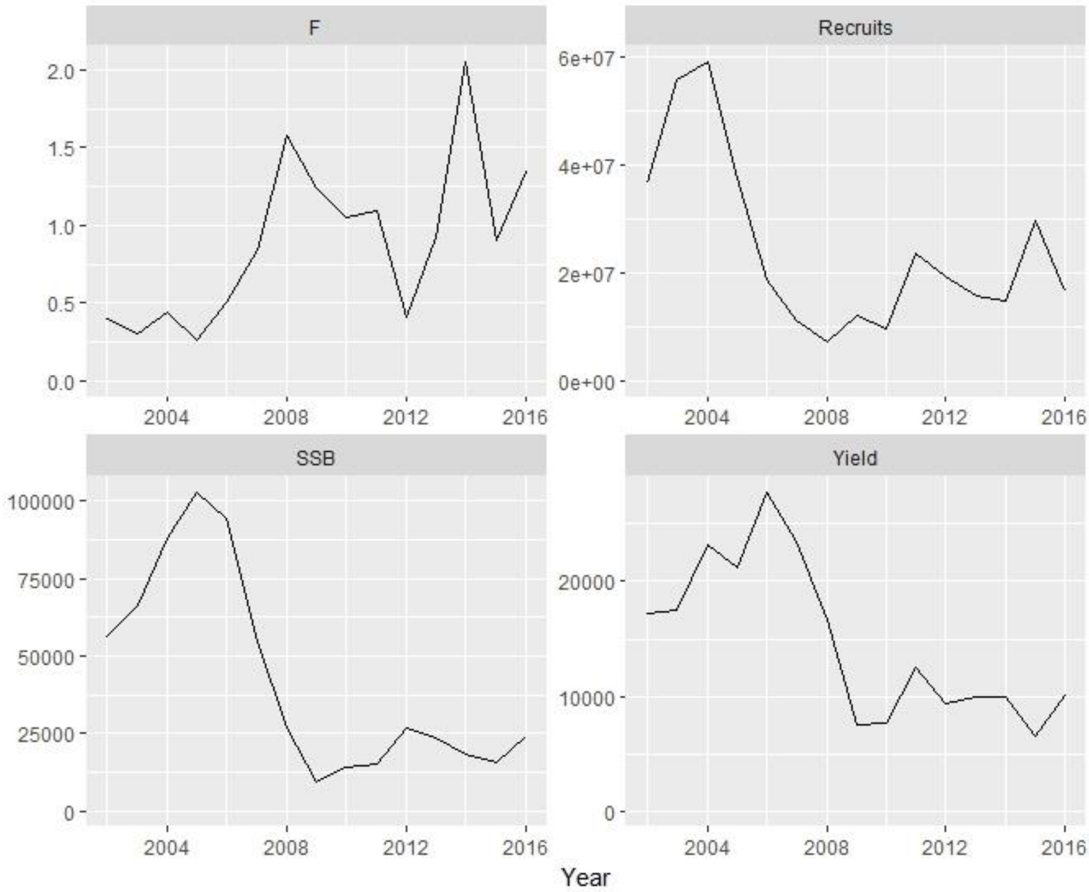


Figure 6.2.2.2.4 Sardine in GSA 6. XSA assessment summary results. SSB and yield in tonnes, recruits in thousands F_{bar} ages 0-3..

Table 6.2.2.2.3. Sardine in GSA 6. XSA assessment summary results SSB and yield in tonnes, recruits in thousands F_{bar} ages 0-3.

Year	Biomass	Catch	SSB	Recruits	Fbar
2002	641143	17168	56300	36552662	0.40
2003	846270	17523	66604	55690477	0.30
2004	797232	23172	88135	59091377	0.44
2005	667537	21229	102925	37640762	0.26
2006	374241	27800	94513	18648556	0.50
2007	224030	23552	55007	11268188	0.84
2008	135261	16671	26768	7232872	1.58
2009	178485	7507	9542	12067414	1.24
2010	140612	7627	14086	9732761	1.05
2011	321100	12568	14971	23548384	1.10
2012	241687	9395	26910	19525169	0.41
2013	198294	9929	23579	15883236	0.92
2014	152869	9877	18182	14965286	2.05
2015	343231	6450	15706	29774953	0.91

2016	225904	10042	24242	16805206	1.35

6.2.2.3 REFERENCE POINTS

Based on Patterson (1992), the F_{MSY} reference point F= 0.526 is proposed.

This value corresponds at F at E=0.4 and has been calculated based on the Mvector weighed by Fvector (mean of the last three years, 2014-2016), age+ excluded.

Fbar is much higher than the proposed F_{MSY}, thus, sardine in GSA 6 is considered overexploited.

6.2.2.4 SHORT TERM FORECAST AND CATCH OPTIONS

Short term forecast was carried out using the routine made available by JRC. The reference point used for the analysis is F=0.52 corresponding to E=0.4. The recruitment from 2017 to 2019 was assumed equal to the geometric mean of the last three years (2014-2016). F(status quo) was assumed equal to the geometric mean of the last three years (2014-2016) and 22 different F scenarios were simulated in order to evaluate the change in SSB and in the catch in the short term (Table 6.2.2.4.1).

Table 6.2.2.4.1. Sardine in GSA 6. Short term forecast for the period 2017-2019, considering different Fbar scenarios, from no fishing (F factor=0) to F factor=2. Catch (2017) = 11663 tons and SSB (2018) = 19561 tons, Recruitment (2017) = 19562 thousands and geometric mean of F in last three years F_{bar} (2017) = 1.36

Rationale	Ffactor	Fbar	Landings 2018	Landings 2019	SSB 2019	Change_SSB 2018-2019(%)	Change_Landings 2016-2018(%)
Zero catch	0	0	0	0	26917	37.63	-100.00
High long term yield (Fmsy)	1	1.360	10541	10811	19908	1.79	4.96
Status quo	0.39	0.526	5161	6743	23135	18.29	-48.60
Different scenario	0.1	0.136	1538	2461	25727	31.54	-84.68
	0.2	0.272	2919	4315	24702	26.30	-70.93
	0.3	0.408	4168	5746	23814	21.76	-58.50
	0.4	0.544	5306	6879	23038	17.79	-47.16
	0.5	0.680	6349	7801	22356	14.31	-36.78
	0.6	0.816	7311	8572	21752	11.22	-27.20
	0.7	0.952	8203	9234	21215	8.47	-18.32
	0.8	1.088	9034	9815	20733	6.01	-10.04
	0.9	1.224	9811	10336	20300	3.79	-2.30
	1.1	1.496	11229	11251	19553	-0.03	11.81

	1.2	1.632	11879	11662	19229	-1.68	18.29
	1.3	1.768	12496	12051	18933	-3.20	24.44
	1.4	1.904	13083	12422	18661	-4.59	30.28
	1.5	2.040	13642	12777	18411	-5.86	35.85
	1.6	2.176	14177	13119	18181	-7.04	41.17
	1.7	2.312	14689	13449	17967	-8.13	46.26
	1.8	2.448	15180	13768	17770	-9.14	51.15
	1.9	2.584	15652	14079	17586	-10.08	55.85
	2	2.720	16106	14381	17415	-10.96	60.38

6.2.2.5 Data Deficiencies

Growth parameters of sardine in GSA 6 should be revised (t_0 values are very negative). The procedure for transforming landings lengths into ages is not known. The availability of this procedure might help in the interpretation of the lengths and ages structures within a given area and among areas. ALK should be available from the acoustic surveys.

6.2.3 SARDINE IN GSA 7

No new information was available to the EWG 17-09 on stock identification and boundaries in relation to that reported by STECF (2016, 2017). The Gulf of Lions may not correspond to a complete stock unit. According to GFCM (2015), large individuals would not move to the adjacent Catalan coast (northern GSA 6).

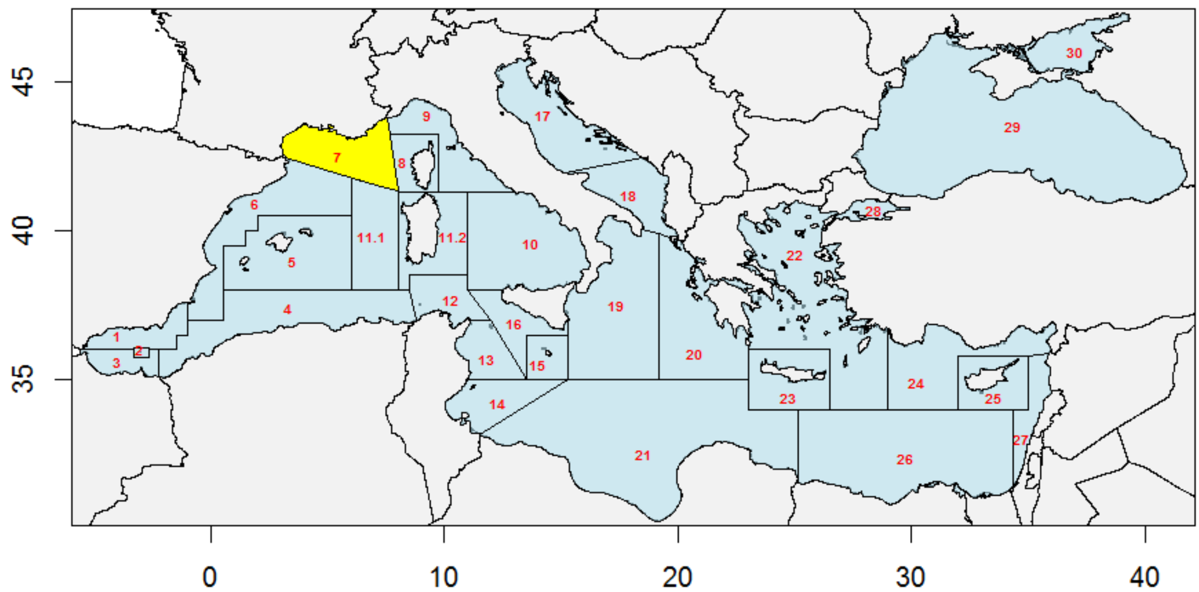


Figure 6.2.3.1 Geographical location of GSA6

6.2.3.1 DATA

Sardine landings come from OTM (Midwater Otter Trawl). In the last years (2012-2016) a small amount is reported for PS (purse seine), and in 2016 a very small amount of landings is reported for a number of small scale fishing. Landings displayed a marked decreasing trend in the last years, against the observed stabilized, although at low level, sardine landings in GSA 6. Older individuals are absent in the landings. France reported very low OTB and OTM sardine discards.

Spain reported 10 t landed in 2016.

It is worth mentioning the different trends displayed by the biomass of sardine in GSA 6 and 7 (Figure 6.2.3.4.1).

6.2.3.1.1 CATCH (LANDINGS AND DISCARDS)

Table 6.2.3.1.1.1 Sardine in GSA 7. Landings by fishing gear over the period 2002-2016 reported by France and Spain (tonnes; FPO- pots and traps; GND- driftnet; GTR- trammel net; OTB- bottom otter trawl; OTB-otter bottom trawl, OTM- midwater otter trawl; OTT- multi-rig otter trawl; SB- beach seine; PS-purse seine).

	GSA 7										SA 7				
	FPO	GND	GTR	LLD	NA	OTB	OTM	OTT	PS	SB	OTB	OTM	OTT	PS	Total
2002												9416.4			9416.4
2003												5095.2			5095.2
2004												7493.4			7493.4
2005												9472.2			9472.2
2006												10381.1			10381.1
2007												13339.6			13339.6
2008												6740.5			6740.5
2009												7240.6			7240.6
2010												1813.7			1813.7
2011												748.4			748.4
2012												46.0		589.4	635.4
2013												406.2		582.8	989.0
2014											14.6	82.5		535.0	632.1
2015											26.0	53.4	0.0	262.8	342.1
2016	5.8	17.8	0.7	2.8	0.9	7.0	77.8	0.8	725.1	7.0					845.6

Table 6.2.3.1.1.2 Sardine in GSA 7. Landings length structure over 2002-2016 (thousands; TL in cm; DCF numbers in 2013 are /1000 in the table).

	2002	2003	2004	2005	2006	2007	2008	2009
0	0	0	0	0	0	0	0	0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	72.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	45.6
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	286.0
9	0.0	0.0	191.6	167.1	0.0	0.0	0.0	754.6
10	351.8	0.0	871.3	354.5	0.0	121.7	2199.4	1563.4
11	1920.3	170.8	2152.8	803.6	0.0	0.0	8775.5	1917.8
12	6189.5	2746.0	6551.4	4691.7	881.5	839.5	4058.9	20320.1
13	8402.0	10875.3	15614.3	21158.5	5348.0	1966.9	5040.0	35876.9
14	34251.9	46758.8	81588.6	68371.4	18965.5	10491.8	10426.8	44457.4
15	91823.7	58718.8	92433.4	110237.0	84965.4	81996.3	49492.1	71133.1
16	91026.6	45852.6	43096.4	66555.4	114601.5	137946.4	83803.4	73919.1
17	41941.8	15444.1	14392.1	18209.3	44088.8	105699.9	48022.1	38338.1
18	9140.2	3359.8	3316.7	2552.6	10123.8	33010.4	12055.0	7677.9
19	1491.4	503.3	537.0	586.8	971.2	4817.2	2531.0	873.8
20	0.0	0.0	0.0	79.7	260.4	639.5	78.6	255.6
21	0.0	0.0	0.0	0.0	0.0	172.1	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	2010	2011	2012	2013	2014	2015	2016
0	0	0	0	0	0	0	0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	1.1	0.0	0.0	0.0	0.0
8	0.0	0.0	225.7	0.0	0.0	0.0	0.0
9	0.0	0.0	376.1	0.0	0.0	0.0	0.0
10	1266.5	58.1	376.1	58.1	0.0	149.7	115.2
11	4190.4	1369.9	835.5	1369.9	517.9	700.1	0.0
12	18312.2	6747.4	3345.1	6747.4	11108.8	1964.9	12268.7
13	31038.0	12181.5	15163.0	12181.5	14040.3	3378.2	0.0
14	19675.2	7879.4	10844.8	7879.4	4828.3	695.9	7083.1
15	10926.7	1893.4	1235.3	1893.4	1205.6	60.0	0.0
16	4266.5	262.2	525.8	262.2	248.9	15.9	284.2
17	1313.4	0.0	59.7	0.0	0.0	6.6	0.0
18	59.9	0.0	4.7	0.0	0.0	0.0	0.0
19	0.0	0.0	3.7	0.0	0.0	2.7	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	1.1	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 6.2.3.1.1.3 Sardine in GSA 7. Landings age structure over 2002-2016 (thousands).

	2002	2003	2004	2005	2006	2007	2008	2009
0	0.0	0.0	0.0	0.0	0.0	1302.0	15486.3	2003.9
1	27264.5	29242.0	0.0	0.0	56115.8	136074.7	12893.0	28288.5
2	122723.7	86332.1	0.0	0.0	149082.3	145646.8	98716.3	84280.2
3	112685.1	58826.9	0.0	0.0	50604.2	45261.4	60804.1	112909.2
4	12578.1	5232.5	0.0	0.0	21836.9	39529.0	27506.1	63329.7
5	2328.0	706.9	0.0	0.0	1931.0	8559.1	4652.5	6655.9
6	0.0	669.0	0.0	0.0	177.8	878.1	6128.5	0.0
7	0.0	0.0	0.0	0.0	413.4	328.9	188.7	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	107.4	0.0
	2010	2011	2012	2013	2014	2015	2016	
0	51.4	0.0	646.2	1692.0	435.8	199.4	64.6	
1	11965.0	0.0	5725.0	17377.8	10607.8	9624.6	7772.8	
2	48168.5	0.0	15487.1	21328.4	20139.5	9798.9	7783.7	
3	27915.4	0.0	10160.1	12584.4	5772.8	835.2	4193.4	
4	2948.2	0.0	967.9	577.6	410.4	11.6	172.6	
5	0.0	0.0	32.5	0.0	9.6	0.0	0.0	
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

Table 6.2.3.1.1.4 Sardine in GSA 7. Discards by fishing gear (tonnes).

year	OTB	OTM
2003	10.91	
2005	4.39	
2006	2.67	
2007	4.56	0.15
2008	1.84	0.6
2014	56	320
2015	0	0

Table 6.2.3.1.1.5. Sardine in GSA 7. Discards length structure over 2002-2016 (thousands; TL in cm).

PIL discards GSA 7					
	2005	2006	2007	2008	2014
0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.3
7	0.0	0.0	0.0	0.5	0.7
8	0.0	0.0	0.1	2.0	8.7
9	0.0	0.0	0.7	4.8	73.2
10	0.1	0.0	0.1	10.7	188.1
11	3.4	5.7	0.2	16.7	303.6
12	49.8	14.1	0.0	9.0	179.7
13	82.6	14.1	0.1	4.1	82.0
14	63.5	18.8	7.4	7.5	35.0
15	14.7	24.4	58.4	33.8	2.7
16	9.0	24.5	54.6	20.1	3.8
17	2.4	9.9	20.0	3.8	0.1
18	1.1	2.8	8.4	2.3	0.0
19	0.0	0.0	0.8	0.2	0.1
20	0.0	0.0	0.7	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0

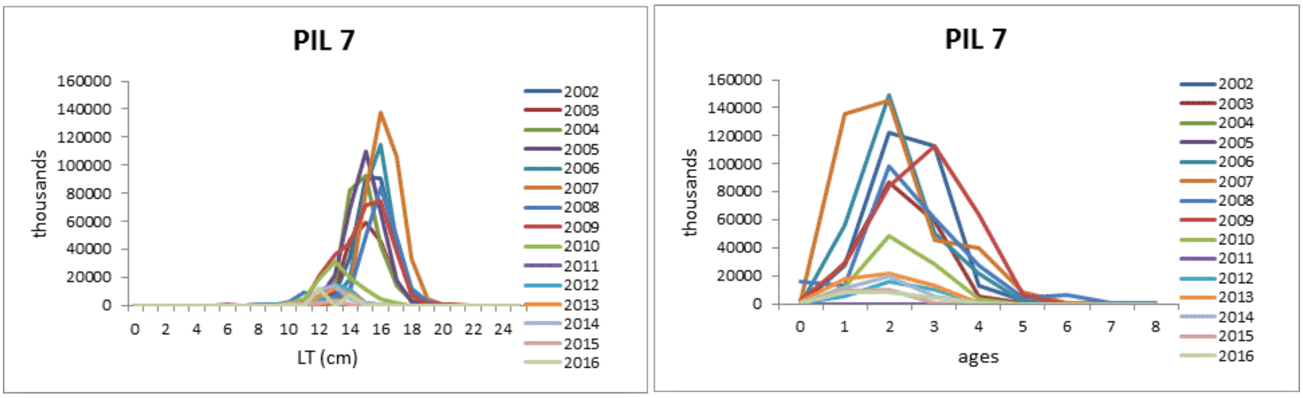


Figure 6.2.3.1.1.1 Sardine in GSA 7. Length structure (left) and age structure of landings as reported by France (thousands).

6.2.3.1.2 Effort

Table 6.2.3.1.2.1 Sardine in GSA7. Fishing effort in GSA 7, expressed in gt_days_at_sea and fishing days.

	gt_days_at_sea		days	
	OTM 7	PS 7	OTM 7	PS 7
2004		33436		755
2005		23559		515
2006		10879		247
2007		13247		293
2008		8174		184
2009		4069		94
2010		109		4
2011		7457		167
2012		652		15
2013		3418		52
2014				
2015	55063	105818	372	876
2016	64827	200366	456	1476

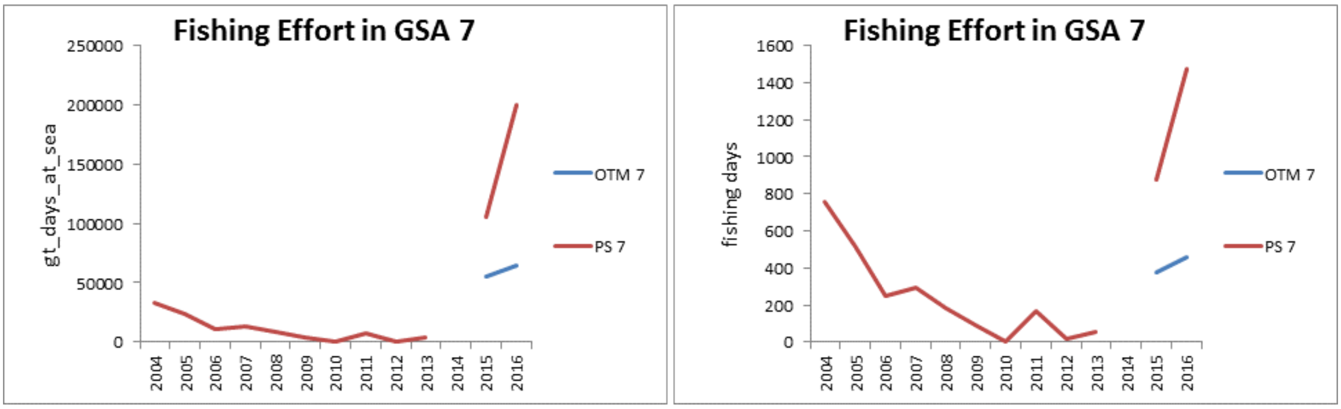


Figure 6.2.3.1.2.1 Sardine in GSA7 Fishing effort in GSA 7 expressed as gt_days_at_sea (left) and fishing days (right; OTB-midwater trawl; PS-purse seine).

6.2.3.1.3 Survey data

Table 6.2.3.1.3.1 Sardine in GSA 7. Abundance index/year /size structure from the acoustic surveys PELMED, conducted in summer, over the period 2002-2016 (thousands; TL in cm).

	2002	2003	2004	2005	2006	2007	2008	2009
0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	2440	0	0	0	0	0
6	6334	0	39038	0	0	0	0	0
7	64696	6801	130623	0	0	0	6171	0
8	396392	133900	1079312	193993	0	0	277650	1589277
9	547851	770490	2488184	1746034	1911	0	2668251	3100078
10	579216	1028834	1136132	1540565	6203	0	3749864	972702
11	320488	416162	38363	470468	20115	344	1350806	583564
12	75917	149154	147585	375886	33229	3008	202780	805378
13	178792	736227	1075895	1229300	29761	0	31977	224881
14	841156	1375512	1959388	1736783	408524	25377	165726	83201
15	879920	1193861	1755828	2022955	1310015	593202	469454	41013
16	1166186	641353	1267866	2174909	874013	968976	392127	36387
17	624990	299843	462160	759362	448954	684424	225892	90805
18	138779	79559	129669	138145	99323	268260	63584	30714
19	8840	0	0	57243	15659	60535	17807	1805
20	0	0	0	0	3898	10583	892	0
21	0	0	0	0	0	0	265	0
22	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0

	2010	2011	2012	2013	2014	2015	2016
0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0
6	0	0	352	0	0	0	0
7	116472	127897	30327	0	0	58083	41896
8	934920	182305	454969	330515	42166	623088	922134
9	3356134	1324413	2518439	1508309	239286	1385116	2877988
10	2227156	1764843	2924410	1331572	834368	1235901	910040
11	728508	1262712	1158300	3279511	2246835	1640894	1979202
12	200100	563430	1293123	1166728	1570177	1690864	1093795
13	334628	326363	823667	238294	498119	383542	249123
14	115514	57125	153697	61873	151956	61666	44121
15	11772	20482	7137	11060	25397	17322	3376
16	37301	6733	4263	0	3657	1706	0
17	0	0	2153	0	219	0	0
18	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0

Table 6.2.3.1.3.2 Sardine in GSA 7. Abundance index/year /age structure from the acoustic surveys PELMED, conducted in summer, over the period 2002-2016 (thousands; TL in cm).

	PIL	GSA7Abundance by age							
	PELMED	PELMED	PELMED	PELMED	PELMED	PELMED	PELMED	PELMED	PELMED
	age0	age1	age2	age3	age4	age5	age6	age7	age8
2002	1726404	747643	1442140	1377960	476855	40157	18399		
2003	2072138	1474195	1924056	1081247	254409	20394	5257		
2004	4710993	1860159	2888642	1783425	426824	32047	10392		
2005	3623461	2205948	3327392	2505464	662167	46141	75071		
2006	7384	1020112	1448706	469795	236912	38617	24144	5685	253
2007	668	408978	1243266	534177	294801	80253	40336	11254	976
2008	51233	8598572	611527	212609	110795	22421	12351	3450	287
2009	5634548	1164592	506492	176371	72123	5679			
2010	6372136	1154358	387434	137918	10657				
2011	3480503	1554512	485826	113538	1924				
2012	6156984	1885196	1197001	126659	4995				
2013	3276392	3983763	563934	96276	7496				
2014	311251	2543110	2420066	286921	50833				
2015	2910131	2570671	1351265	254718	11399				
2016	4266350	2443894	1149346	260424	1660				

Table 6.2.3.1.3.3 Sardine in GSA 7. Biomass index/year /age structure from the acoustic surveys PELMED, conducted in summer, over the period 2002-2016 (thousands; TL in cm).

	PIL PELMED age0	GSA7 Biomass by age PELMED age1	PELMED age2	PELMED age3	PELMED age4	PELMED age5	PELMED age6	PELMED age7	PELMED age8
2002	10677	12466	37635	43569	17794	1627	781	0	0
2003	15624	24769	44927	30837	9008	793	162	0	0
2004	25982	35370	76028	58758	17572	1481	368	0	0
2005	22542	36983	87885	83575	26719	2094	4226	0	0
2006	100	26681	46837	16909	8691	1793	988	263	15
2007	9	11977	41037	19150	10531	3424	1627	492	51
2008	549	62567	16933	6579	3470	869	428	137	14
2009	28020	11274	6939	4116	2419	210	0	0	0
2010	33745	9674	5641	2468	292	0	0	0	0
2011	21225	14793	6869	1980	59	0	0	0	0
2012	36605	22745	18828	2242	172	0	0	0	0
2013	23851	44831	8360	1977	163	0	0	0	0
2014	1695	23630	31010	5048	1075	0	0	0	0
2015	18271	27199	17673	3769	229	0	0	0	0
2016	24891	26789	14945	3723	39	0	0	0	0

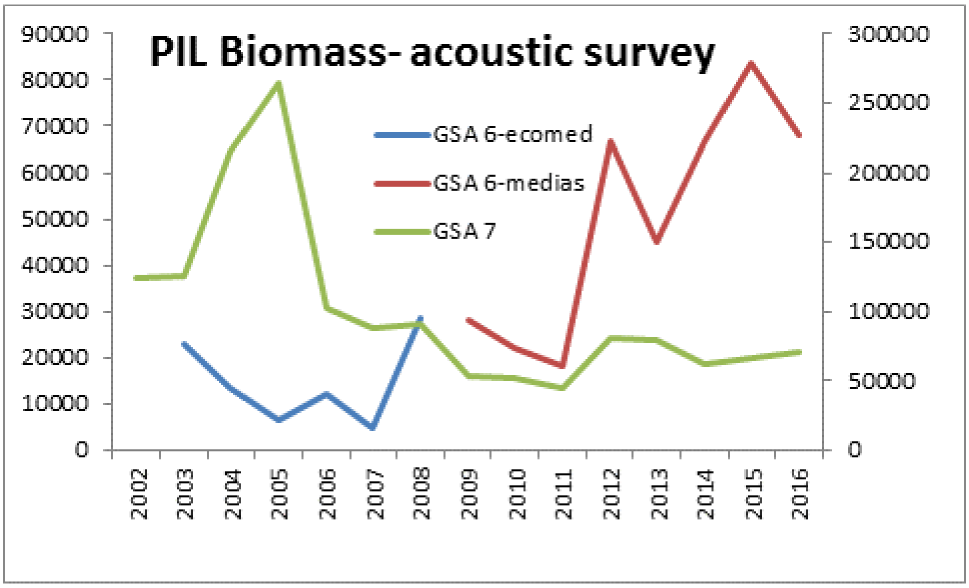


Figure 6.2.3.1.3.1 Sardine in GSA7. Sardine biomass (t) in GSAs 6 (left axis) and 7 (right axis). Sardine biomass displayed an increasing trend since 2011 in GSA 6, trend that was not observed in GSA 7, where biomass has fluctuated around 60000 t in the last years.

6.2.3.2 Stock assessment

Several different runs were performed with the biomass model SPiCT (see below), but diagnostics indicated that the performance of the model was not acceptable and the assessment could not be accepted.

The data series of demographic structure of sardine is GSA 7 has discontinuities. As regards age structure, no information is available for 2004, 2005 and 2011 the age structured analysis could not be carried out.

The stock of sardine in GSA 7 was assessed with the biomass index proposed by ICES (2012) for data limited stocks.

Biomass index

Biomass Index refers to the ICES data limited approach using a stock status indicator (ICES 2012). In the last years sardine biomass has been fluctuating around 60000 tonnes. The change in biomass over the last five years was used to provide an index for change (0.93). Following the ICES approach, because this index is less than 1.2 and more than 0.8, the index value is used to multiply the catch (mean catch over 2014-2016). Because the exploitation rate is thought to be above MSY (see length analysis below and Figure 6.2.3.3.3) and the state of the stock relative to B_{msy} is unknown a precautionary buffer (catch multiplier of 0.8) is applied giving a factor of 0.744. Mean catch for the last three years is 608.2 tonnes. The catch advice which is applicable for two years is 452.5 t.

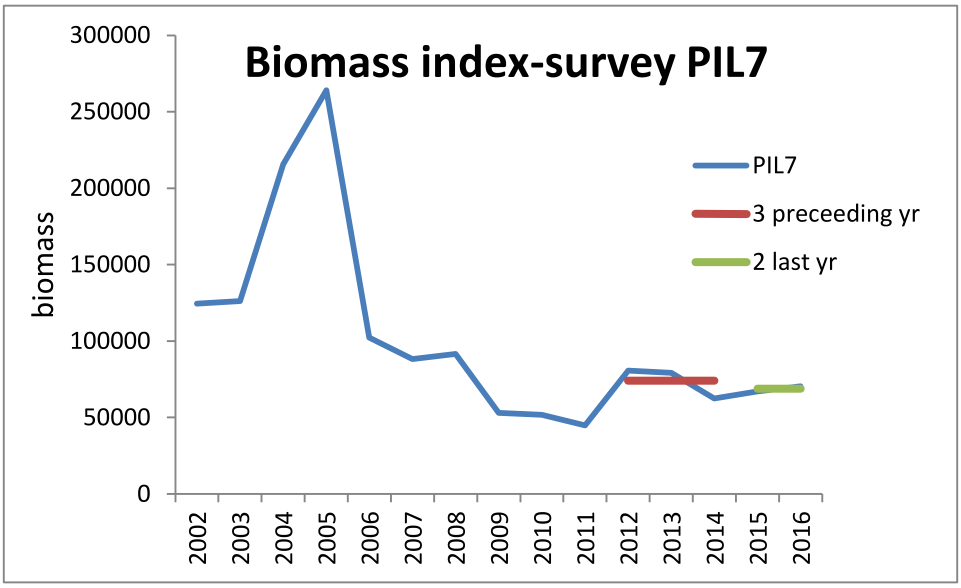


Figure 6.2.3.2.1. Sardine in GSA 7. Biomass index estimated by direct acoustic method from PELMED survey. In green the mean of the last two years compared to the previous three years (red).

Method: SPiCT

Several runs with the SPiCT model where conducted for sardine in GSA 7.

<u>Input data run #1</u>

Landings

- Landings time series for the time period 2002 to 2016 from the DCF 2017 data call

Index

- Acoustic index for the period 2002 to 2016 (DCF)

<u>Input data run #2</u>

Landings

- Landings time series for the time period 2002 to 2016 from the DCF 2017 data call

Index

- Acoustic index for the period 1993 to 2016 (PELMED)

Input data run #3

Landings

- Landings time series for the time period 1950 to 2016 from (FAO database Global Capture Production (http://www.fao.org/fishery/statistics/global-capture-production/query/en) and DCF

Index

- Acoustic index for the period 2002 to 2016 (DCF)

Input data run for several runs

Landings

Landings time series starting for the time period 1865 to 2015 from IFREMER (an additional source of data is the reconstructed time series of landings of sardine in GSA 7 performed by IFREMER and kindly provided by C. Saraux.) and for 2016 from the DCF 2017 data call

Index

- An incremental approach was taken with the index in this case to examine which years are the ones causing the non-convergence. In each run a year was added progressively obtaining the results until the first year of the index was reached (1993) (Table 6.2.3.5.1)

Results

The SPiCT model did converge in several cases but the diagnostics indicated that the performance of the model was not acceptable. The results were highly pessimistic (the stock was assessed as depleted) and were not in line with the GFCM (2015) assessment for this stock, nor with the biomass estimated with the acoustic surveys. That assessment concluded that this stock is unbalanced, its poor condition related to external factors (environment) rather than the fisheries pressure. The problem seems to be in the early index years. The model could not be accepted for advice.

Table 6.2.3.2.1 Sardine in GSA7. Input data for several runs for the incremental approach with the SPiCT model for sardine in GSA 7.

Year	Landings	PIL_MED	PIL_1	PIL_2	PIL_3	PIL_4	PIL_5	PIL_6	PIL_7	PIL_8
1865	765.8232	NA	NA	NA	NA	NA	NA	NA	NA	NA
1866	831.9122	NA	NA	NA	NA	NA	NA	NA	NA	NA
1867	809.4722	NA	NA	NA	NA	NA	NA	NA	NA	NA
1868	1534.977	NA	NA	NA	NA	NA	NA	NA	NA	NA
1869	1166.841	NA	NA	NA	NA	NA	NA	NA	NA	NA
1870	1217.694	NA	NA	NA	NA	NA	NA	NA	NA	NA
1871	1627.803	NA	NA	NA	NA	NA	NA	NA	NA	NA
1872	1173.244	NA	NA	NA	NA	NA	NA	NA	NA	NA
1873	1573.99	NA	NA	NA	NA	NA	NA	NA	NA	NA
1874	1552.684	NA	NA	NA	NA	NA	NA	NA	NA	NA
1875	2778.734	NA	NA	NA	NA	NA	NA	NA	NA	NA
1876	2449.554	NA	NA	NA	NA	NA	NA	NA	NA	NA
1877	1892.868	NA	NA	NA	NA	NA	NA	NA	NA	NA
1878	2227.21	NA	NA	NA	NA	NA	NA	NA	NA	NA
1879	3072.938	NA	NA	NA	NA	NA	NA	NA	NA	NA
1880	3183.698	NA	NA	NA	NA	NA	NA	NA	NA	NA
1881	1934.714	NA	NA	NA	NA	NA	NA	NA	NA	NA
1882	980.152	NA	NA	NA	NA	NA	NA	NA	NA	NA
1883	1834.541	NA	NA	NA	NA	NA	NA	NA	NA	NA
1884	1233.083	NA	NA	NA	NA	NA	NA	NA	NA	NA
1885	1618.457	NA	NA	NA	NA	NA	NA	NA	NA	NA
1886	1392.798	NA	NA	NA	NA	NA	NA	NA	NA	NA
1887	1739.266	NA	NA	NA	NA	NA	NA	NA	NA	NA
1888	1771.278	NA	NA	NA	NA	NA	NA	NA	NA	NA
1889	2058.657	NA	NA	NA	NA	NA	NA	NA	NA	NA
1890	2201.74	NA	NA	NA	NA	NA	NA	NA	NA	NA
1891	1203.913	NA	NA	NA	NA	NA	NA	NA	NA	NA
1892	1383.146	NA	NA	NA	NA	NA	NA	NA	NA	NA
1893	932.2231	NA	NA	NA	NA	NA	NA	NA	NA	NA
1894	1029.801	NA	NA	NA	NA	NA	NA	NA	NA	NA
1895	1029.744	NA	NA	NA	NA	NA	NA	NA	NA	NA
1896	2214.375	NA	NA	NA	NA	NA	NA	NA	NA	NA
1897	1519.052	NA	NA	NA	NA	NA	NA	NA	NA	NA
1898	1474.052	NA	NA	NA	NA	NA	NA	NA	NA	NA
1899	1429.113	NA	NA	NA	NA	NA	NA	NA	NA	NA

1900	909.505	NA	NA	NA	NA	NA	NA	NA	NA	NA
1901	1507.308	NA	NA	NA	NA	NA	NA	NA	NA	NA
1902	936.247	NA	NA	NA	NA	NA	NA	NA	NA	NA
1903	1024.37	NA	NA	NA	NA	NA	NA	NA	NA	NA
1904	1091.649	NA	NA	NA	NA	NA	NA	NA	NA	NA
1905	1198.201	NA	NA	NA	NA	NA	NA	NA	NA	NA
1906	1357.841	NA	NA	NA	NA	NA	NA	NA	NA	NA
1907	1907.801	NA	NA	NA	NA	NA	NA	NA	NA	NA
1908	2104.082	NA	NA	NA	NA	NA	NA	NA	NA	NA
1909	1807.332	NA	NA	NA	NA	NA	NA	NA	NA	NA
1910	1819.401	NA	NA	NA	NA	NA	NA	NA	NA	NA
1911	984	NA	NA	NA	NA	NA	NA	NA	NA	NA
1912	848.79	NA	NA	NA	NA	NA	NA	NA	NA	NA
1913	484.029	NA	NA	NA	NA	NA	NA	NA	NA	NA
1914	967.012	NA	NA	NA	NA	NA	NA	NA	NA	NA
1915	998.777	NA	NA	NA	NA	NA	NA	NA	NA	NA
1916	1262.669	NA	NA	NA	NA	NA	NA	NA	NA	NA
1917	1559.38	NA	NA	NA	NA	NA	NA	NA	NA	NA
1918	1584.697	NA	NA	NA	NA	NA	NA	NA	NA	NA
1919	985.522	NA	NA	NA	NA	NA	NA	NA	NA	NA
1920	1630.063	NA	NA	NA	NA	NA	NA	NA	NA	NA
1921	1124.075	NA	NA	NA	NA	NA	NA	NA	NA	NA
1922	1224.275	NA	NA	NA	NA	NA	NA	NA	NA	NA
1923	1713.035	NA	NA	NA	NA	NA	NA	NA	NA	NA
1924	1794.941	NA	NA	NA	NA	NA	NA	NA	NA	NA
1925	1889.964	NA	NA	NA	NA	NA	NA	NA	NA	NA
1926	2272.977	NA	NA	NA	NA	NA	NA	NA	NA	NA
1927	2523.708	NA	NA	NA	NA	NA	NA	NA	NA	NA
1928	1943.585	NA	NA	NA	NA	NA	NA	NA	NA	NA
1929	2856.493	NA	NA	NA	NA	NA	NA	NA	NA	NA
1930	2607.196	NA	NA	NA	NA	NA	NA	NA	NA	NA
1931	2190.027	NA	NA	NA	NA	NA	NA	NA	NA	NA
1932	2316.637	NA	NA	NA	NA	NA	NA	NA	NA	NA
1933	1751.898	NA	NA	NA	NA	NA	NA	NA	NA	NA
1934	1789.035	NA	NA	NA	NA	NA	NA	NA	NA	NA
1935	1035.877	NA	NA	NA	NA	NA	NA	NA	NA	NA

1936	1152.915	NA	NA	NA	NA	NA	NA	NA	NA	NA
1937	1227.614	NA	NA	NA	NA	NA	NA	NA	NA	NA
1938	490.942	NA	NA	NA	NA	NA	NA	NA	NA	NA
1939	490.942	NA	NA	NA	NA	NA	NA	NA	NA	NA
1940	490.942	NA	NA	NA	NA	NA	NA	NA	NA	NA
1941	490.942	NA	NA	NA	NA	NA	NA	NA	NA	NA
1942	490.942	NA	NA	NA	NA	NA	NA	NA	NA	NA
1943	490.942	NA	NA	NA	NA	NA	NA	NA	NA	NA
1944	490.942	NA	NA	NA	NA	NA	NA	NA	NA	NA
1945	1881.76	NA	NA	NA	NA	NA	NA	NA	NA	NA
1946	2099.616	NA	NA	NA	NA	NA	NA	NA	NA	NA
1947	1018.045	NA	NA	NA	NA	NA	NA	NA	NA	NA
1948	1827.829	NA	NA	NA	NA	NA	NA	NA	NA	NA
1949	1756.646	NA	NA	NA	NA	NA	NA	NA	NA	NA
1950	1641.383	NA	NA	NA	NA	NA	NA	NA	NA	NA
1951	2103.063	NA	NA	NA	NA	NA	NA	NA	NA	NA
1952	2301.836	NA	NA	NA	NA	NA	NA	NA	NA	NA
1953	1888.431	NA	NA	NA	NA	NA	NA	NA	NA	NA
1954	2436.831	NA	NA	NA	NA	NA	NA	NA	NA	NA
1955	2352.964	NA	NA	NA	NA	NA	NA	NA	NA	NA
1956	2498	NA	NA	NA	NA	NA	NA	NA	NA	NA
1957	3361	NA	NA	NA	NA	NA	NA	NA	NA	NA
1958	3050	NA	NA	NA	NA	NA	NA	NA	NA	NA
1959	1388	NA	NA	NA	NA	NA	NA	NA	NA	NA
1960	2890	NA	NA	NA	NA	NA	NA	NA	NA	NA
1961	5887	NA	NA	NA	NA	NA	NA	NA	NA	NA
1962	3974	NA	NA	NA	NA	NA	NA	NA	NA	NA
1963	7891	NA	NA	NA	NA	NA	NA	NA	NA	NA
1964	7535	NA	NA	NA	NA	NA	NA	NA	NA	NA
1965	5978	NA	NA	NA	NA	NA	NA	NA	NA	NA
1966	13182	NA	NA	NA	NA	NA	NA	NA	NA	NA
1967	13699	NA	NA	NA	NA	NA	NA	NA	NA	NA
1968	9641	NA	NA	NA	NA	NA	NA	NA	NA	NA
1969	13024	NA	NA	NA	NA	NA	NA	NA	NA	NA
1970	16574	NA	NA	NA	NA	NA	NA	NA	NA	NA
1971	12295.74	NA	NA	NA	NA	NA	NA	NA	NA	NA

1972	11158.17	NA	NA	NA	NA	NA	NA	NA	NA	NA
1973	9251.802	NA	NA	NA	NA	NA	NA	NA	NA	NA
1974	6767.18	NA	NA	NA	NA	NA	NA	NA	NA	NA
1975	9806.338	NA	NA	NA	NA	NA	NA	NA	NA	NA
1976	6961.194	NA	NA	NA	NA	NA	NA	NA	NA	NA
1977	7982.834	NA	NA	NA	NA	NA	NA	NA	NA	NA
1978	7690.081	NA	NA	NA	NA	NA	NA	NA	NA	NA
1979	5589.153	NA	NA	NA	NA	NA	NA	NA	NA	NA
1980	9121.313	NA	NA	NA	NA	NA	NA	NA	NA	NA
1981	11609.92	NA	NA	NA	NA	NA	NA	NA	NA	NA
1982	16056.9	NA	NA	NA	NA	NA	NA	NA	NA	NA
1983	12030.86	NA	NA	NA	NA	NA	NA	NA	NA	NA
1984	10519.63	NA	NA	NA	NA	NA	NA	NA	NA	NA
1985	15169.18	NA	NA	NA	NA	NA	NA	NA	NA	NA
1986	14448.05	NA	NA	NA	NA	NA	NA	NA	NA	NA
1987	16603.19	NA	NA	NA	NA	NA	NA	NA	NA	NA
1988	17968.07	NA	NA	NA	NA	NA	NA	NA	NA	NA
1989	10028.01	NA	NA	NA	NA	NA	NA	NA	NA	NA
1990	10501.14	NA	NA	NA	NA	NA	NA	NA	NA	NA
1991	11855.42	NA	NA	NA	NA	NA	NA	NA	NA	NA
1992	11798.59	NA	NA	NA	NA	NA	NA	NA	NA	NA
1993	12036.23	125529	NA	NA	NA	NA	NA	NA	NA	NA
1994	10796.95	NA	NA	NA	NA	NA	NA	NA	NA	NA
1995	10123.4	83343	NA	NA	NA	NA	NA	NA	NA	83343
1996	9228.198	51536	NA	NA	NA	NA	NA	NA	51536	51536
1997	8875.979	26054	NA	NA	NA	NA	NA	26054	26054	26054
1998	8141.586	52206	NA	NA	NA	NA	52206	52206	52206	52206
1999	8321.713	76371	NA	NA	NA	76371	76371	76371	76371	76371
2000	11752.91	64819	NA	NA	64819	64819	64819	64819	64819	64819
2001	11437	70547	NA	70547	70547	70547	70547	70547	70547	70547
2002	7895.447	124549	124549	124549	124549	124549	124549	124549	124549	124549
2003	7287.143	126120	126120	126120	126120	126120	126120	126120	126120	126120
2004	7772.993	215560	215560	215560	215560	215560	215560	215560	215560	215560
2005	10031.03	264024	264024	264024	264024	264024	264024	264024	264024	264024
2006	12620.11	102276	102276	102276	102276	102276	102276	102276	102276	102276
2007	14378.95	88297	88297	88297	88297	88297	88297	88297	88297	88297

2008	7300.832	91546	91546	91546	91546	91546	91546	91546	91546	91546
2009	3712.876	52977	52977	52977	52977	52977	52977	52977	52977	52977
2010	746.0435	51819	51819	51819	51819	51819	51819	51819	51819	51819
2011	756.4221	44926	44926	44926	44926	44926	44926	44926	44926	44926
2012	680.6887	80537	80537	80537	80537	80537	80537	80537	80537	80537
2013	567.2034	79181	79181	79181	79181	79181	79181	79181	79181	79181
2014	633	62458	62458	62458	62458	62458	62458	62458	62458	62458
2015	346	67140	67140	67140	67140	67140	67140	67140	67140	67140
2016	845.63	70387	70387	70387	70387	70387	70387	70387	70387	70387

Length Indicator Analysis

The length indicator analysis (See details in annex 1 to this report) was carried out for most stocks including sardine in GSA 7 the results by year are given in Figure 6.2.3.2.2 and summarised over years in Figure 6.2.3.2.3. The exploitation rate indicator L_{fem}/L_{mean} is seen to be below 1.0 in the last three years, so the indicator suggests the stock is over exploited.

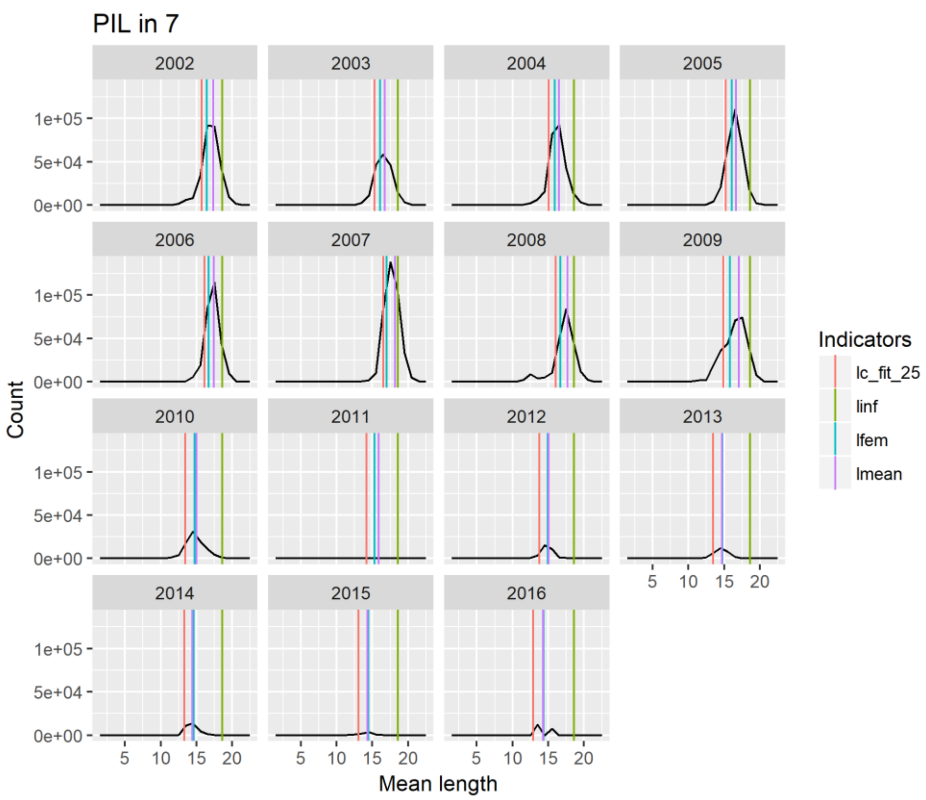


Figure 6.2.3.2.2, Results of year by year length indicator analysis showing distribution of length in the catch, and the L_{fem} and L_{mean} that are used to evaluate exploitation relative to MSY.

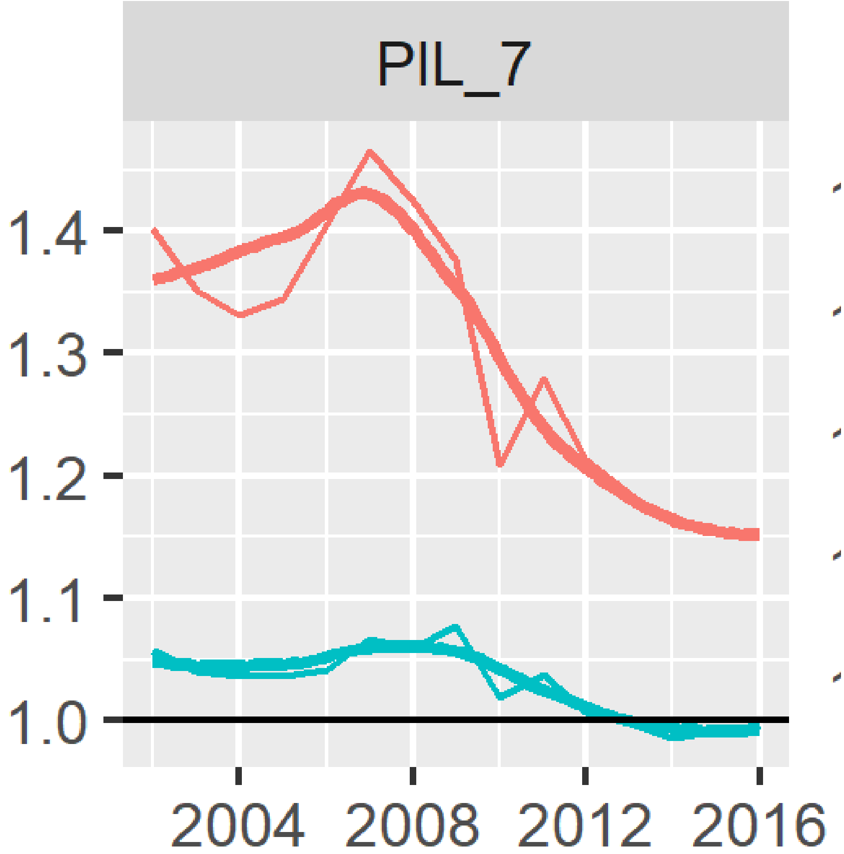


Figure 6.2.3.2.3, Summary of length indicator analysis showing distribution of length in the catch, and the L_{fem} and L_{mean} that are used to evaluate exploitation relative to MSY.

6.2.3.3 Reference Points

No reference points were estimated.

6.2.3.4 Short term Forecast and Catch Options

No short term predictions were performed.

Based on the biomass index, the catch advice which is applicable for two years is 1343 t.

6.2.3.5 Data Deficiencies

The use of two different codes for the same area, GSA 7 and SA 7 should be avoided. This issue can lead to an incomplete selection of data from the Gulf of Lions.

OTM fishing effort, the main fishing gear targeting small pelagics in the area, is reported for 2015-2016.

As indicated in previous reports, the growth parameters should be revised (t_0 values are very negative). The procedure for transforming landings lengths into ages is not known. The availability of this procedure might help in the interpretation of the lengths and ages structures within a given area and among areas. ALK should be available from the acoustic surveys.

GSA 7- PIL landings 2016 – check unit used in 2016
GSA 7- PIL no length data in 2011
GSA 7- PIL no age data in 2004, 2005, 2011
GSA 7- check reported OTB discards in 2014 (376 t) should be checked.
GSA 7- PIL numbers in the size structure in 2013 should be checked.

6.3 ATLANTIC HORSE MACKEREL IN GSAs 1, 6, 5 & 7

According to the main outcomes of the EU StockMed project carried out in MAREA framework, HOM in the GSAs 1, 5, 6, 7 belongs to a single stock unit. STECF EWG 17-13 was asked to assess the state of Atlantic horse mackerel in the whole area.

The area, (GSAs 1, 5, 6 & 7), include data from 2 countries (ESP; FRA). It covers a surface of about 71775 km2 in the depth range between 10-800 m (Figure 6.3.1).

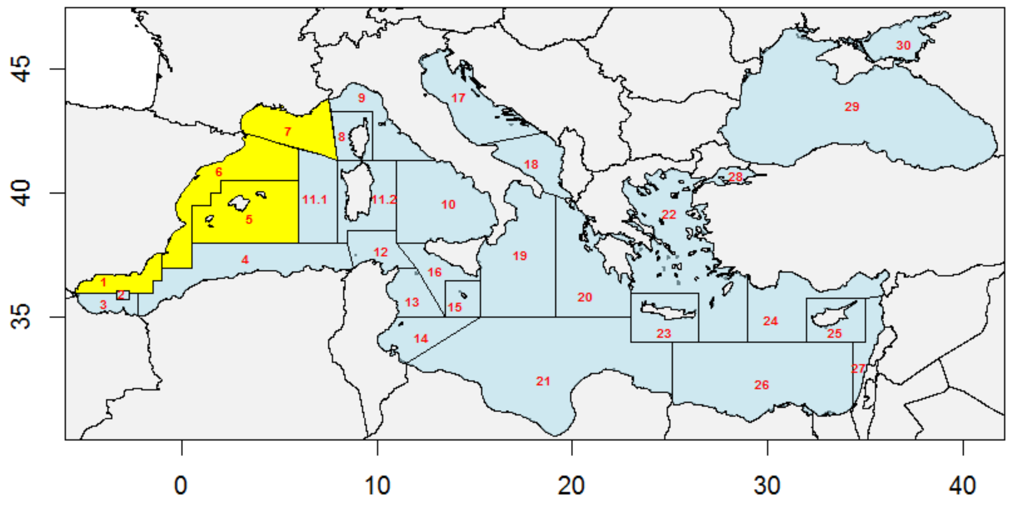


Figure 6.3.1 Geographical location of GSAs 1, 5, 6 and 7

Of the three species of horse mackerel living in Mediterranean (*T. trachurus*, *T. mediterraneaus* and *T. picturatus*), *Trachurus trachurus* can be distinguish by the accessory lateral line along the whole back which is provided with very large bone scutes. However sometimes, particularly in juveniles, the identification of the species is not easy.

It is a gregarious bentho-pelagic species whit a broad geographical distribution which cover the whole Mediterranean, Black Sea included (Bini, 1968; Relini and Lanteri, 2010), the Atlantic Ocean from Iceland to Senegal and the Canary Islands, Madeira and Cape Verde (Abaunza et al., 2008), and the western coasts of the Pacific Ocean (Karaiskou et al., 2003).

Adults of *T. trachurus* form large shoals in deep waters and medium-deep waters and is frequently found at a depth between 10 and 500 m. Juveniles swim in small shoals, under floating objects or megaplancton (such as Rhizostoma pulmo or Cotylorhiza tubercolata), and tend to concentrate within 100-150 m depth (Nannini et al., 1997; Matarrese et al., 1998).

The Horse Mackerel species can reach a maximum size of 60 cm TL, although in the Mediterranean Sea, specimens caught with trawl or seine do not exceed 30 cm TL, while those caught with bottom longline can reach up to 50 cm TL (Relini et al., 1999).

As concern feeding HOM change feeding habits with age, shifting from zooplanktivorous (feeds mainly on planktonic crustaceans) to ichthyophagous (youth stages of other fishes, and also adult stages of anchovies and sardine) with rising age (ICES 2013 southern horse mackerel stock annex).

6.3.1 DATA

6.3.1.1 CATCH (LANDINGS AND DISCARDS)

The following data sources were evaluated, DCF data call for biological/fisheries data 2016 and 2017. The most recent DCF Economic transversal data and the FAO on line database.

Landings

The DCF 2016 and 2017 databases were consistent, with additional landing and discard data added for 2016 in the most recent database. Landings data were available for 2002 to 2016 for Spain for GSAs 1 and 6 with small landings reported for GSA 5 and 7 (Figure 6.3.1). France reported only data on horse mackerel for 2016 for GSA 7, no other years were reported. The FAO database showed negligible landings of horse mackerel by France from 2017 onwards, and significant but different landings from Spain for the period 2002 to 2016. However, both Spain and France reported landings of horse mackerel from 2011 to 2015 in the annual economic report and the data was obtained for years 2011 to 2015 (Figure 6.3.2). These data for Spain are of a similar magnitude to the biological reported data but do not correspond exactly. The data from France indicates that France lands around 20% of the landings during 2011 to 2015, but these data are not reported in the biological data received from the data call. Given the uncertainty in the reported landings by different sources of landings data it is not considered acceptable to use the ratio of French and Spanish catches in the Economic data to obtain a time series for the biological data.

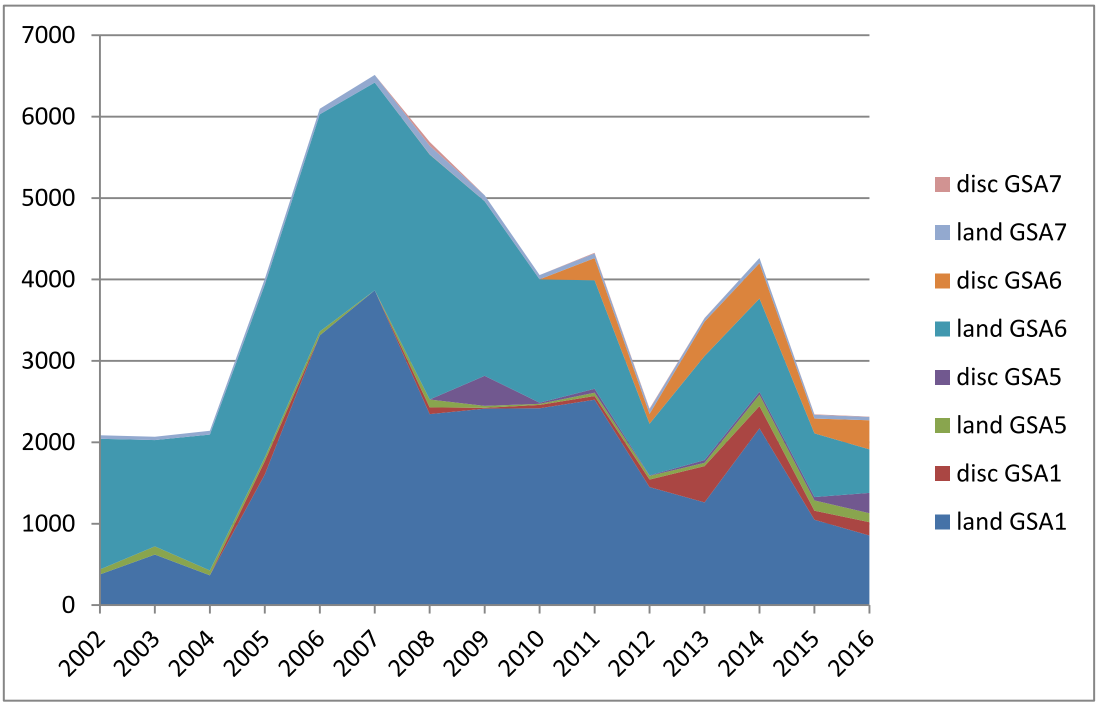


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Figure 6.3.1.1.1 Atlantic horse mackerel in GSAs 1, 5, 6 & 7. Landings and discards (tonnes) by GSA by Spain from 2002 to 2016 reported in the 2017 DCF data call for biological data

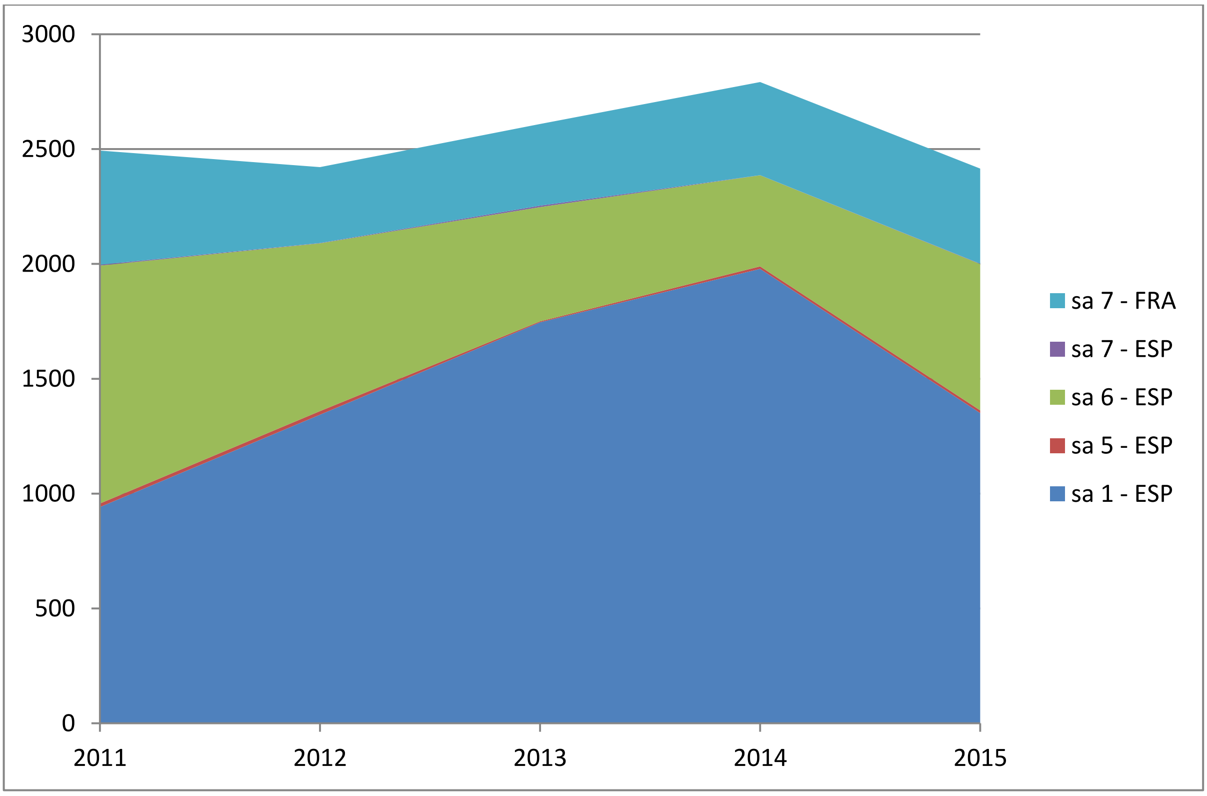


Figure 6.3.1.1.2 Atlantic horse mackerel in GSAs 1, 5, 6 & 7. Landings and discards (tonnes) by GSA by France and Spain from 2011 to 2015 reported in the annual economic report.

Landing at length are available from Spain by GSA (Figure 6.3.1.1.3), no landings at length is available from France.

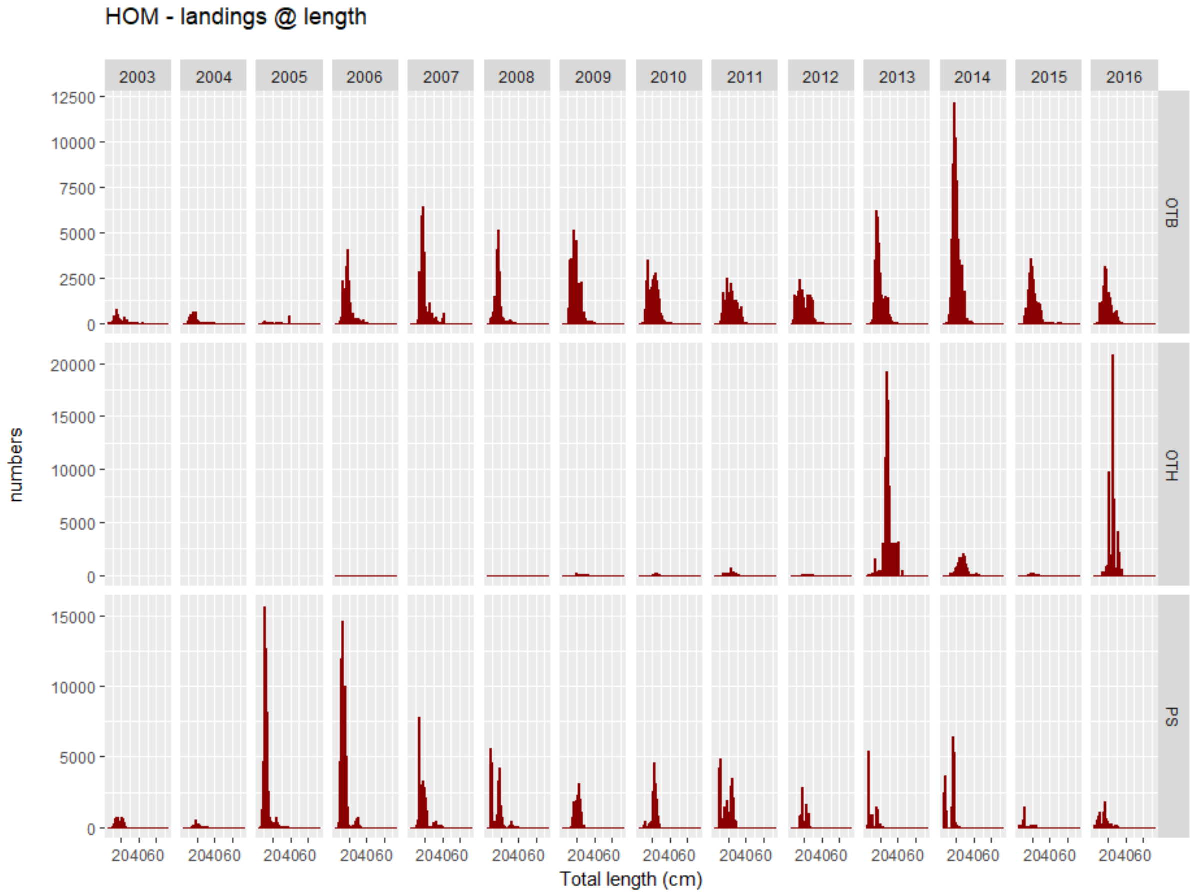


Figure 6.3.1.1.3 Atlantic horse mackerel in GSAs 1, 5, 6 & 7. Landings at length for Spain by gear from DCF data.

Discards and catch data

Discards at length are available by gear and by GSA from Spain from 2009 onwards (Figure 6.3.1.1.4). No discard data is available from France.

Based on the data available the overall discarding contributes about 10% of the catch, though the data indicates this is increasing in recent years.

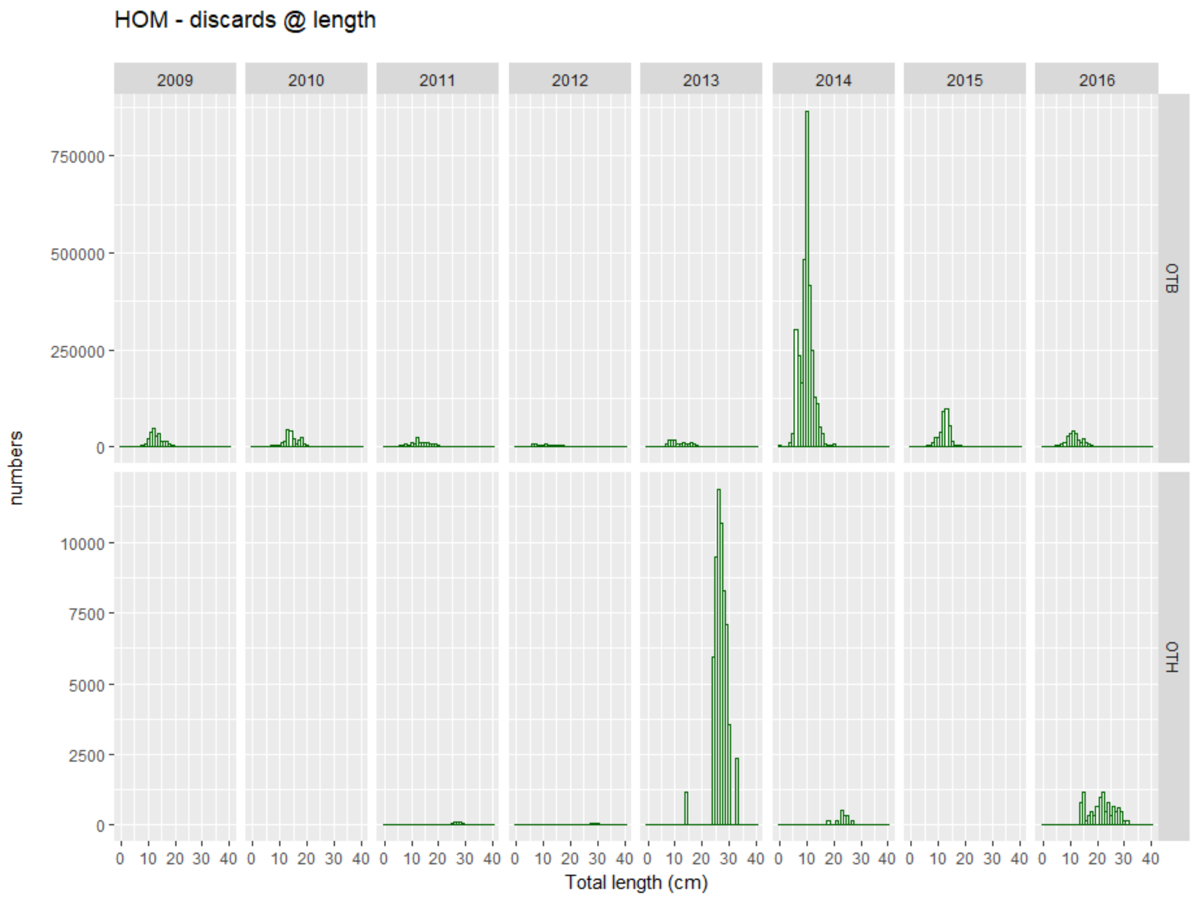


Figure 6.3.1.1.4 Atlantic horse mackerel in GSAs 1, 5, 6 & 7. Discards at length for Spain by gear from DCF data.

In conclusion it has not been possible to estimate total landings or catch for the combined area, and it is thought that there are significant landings and catches that have not been reported in the biological data call by France.

6.3.1.2 Effort

There is no directed fishery for horse mackerel so effort data is not applicable and is not reported.

6.3.1.3 Survey data

Survey data is available for MEDITS from 1994 to 2016. The index of total biomass from the survey (Figure 6.3.1.3.1) shows an increase in biomass in 2006 and 2007 which decays in in subsequent years. The length frequency data indicates recruitment in 2004 which grows in length in subsequent years (Figure 6.3.1.3.2). The mean weight per individual and mean length per individual have been calculated (Figure 6.3.1.3.3). These both a low in 2005 with a rise in value from onwards followed by a decline indicting the survey is responding to a recruitment event with changes in biomass, mean weight and mean length that corresponds to this event. The same recruitment also appears as an increase in landings (Figure 6.3.1.3.1).

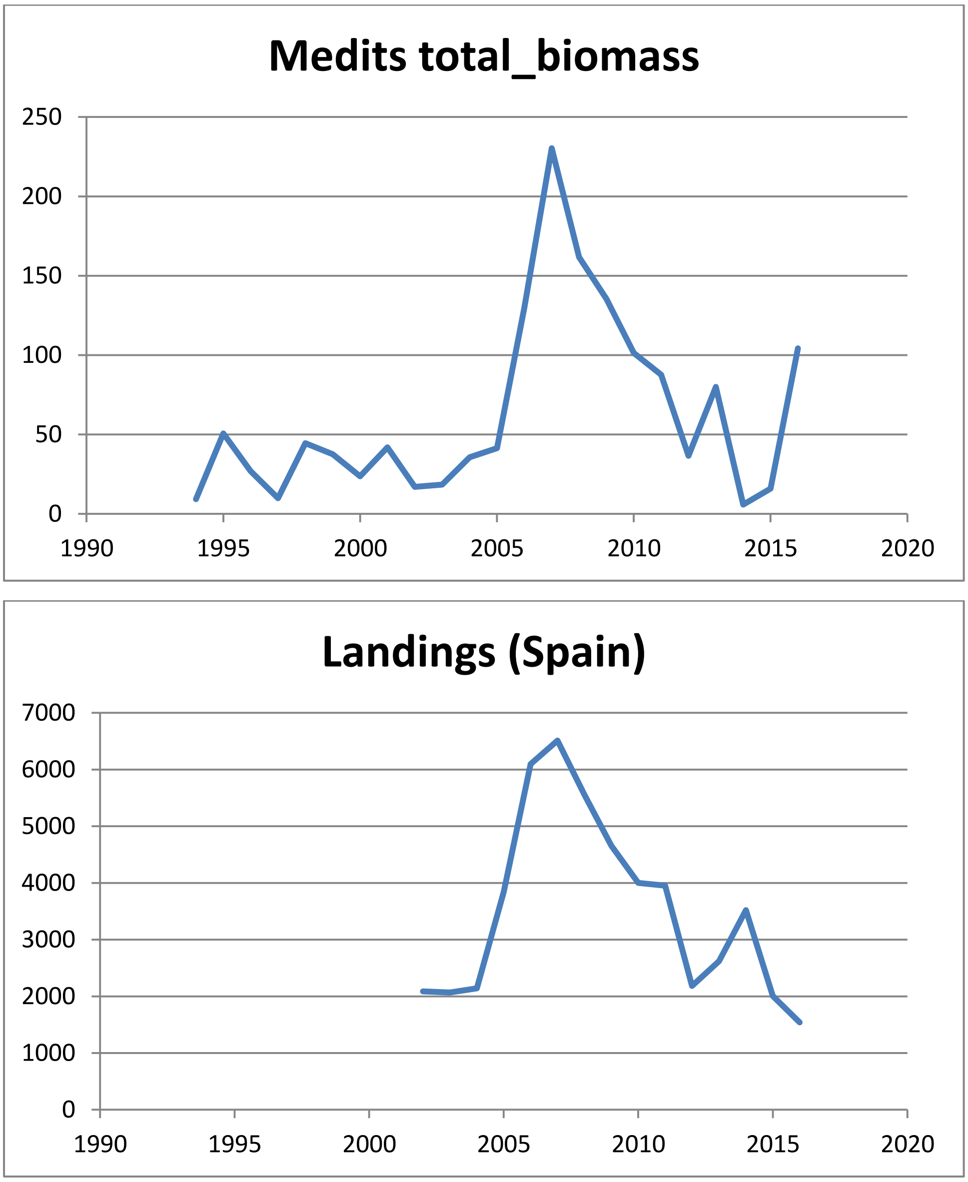


Figure 6.3.1.3.1 Atlantic horse mackerel in GSAs 1, 5, 6 & 7. MEDITS total biomass index 1994 to 2016 for GSA 1,5,6,7 combined, and Spanish reported landings for GSAs 1, 5, 6 and 7 from 2002 to 2016.

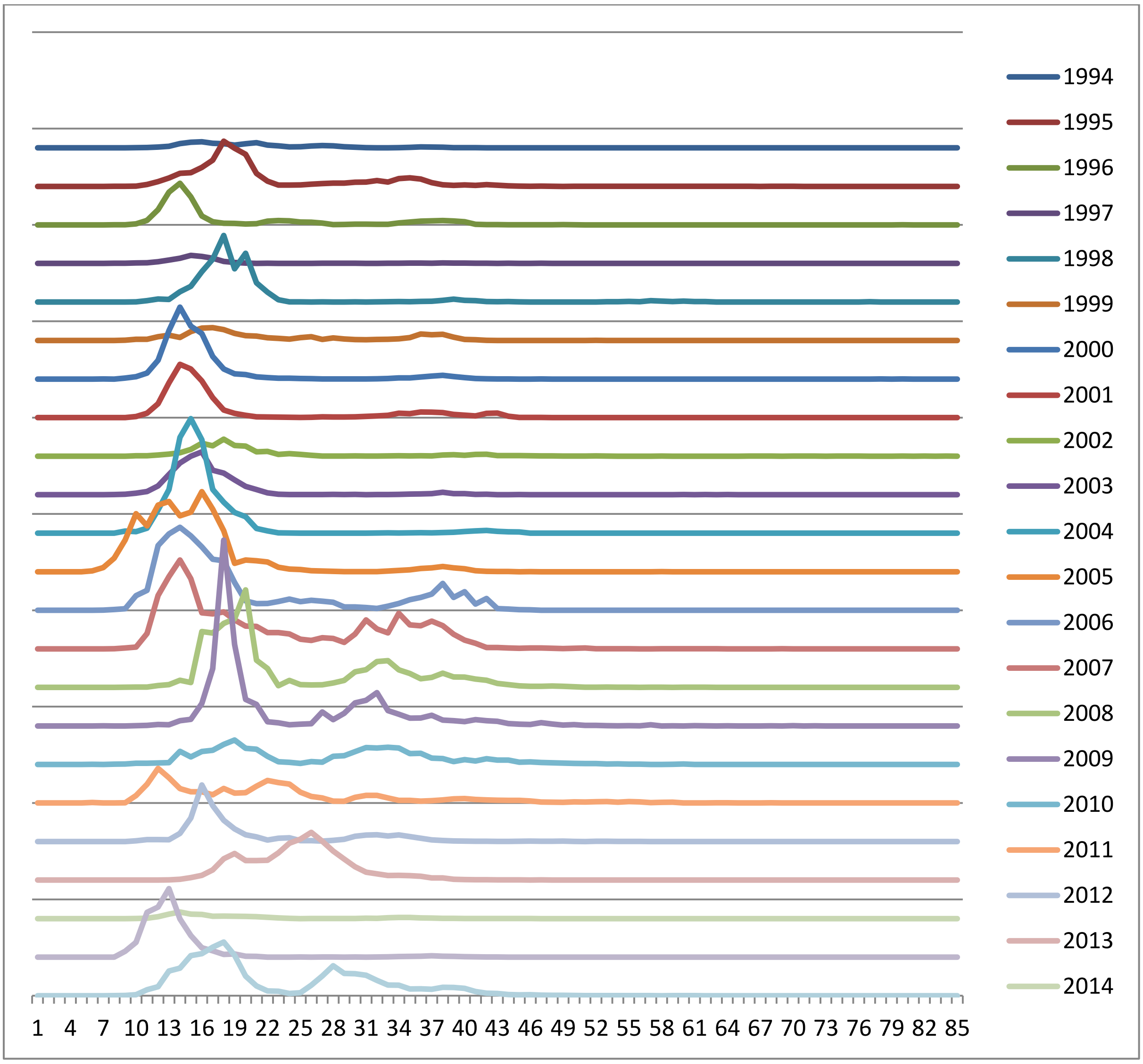


Figure 6.3.1.3.2 Atlantic horse mackerel in GSAs 1, 5, 6 & 7. Length frequency by year 1994 to 2016 for GSAs 1,5,6,7 combined. Recruitment in 2004 is seen to grow and to reduce in abundance in subsequent years.

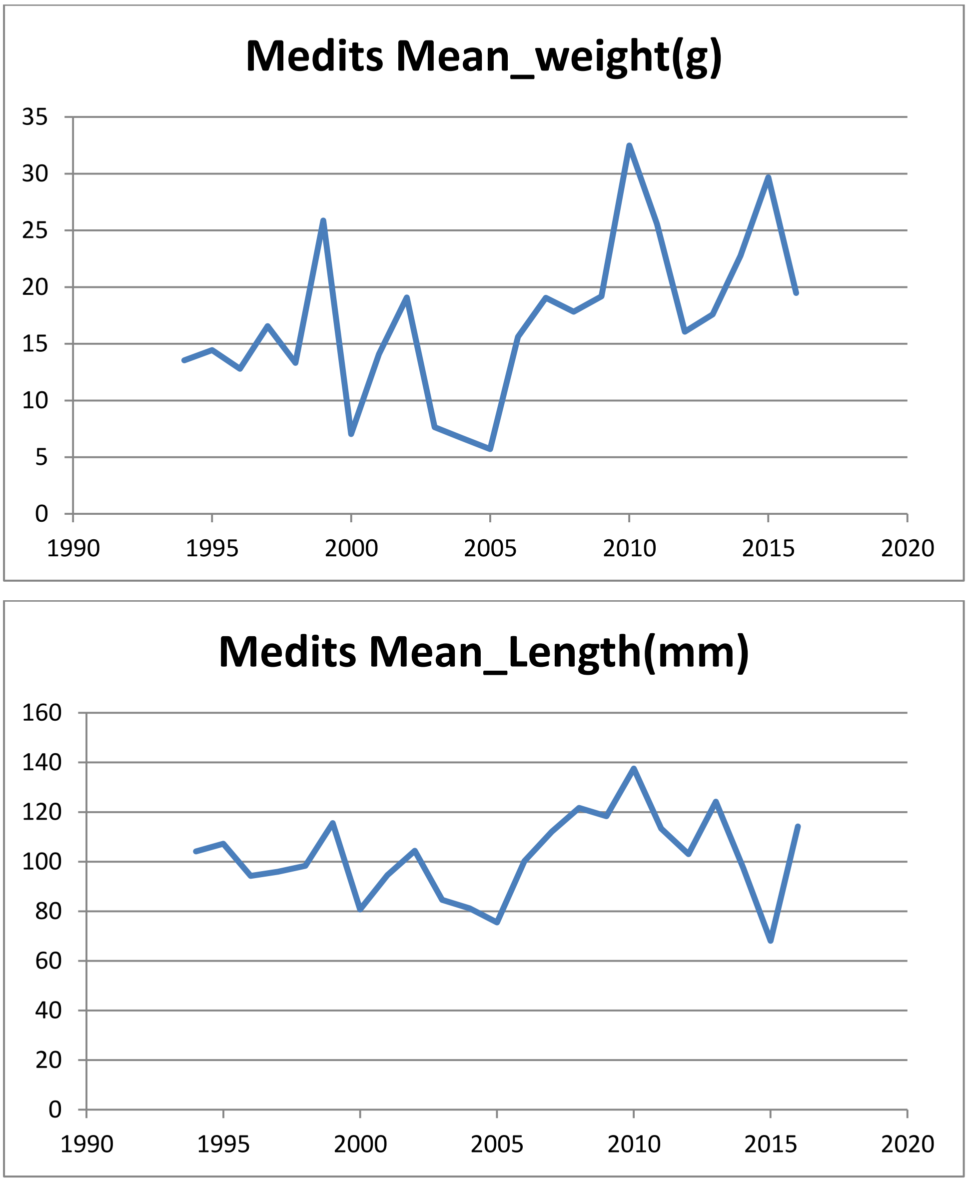


Figure 6.3.1.3.3 Atlantic horse mackerel in GSAs 1, 5, 6, & 7. Survey mean weight and mean length by year for 1994 to 2016 for GSAs 1,5,6,7 combined from MEDITS survey

6.3.2 Stock assessment

As only partial landings data are available, and additional catch for some years is reported in the economic data we are not able to estimate the total landings by year for the area. If the landings can be there may be potential for stock assessment.

The length analysis (Annex 1) shows that horse mackerel in GSA 1, 5, 6 and 7 is exploited above MSY.

6.3.3 Reference Points

Without a stock assessment reference points are not calculated

6.3.4 Short term Forecast and Catch Options

The biomass index based on total biomass from MEDITS for areas 1, 5, 6 and 7 has been identified as a suitable index of stock development.

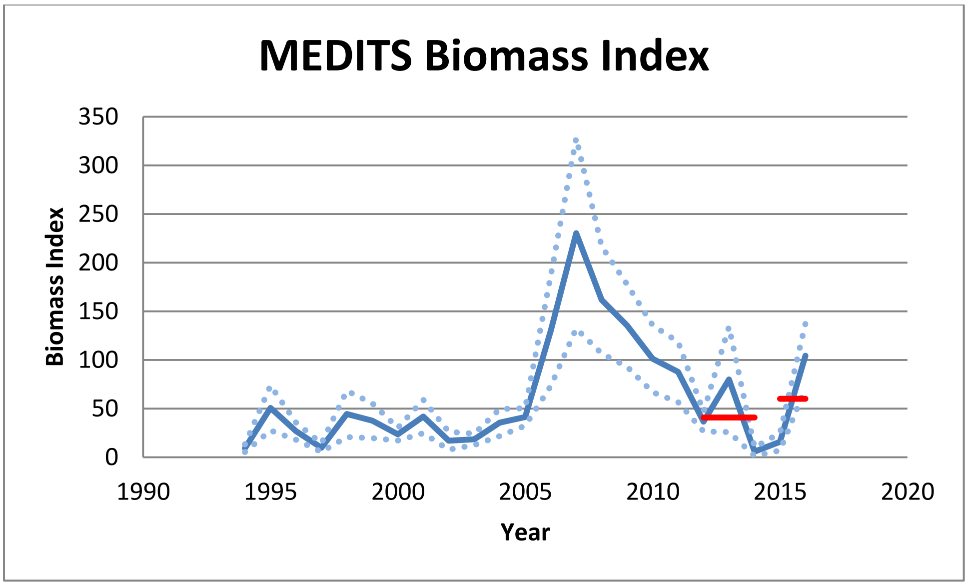


Figure 6.3.4.1 Atlantic horse mackerel in GSAs 1, 5, 6 & 7. Change in biomass index over the last 5 years

Advice on catch is based on the ICES survey index approach, using the mean of last two years relative to the mean of previous three years as an index of stock change. For this stock this factor is 1.47, following the ICES procedure this is limited to a through use of a noise buffer to a factor of 1.2. Evaluation of the length distribution Figure 6.3.4.3 (see detail in Annex 1) shows that exploitation is above MSY, implying overexploitation and an additional 20% reduction is required as a precautionary consideration. Catch should be changed by 0.8*1.2 = 0.96. To provide catch/landings advice for 2018 and 2019 this factor should be applied to the average of most recent 3 years of catch/landings. Currently French catch/landings data is not available so no advice can be applied for the combined stock area.

Length Indicator Analysis

The length indicator analysis (See details in annex 1 to this report) was carried out for most stocks including anchovy in GSA 7 the results by year are given in Figure 6.3.4.2 and summarised over years in Figure 6.3.4.3. The exploitation rate indicator L_{fem}/L_{mean} is seen to be below 1.0 in all years so the indicator suggests the stock is over exploited.

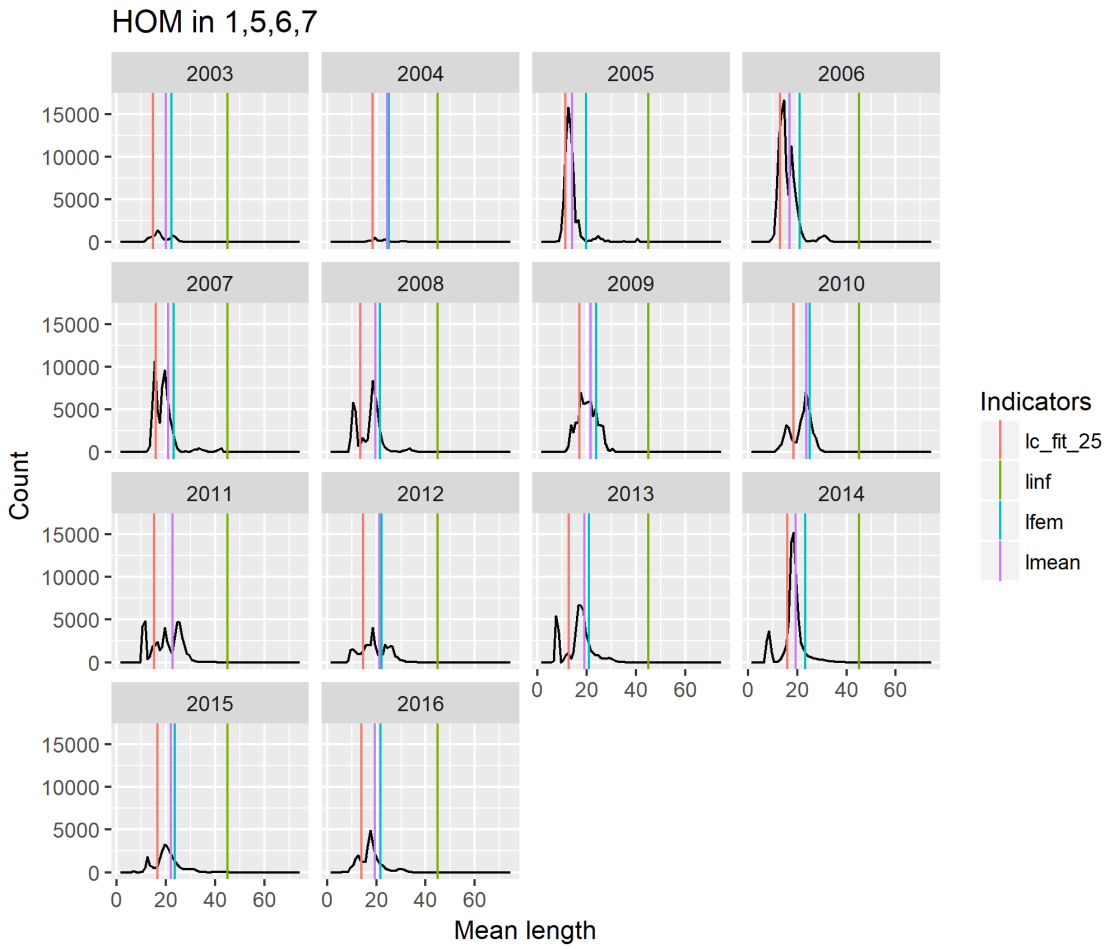


Figure 6.3.4.2, Results of year by year length indicator analysis showing distribution of length in the catch, and the L_{fem} and L_{mean} that are used to evaluate exploitation relative to MSY.

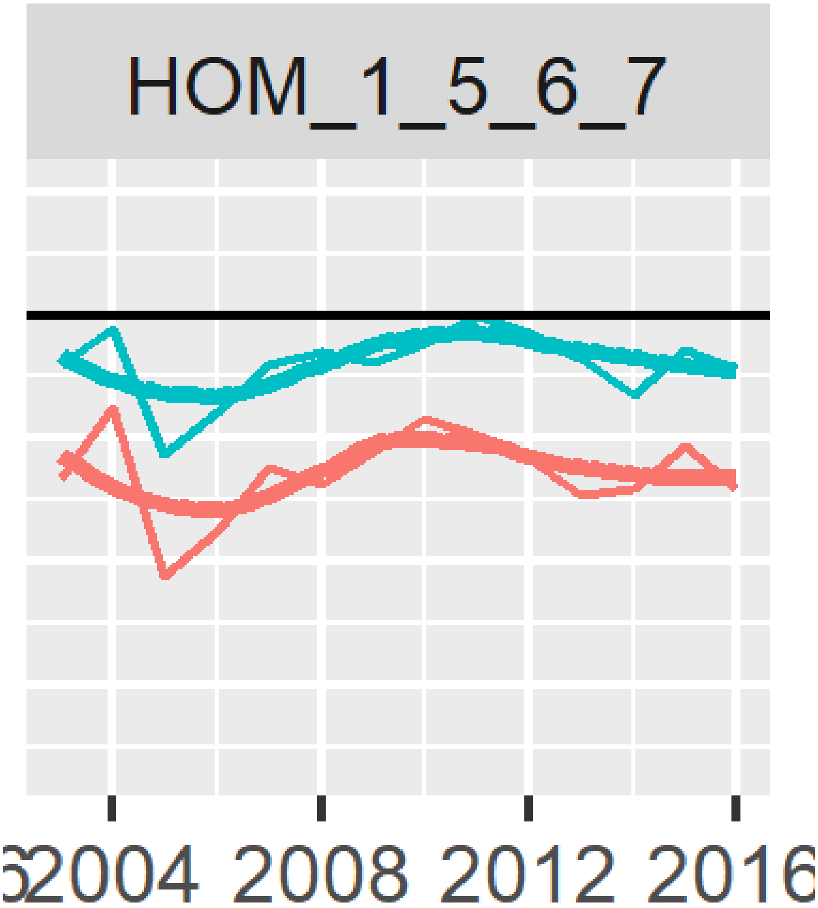


Figure 6.3.4.3, Summary of length indicator analysis showing distribution of length in the catch, and the L_{fem} and L_{mean} that are used to evaluate exploitation relative to MSY.

6.3.5 Data Deficiencies

Data reporting by France is poor and uncertain; landings data given in the biological data call is inconsistent with the data reported under the economic data call. A complete set of horse mackerel data should be requested for both economic and biological data with any differences explained.

6.4 STOCK ASSESSMENT ON ANCHOVY IN GSAs 9, 10 & 11

Stock Identity and biology

STECF 17-09, after analysing the results of the STOCKMED project, concluded that the region represented by the GSAs 8, 9, 10 and 11, corresponding to the Tyrrhenian Sea, is considered inhabited by a unique stock unit. Considering that no data are available for GSA 8, the present assessment covers the areas 9, 10 and 11.

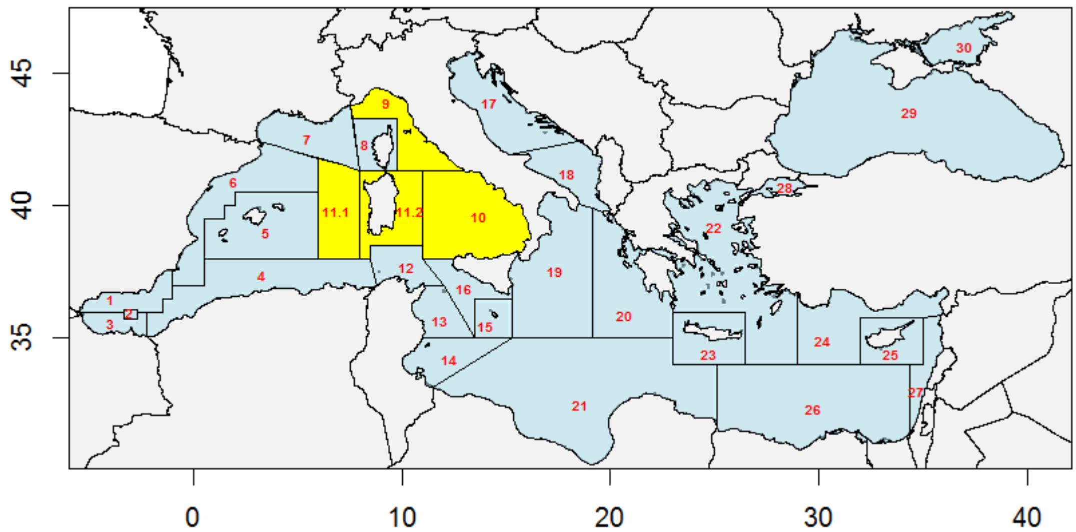


Figure 6.4.1 Geographical location of GSAs 9, 10 & 11.

Growth

The von Bertalanffy parameters from the official Data call by GSA are reported in Table 6.4.1. No growth parameters are available for GSA 11 for this species.

The EWG re-estimated a von Bertalanffy curve for sex combined, based on age readings data from GSA 9 and 10, according to the recommendations of STECF EWG17-09, i.e. constraining t_0 parameter to be higher or equal to -0.2. This combined curve is reported in table 6.4.1.

The comparison of the three curves is reported in the figure 6.4.1.

Table 6.4.1 European anchovy in GSAs 9, 10 & 11. Von Bertalanffy growth parameters for sardine by GSA.

GSA	L_{inf} (cm)	K	t_0
9	17.8	0.48	-0.188
10	20	0.204	-2.52
9-10	18	0.6	-0.2

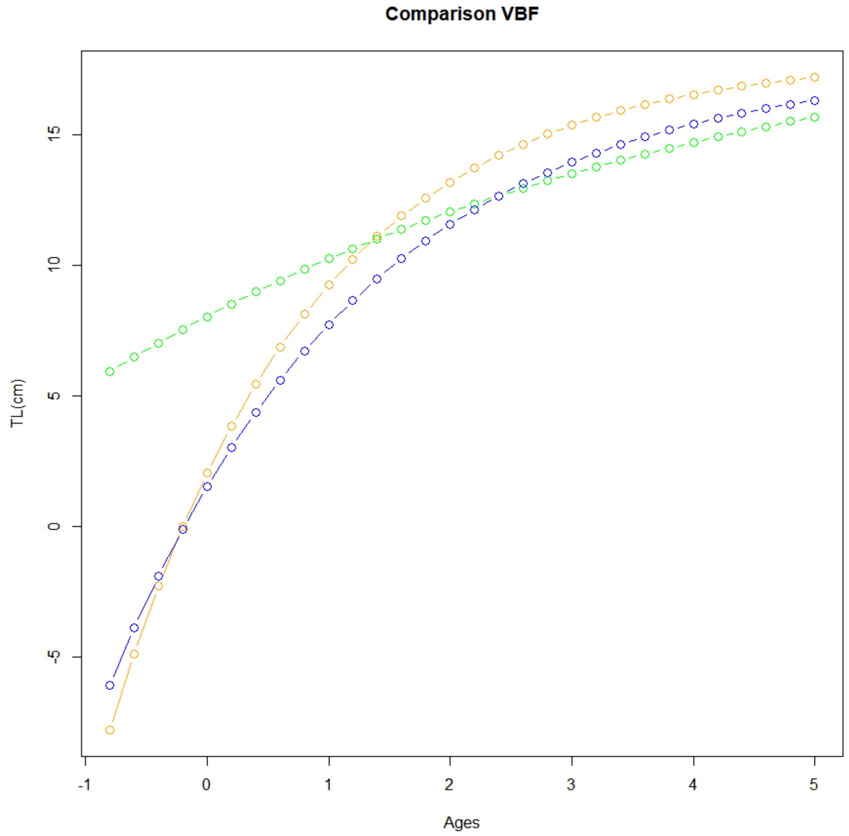


Figure 6.4.1 European anchovy in GSAs 9, 10 & 11. Von Bertalanffy growth functions for GSA 9 (blue), GSA 10 (green) and combined GSA 9 and 10 (orange).

Maturity

Maturity vector by length and by age is available for GSA 9 and 10. No information is available for GSA 11. The size at first maturity for this species in this area is about 10.5 cm. The maturity at age vector was obtained according to the re-estimated set of von Bertalanffy parameters and reported in table 6.4.2.

Table 6.4.2 European anchovy in GSAs 9, 10 & 11. Maturity at age of anchovy in GSA 9, 10 and 11.

Maturity	Age
0	0
1	0.7
2	1
3	1

4+	1

Natural mortality

The natural mortality vector by length was obtained using the Gislason method. The natural mortality by age was derived accordingly to the new set of von Bertalanffy parameters and reported in table 6.4.3.

Table 6.4.3 European anchovy in GSAs 9, 10 & 11. Natural mortality at age of European anchovy in GSA 9, 10 and 11.

M	Age
0	1.16
1	0.57
2	0.39
3	0.33
4+	0.3

6.4.1 DATA

6.4.1.1 CATCH (LANDINGS AND DISCARDS)

Landing data in weight are reported in the official Data call for the GSA 9 and 10 from 2002. No information is available on GSA 11. The length and the age structures of landing and discard are also reported for GSAS 9 and 10. Official transversal data showed that the amount of anchovy landed in GSA 11 is negligible and biological data from official Data call shows that the discard is practically zero in the GSAs 9 and 10. Only in 2011 there is a 2% of discard in GSA 10. Thus, discard was neglected.

Table 6.4.1.1.1 European anchovy in GSAs 9, 10 & 11. Landings of anchovy in GSA 9 and 10 by year. Weights are in tons.

Years/GSA	Landings 9	Landings 10	TOTAL
2006	3725	8378	12103
2007	2290	4002	6291
2008	1350	3687	5037
2009	2504	5613	8117
2010	2999	6479	9478
2011	4449	7299	11748
2012	4912	6088	11000
2013	5402	4150	9552
2014	3440	3361	6802
2015	3958	3667	7738
2016	4423	4439	8862

The length-frequency distributions for GSAs 9 and 10 show that the landings in GSA 9 is more concentrated between 9 cm and 15 cm, while in GSA 10 the length frequency distribution are generally between 7-8 cm and 14 cm.

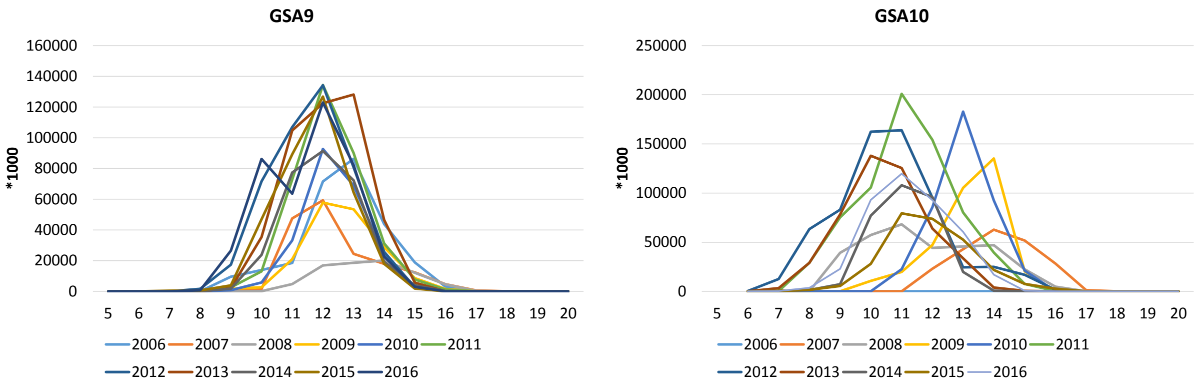


Figure 6.4.1.1.1 European anchovy in GSAs 9, 10 & 11. Length-frequency distributions of the landing of anchovy for the GSA 9 and 10.

6.4.1.2 Effort

The effort data are available for GSA9, 10 and 11. In table 6.4.1.2.1 is reported the nominal effort for the gear targeting this species.

Table 6.4.1.2.1 European anchovy in GSAs 9, 10 & 11. Nominal effort in GSA 9, 10 and 11 of the gear targeting sardine in the same area.

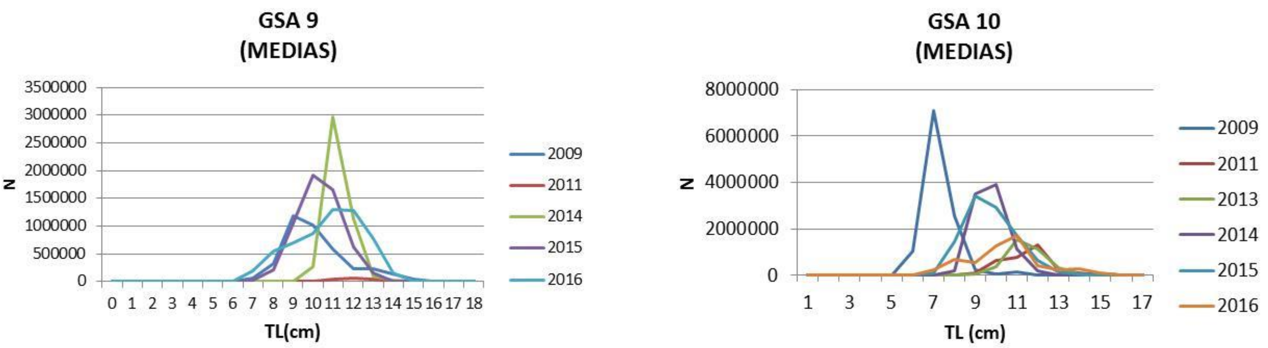
Gear	GND	GNS			OTM	PS		PTM	
Fishery	SPF	-1	DEMSP	SLPF	MDPSP	-1	SPF	SPF	Total
2002		6504001				1971827			3482552
2003		6925653				2131812			3729759
2004	33051		470584	8321			197055	3087	245597
2005	14704		491883	40677			183408		264619
2006	48989		206888	15803			151326	2300	149210
2007	41274		186348	24466			188900		146150
2008	41390		165415	5810			146375		121753
2009	33873		185829	8188			97204		112135
2010	12754		169039	8531			79166	100	96249
2011	5246		215673	18224			92535		111663
2012	13436		151782	6443			90075	902	88714
2013	7667		108838	11197			84920		75691
2014	7669		131454	10283	95902		79945		84384
2015	2991		103917	21182	114496		96328		83473
2016	8221		134261	13997			102839		93157

6.4.1.3 SURVEY DATA

Acoustic survey data are available from the official Data call only for GSA 10 and 9. No data on biomass or abundance were available in GSA 10 and GSA9 for the years 2010 and 2012. Also for GSA9 data on biomass or abundance was not available 2013. No data were available before 2009.

Length structures from MEDITS data are available since 2011 for GSA9 and since 2012 for GSA10 and GSA11.

Figure 6.4.1.3.1 European anchovy in GSAs 9, 10 & 11. Length-frequency distributions from the acoustic survey MEDIAS and from the MEDITS trawl survey for the GSA 9, 10 and 11.



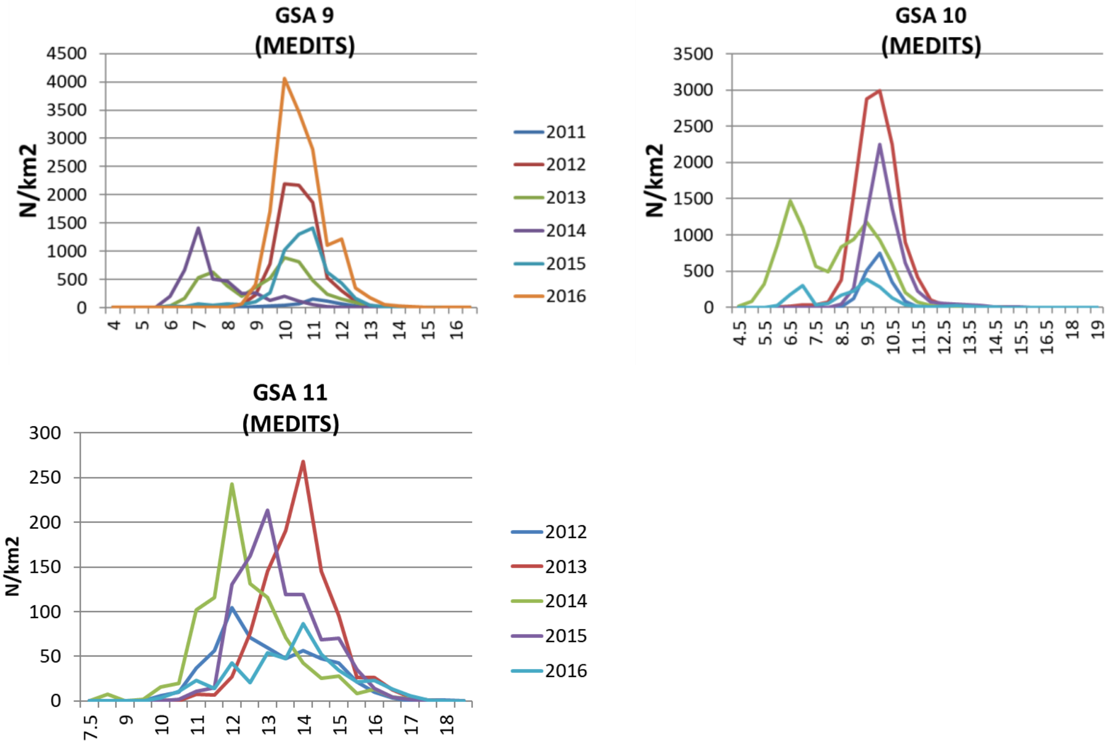


Figure 6.4.1.3.1 European anchovy in GSAs 9, 10 & 11. Length-frequency distributions from the acoustic survey MEDIAS and from the MEDITS trawl survey for the GSA 9, 10 and 11.

6.4.2 Stock assessment

Methods: XSA (Extended Survival Analysis)

During the STECF-16-22 the anchovy stock of GSA 9 was assessed by XSA No previous assessment related to the GSA9, 10 and 11 combined has been carried out.

FLR libraries were employed in order to carry out an XSA based assessment. The major assumption of the method is the flat selectivity for the oldest ages (selectivity as classical ogive), that for this fishery/species was considered plausible. The method performs a tuning by survey index by age and was applied using the age data obtained by the slicing of the length frequency distributions of the catch and survey data.

Input data

The catch at age matrices (for landing and for survey) were derived slicing the length frequency distributions of GSA 9, both for the surveys and for the commercial catches, according the age-length keys estimated for GSA 9 using an

ALK stabilised over the years. An analogous procedure was applied for GSA 10 using the stabilised ALK estimated for this GSA.

The landings at age matrices are reported in table 6.4.2.1. SoP corrections were applied being the differences between the observed catches and SoP less than 3.7% on average.

Table 6.4.2.1 European anchovy in GSAs 9, 10 & 11. Landings at age matrices. Numbers in thousands.

Landing at age	0	1	2	3	4+
2006	22392	134762	276829	282194	101903
2007	11501	36198	123380	128430	78844
2008	11568	124318	127274	106323	36693
2009	8304	54232	199394	202270	49626
2010	12913	68040	285290	222363	44521
2011	68435	343915	419558	190887	24092
2012	143997	418445	367125	138587	21528
2013	85355	336966	338596	152083	8342
2014	30186	203717	263987	97239	5361
2015	45077	167878	283210	122331	17271
2016	69731	278299	324014	135181	11202

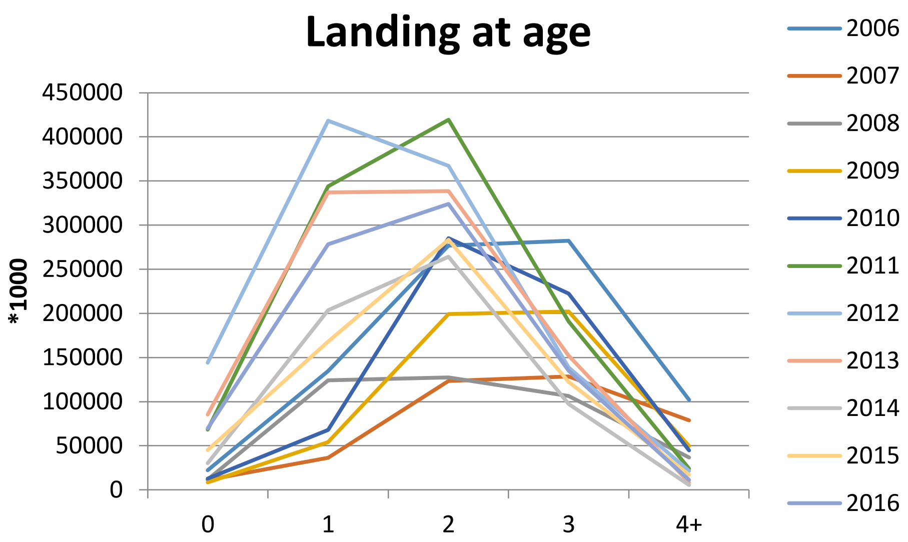


Figure 6.4.2.1 European anchovy in GSAs 9, 10 & 11. Landing at age matrices derived from age-length key.

The landing at age plots show that the most of the individuals are from ages 1 to 3 depending on the year.

Table 6.4.2.2 European anchovy in GSAs 9, 10 & 11. Landing in weight. Weight are in tons.

Year	Landing
2006	12103
2007	6291
2008	5037
2009	8117
2010	9478
2011	11748
2012	11000
2013	9552
2014	6802
2015	7738
2016	8862

The individual weight at age in catches and in the stock are reported in table 6.4.2.3.

Table 6.4.2.3 European anchovy in GSAs 9, 10 & 11. Individual weight at age in the catches and in the stock for the ALK and age slicing runs. Weights are in kg.

	0	1	2	3	4+
Catch in weight	0.006	0.008	0.012	0.016	0.021
Stock in weight	0.002	0.011	0.022	0.030	0.035

The maturity at age vector and the natural mortality vector is reported in table 6.4.2.4.

Table 6.4.2.4 European anchovy in GSAs 9, 10 & 11. Maturity and natural mortality at age for the ALK and age slicing runs.

	0	1	2	3	4+
Maturity	0	0.7	1	1	1
Natural mortality	1.16	0.57	0.39	0.33	0.3

The MEDITS indices by length were re-estimated treating the three GSAs as a unique area, starting from the TC files (Table 6.4.2.5) and re-stratifying the single hauls in the TA files of the three GSAs. The aggregated indices from acoustic surveys MEDIAS were derived summing up the GSA 9 and 10, being absolute numbers.

Table 6.4.2.5 European anchovy in GSAs 9, 10 & 11. Survey (MEDIAS and MEDITS) indices by age.

MEDITS	0	1	2	3	4+
2012	1489	4691	2647	207	34
2013	6001	7432	2792	370	76
2014	11150	3444	975	179	35
2015	2004	5197	3075	498	81
2016	3142	8535	5192	458	64
MEDIAS survey	0	1	2	3	4+
2009	10944775	2817615	911020.5	348198.1	67956.27
2010	NA	NA	NA	NA	NA
2011	50935.99	1265734	1441996	494939.1	64129.88
2012	NA	NA	NA	NA	NA
2013	NA	NA	NA	NA	NA
2014	1768292	7592895	3673971	432163	54716.2
2015	3647208	8366169	3488437	497747.9	40489.94
2016	1962806	4611157	3394627	1157475	162248.4

Two different uses of the data were evaluated, one based on 2006 to 2016 catch with survey starting in 2009, and a second truncated assessment based on 2009 to 2016 survey and catch

Results for 2006 to 2016 catch data.

Sensitivity analyses were conducted to assess the effect of the main parameters. Setting rage value=0 and 1, qage=1 and 2, shk.years=3 and shk.ages=3, values ranging from 0.5 to 3 (0.5 increasing) have been tested.

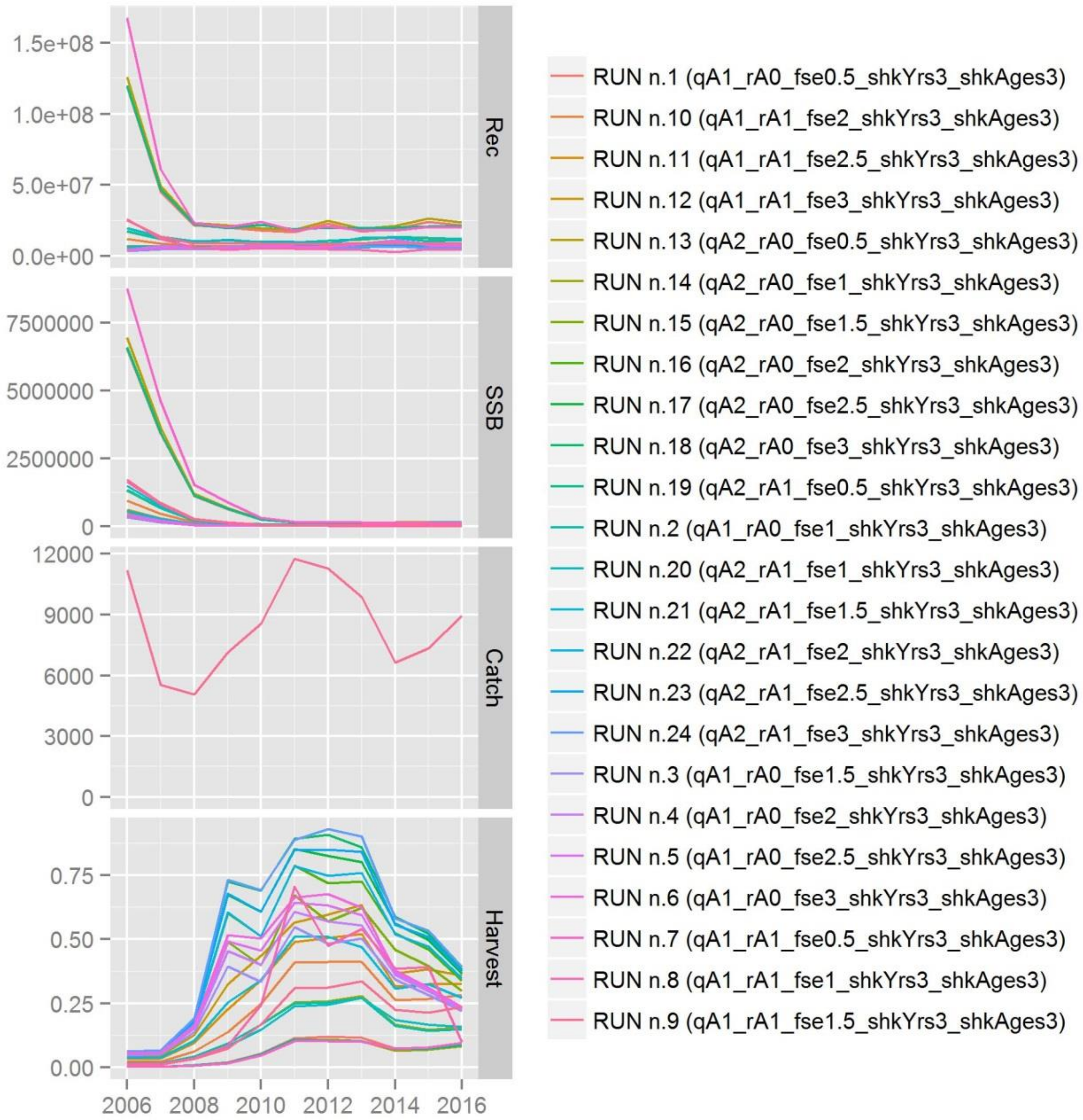


Figure 6.4.2.2 European anchovy in GSAs 9, 10 & 11. Sensitivity of settings and shrinkages.

The results of the different runs showed a value of F between 0.25 and 0.4; moreover, all the runs showed a sharp decrease in SSB and in recruitment from 2006, probably driven by the decrease in the landing and by the lacking information of the survey data in the same years of the time series.

In Table 6.4.2.6 the residuals of the models explored with the different settings are presented.

Table 6.4.2.6 European anchovy in GSAs 9, 10 & 11. Residuals of the models with the different settings.

run	rAGES	qAGES	FSE	shk_yrs	shk_ages	min	max	avg_abs_values	median_abs_values
RUN n.1 (qA1_rA0_fse0.5)	0	1	0.5	3	3	-1.70	1.25	0.55	0.49
RUN n.2 (qA1_rA0_fse1)	0	1	1	3	3	-1.53	1.30	0.59	0.49
RUN n.3 (qA1_rA0_fse1.5)	0	1	1.5	3	3	-0.77	2.03	0.44	0.14
RUN n.4 (qA1_rA0_fse2)	0	1	2	3	3	-0.72	2.09	0.53	0.35
RUN n.5 (qA1_rA0_fse2.5)	0	1	2.5	3	3	-0.72	2.12	0.53	0.34
RUN n.6 (qA1_rA0_fse3)	0	1	3	3	3	-0.71	2.13	0.54	0.34
RUN n.7 (qA1_rA1_fse0.5)	1	1	0.5	3	3	-17.07	3.54	8.07	8.39
RUN n.8 (qA1_rA1_fse1)	1	1	1	3	3	-12.67	0.01	5.62	5.15
RUN n.9 (qA1_rA1_fse1.5)	1	1	1.5	3	3	-11.79	0.01	5.21	4.76
RUN n.10 (qA1_rA1_fse2)	1	1	2	3	3	-11.22	0.02	4.95	4.37
RUN n.11 (qA1_rA1_fse2.5)	1	1	2.5	3	3	-10.91	0.02	4.81	4.20
RUN n.12 (qA1_rA1_fse3)	1	1	3	3	3	-10.66	0.03	4.71	4.05
RUN n.13 (qA2_rA0_fse0.5)	0	2	0.5	3	3	-1.57	0.95	0.49	0.26
RUN n.14 (qA2_rA0_fse1)	0	2	1	3	3	-1.27	1.03	0.43	0.35
RUN n.15 (qA2_rA0_fse1.5)	0	2	1.5	3	3	-1.20	1.01	0.43	0.33
RUN n.16 (qA2_rA0_fse2)	0	2	2	3	3	-0.92	0.81	0.35	0.29
RUN n.17 (qA2_rA0_fse2.5)	0	2	2.5	3	3	-0.92	0.82	0.36	0.29
RUN n.18 (qA2_rA0_fse3)	0	2	3	3	3	-0.92	0.89	0.37	0.27
RUN n.19 (qA2_rA1_fse0.5)	1	2	0.5	3	3	-1.97	1.15	0.40	0.08
RUN n.20 (qA2_rA1_fse1)	1	2	1	3	3	-0.93	0.91	0.33	0.19
RUN n.21 (qA2_rA1_fse1.5)	**1**	**2**	**1.5**	**3**	**3**	**-0.90**	**0.85**	**0.16**	**0.03**
RUN n.22 (qA2_rA1_fse2)	1	2	2	3	3	-0.90	0.85	0.16	0.02
RUN n.23 (qA2_rA1_fse2.5)	1	2	2.5	3	3	-1.66	1.71	0.55	0.26
RUN n.24 (qA2_rA1_fse3)	1	2	3	3	3	-2.14	1.59	0.47	0.23

The settings minimizing the residuals and the mean diagnostics output also in term of good performance in the retrospective analysis corresponded to: *rage=1, qage=2, shrinkage years=3, shrinkage ages=3*, with an intermediate weight of the survey *(fse=1.5)* (run 21 of figure 6.4.2.2). Retrospective analysis was limited due to shortage of time series.

The residuals of the MEDITS trawl survey and MEDIAS survey are quite small and do not show any particular problem except for the plus group (Figure 6.4.2.3).

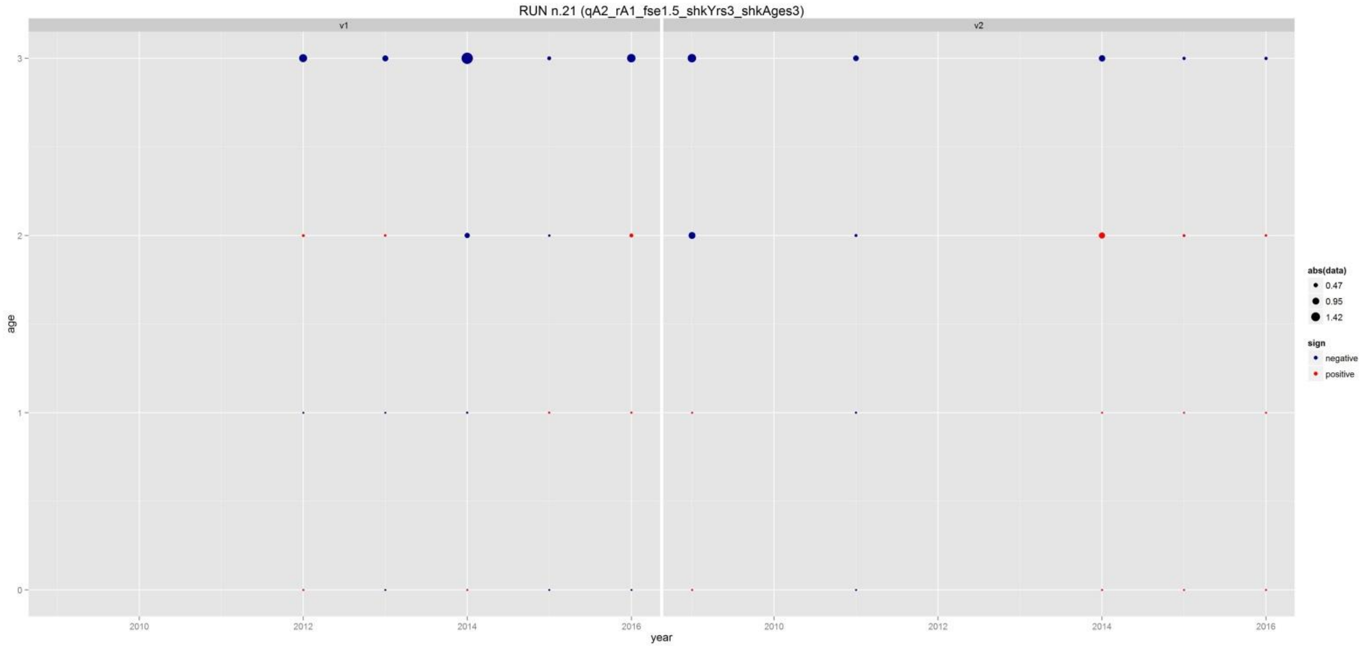


Figure 6.4.2.3 European anchovy in GSAs 9, 10 & 11. Residuals for anchovy GSA9, 10 and 11 for MEDITS (left) and MEDIAS survey.

The results of the retrospective analysis did not show any signal of instability and are shown in Figure 6.4.2.4.

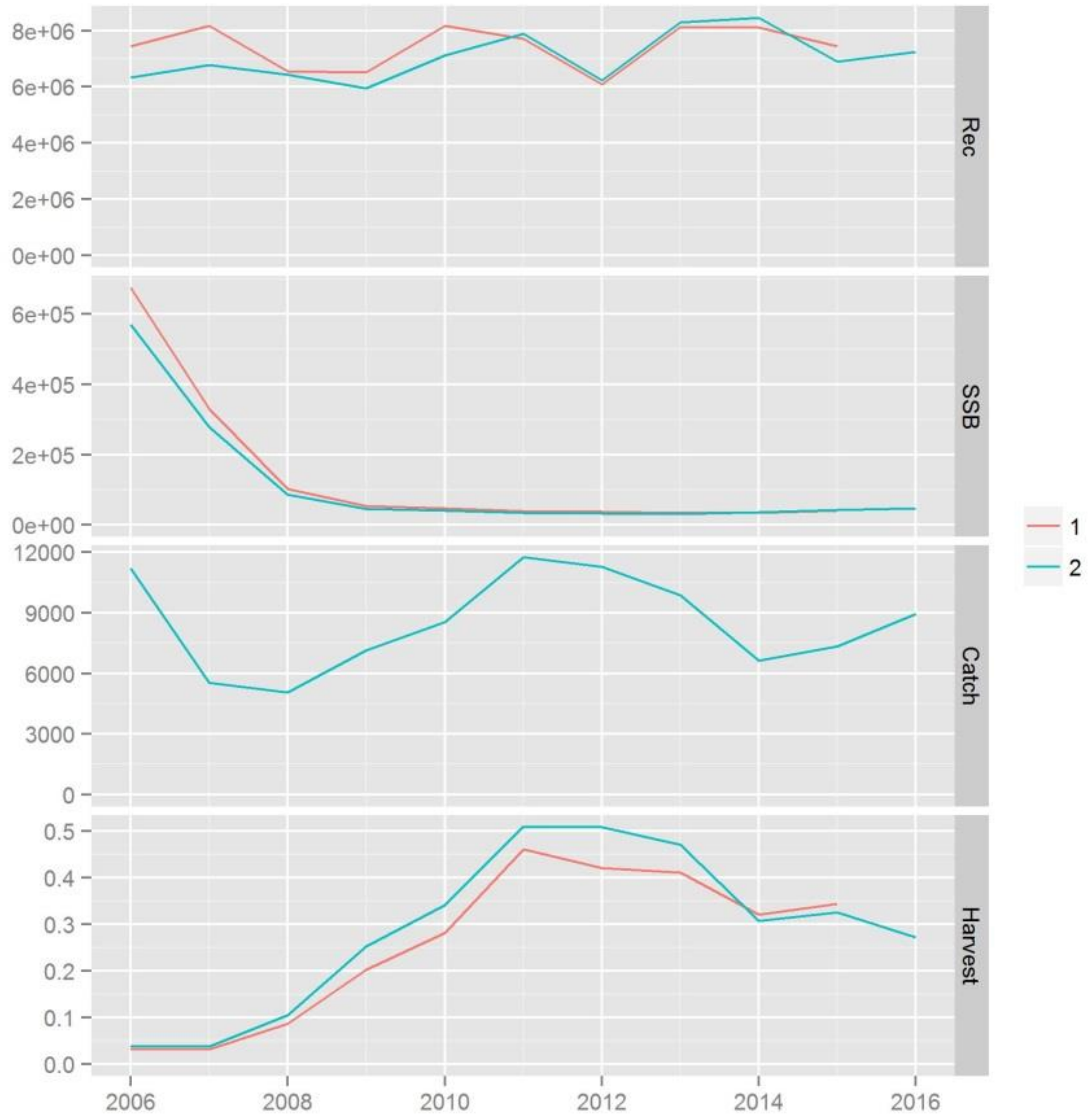


Figure 6.4.2.4 European anchovy in GSAs 9, 10 & 11. 2006 to 2008 time series Retrospective for anchovy GSA 9, 10 and 11.

The results of the run with 2006 to 2016 data based on the XSA assessment are shown in the following figure and tables.

Table 6.4.2.7 European anchovy in GSAs 9, 10 & 11. Stock in numbers for anchovy in GSA 9-10-11 from 2006 to 2016 time series.

	year					
age	2006	2007	2008	2009	2010	2011
0	6324440	6783987	6441405	5946765	7130787	7886725
1	4684895	1970087	2120247	2012814	1859579	2228173
2	7940135	2548085	1086913	1105565	1097514	1000472
3	11277458	5148138	1623677	631176	584462	508333
4	4050668	3143594	556583	152174	114621	62861
age	2012	2013	2014	2015	2016	
0	6228555	8303505	8448663	6895551	7250869	
1	2434063	1871942	2555244	2631638	2136421	
2	1001460	1061848	805228	1291857	1362012	
3	332150	375962	440323	327968	641626	
4	50429	20171	23967	45373	52515	

Table 6.4.2.8 European anchovy in GSAs 9, 10 & 11. Fishing mortality by age and f_{bar} (1-3) for 2006 to 2016 time series anchovy in GSA 9-10-11.

	year					
Age	2006	2007	2008	2009	2010	2011
0	0.01	0.00	0.00	0.00	0.00	0.02
1	0.04	0.02	0.08	0.04	0.05	0.23
2	0.04	0.06	0.15	0.25	0.38	0.71
3	0.03	0.03	0.08	0.47	0.60	0.58
4	0.03	0.03	0.08	0.47	0.60	0.58
f_{bar}(1-3)	**0.04**	**0.04**	**0.11**	**0.25**	**0.34**	**0.51**
Age	2012	2013	2014	2015	2016	
0	0.04	0.02	0.01	0.01	0.02	
1	0.26	0.27	0.11	0.09	0.19	
2	0.59	0.49	0.51	0.31	0.34	
3	0.68	0.65	0.30	0.58	0.29	
4	0.68	0.65	0.30	0.58	0.29	
f_{bar}(1-3)	**0.51**	**0.47**	**0.31**	**0.33**	**0.27**	

Table 6.4.2.9 European anchovy in GSAs 9, 10 & 11. Recruitment (* 1000) and SSB (tons) 2006 to 2016 times series for anchovy in GSA 9, 10, 11.

	SSB (ALK)	**Rec (ALK)**
2006	570071	6324440
2007	278324	6783987

2008	85792	6441405
2009	45407	5946765
2010	40537	7130787
2011	35249	7886725
2012	32982	6228555
2013	31852	8303505
2014	35549	8448663
2015	41874	6895551
2016	47557	7250869

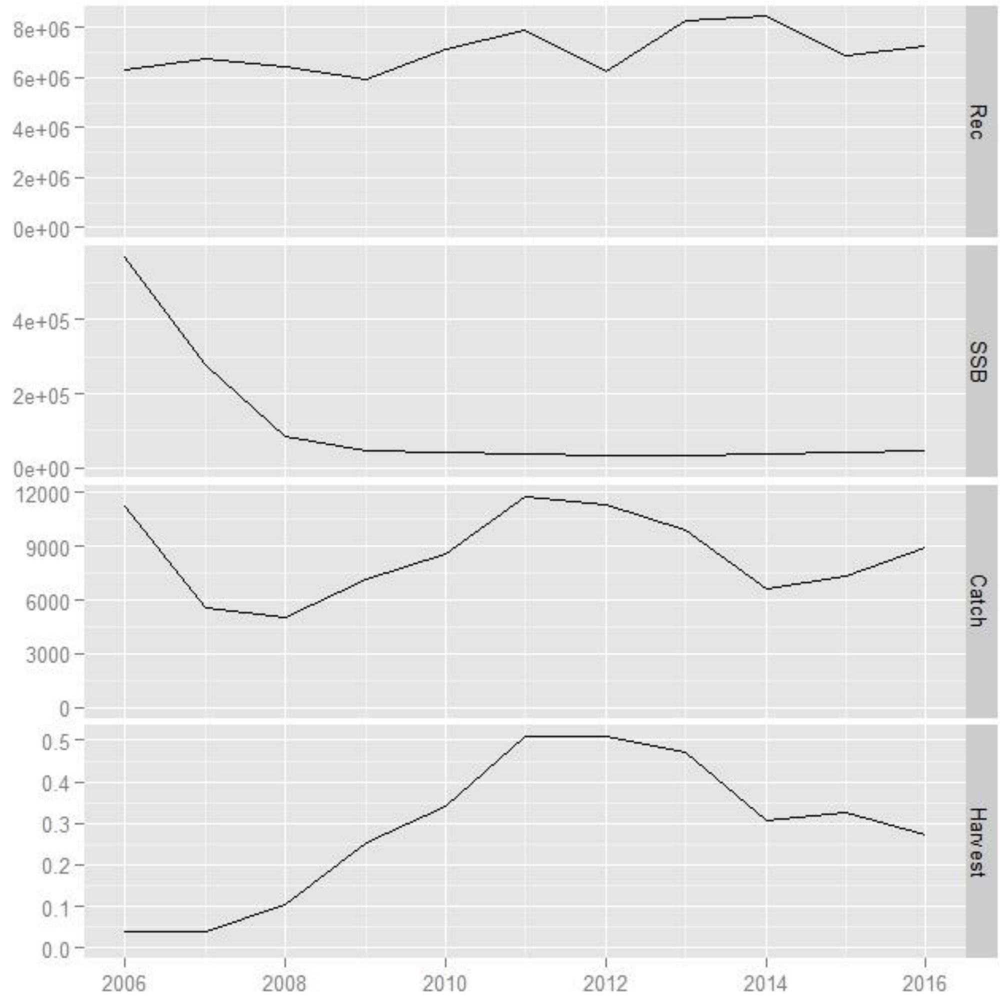


Figure 6.4.2.5 European anchovy in GSAs 9, 10 & 11. Summary of run with 2006 to 2016 catch data results.

Truncated assessment

Due to the lack of survey data in the earlier years, the model applied to the whole time series (2006-2016) shows quite uncertain results in early years, giving a large population on incomplete cohorts and probably overestimating the SSB at the beginning of the period analysed. For this reason, a second run was performed taking into account a shorter time series starting in 2009. The input data is the same as the assessment above, but with catches from 2006 to 2008 omitted, all other inputs remain the same.

Results of truncated assessment catch and surveys 2009 to 2016

The results are presented in the tables and figures below. Survey residuals are given in figure 6.4.2.6 and retrospectives in figure 6.4.2.7

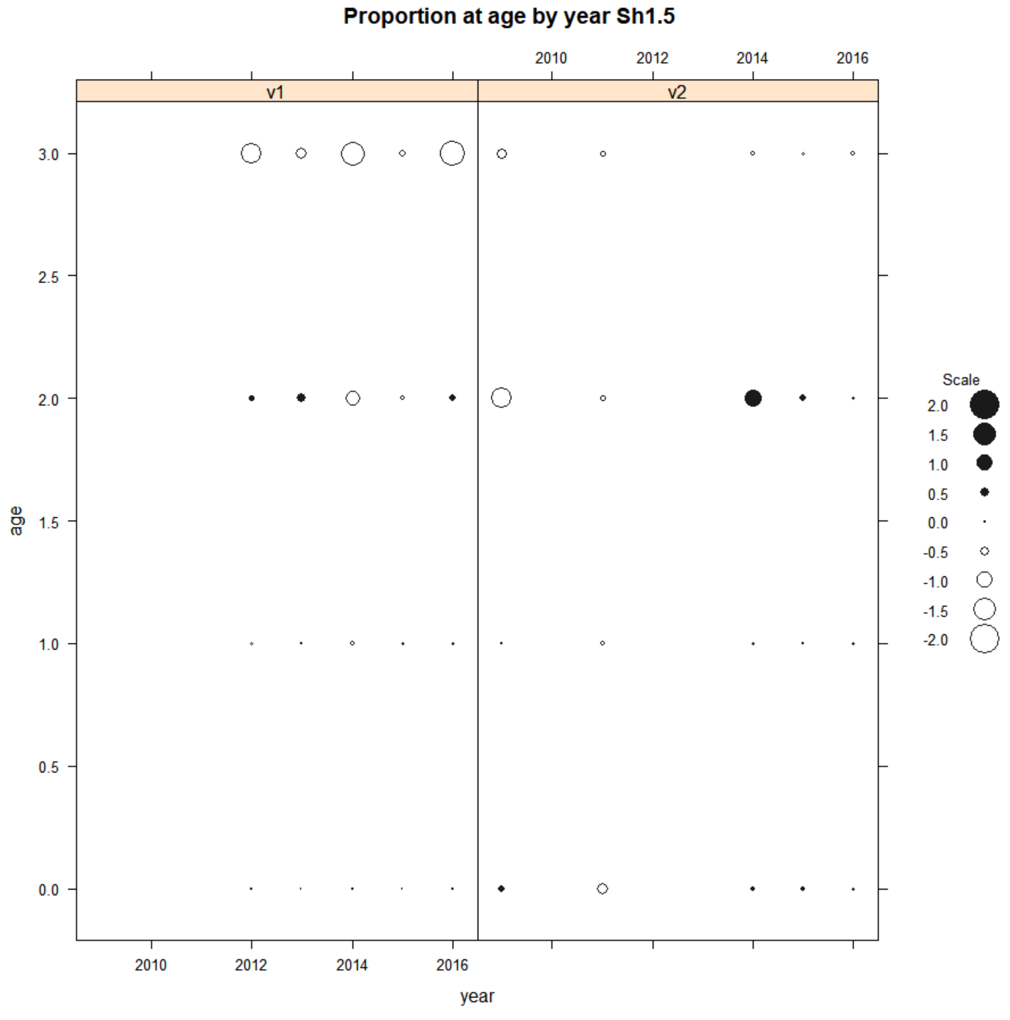


Figure 6.4.2.6. European anchovy in GSAs 9, 10 & 11. Residuals for anchovy GSA9, 10 and 11 for MEDITS (left) and MEDIAS survey.

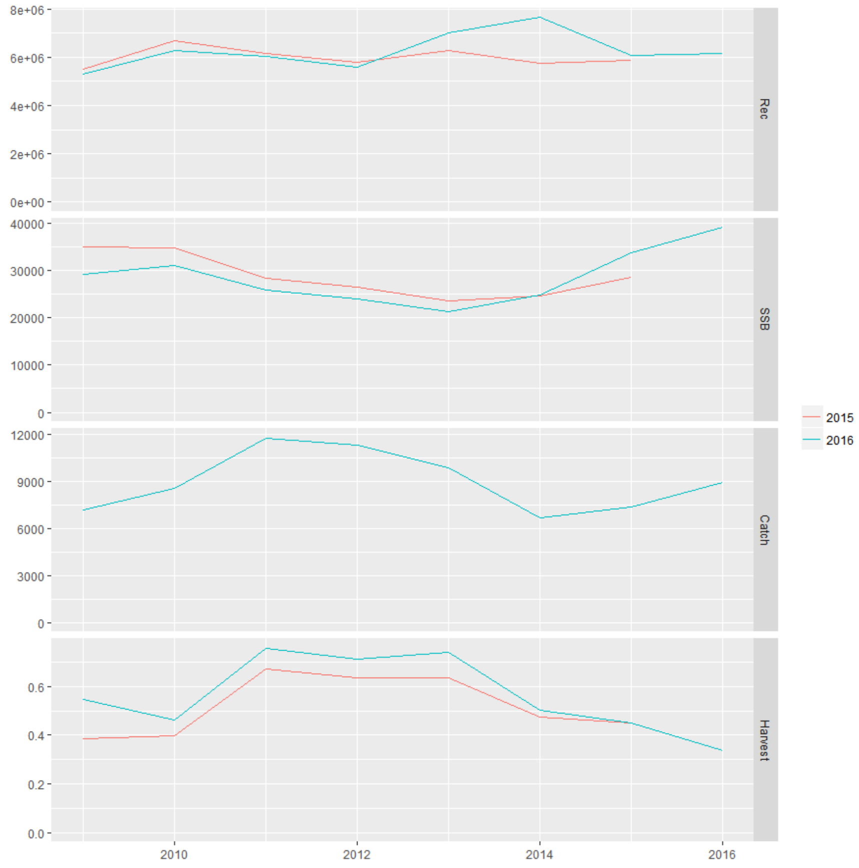


Figure 6.4.2.7. European anchovy in GSAs 9, 10 & 11. Retrospective for anchovy GSA9, 10 and 11.

Stock numbers at age and fishing mortality at age are given in Tables 6.4.2.10 and 6.4.2.11, the stock summary is given in Table 6.4.2.12. This assessment provides very similar results for the period 2009 to 2016 as the previous assessment, but the influence of the early years which produce a potentially spurious biomass estimate in the first years is omitted. As there is no survey data to guide the assessment prior to 2009, the assessment relies on the stability of selection to estimate F and SSB prior to 2009 in the full data set. In this case the results do not look plausible, so the final assessment chosen is the one based on 2009 to 2016 data.

Table 6.4.2.10. European anchovy in GSAs 9, 10 & 11. Stock in numbers for anchovy in GSA 9, 10 & 11.

	Year							
age	2009	2010	2011	2012	2013	2014	2015	2016
0	5293672	6254804	6037315	5587597	6997280	7648074	6077207	6150093

1	1548530	1654844	1953565	1854298	1671011	2145760	2380664	1879881
2	948074	834950	884689	846162	733977	691596	1060284	1220080
3	328198	477832	330562	253758	270817	218335	251032	484838
4	77453	93213	40287	38171	14365	11744	34478	39561

Table 6.4.2.11. European anchovy in GSAs 9, 10 & 11. Fishing mortality by age and F_{bar} (1-3) for anchovy in GSA 9, 10 & 11.

	Year							
age	2009	2010	2011	2012	2013	2014	2015	2016
0	0.00	0.00	0.02	0.05	0.02	0.01	0.01	0.02
1	0.05	0.06	0.27	0.36	0.31	0.13	0.10	0.22
2	0.30	0.54	0.86	0.75	0.82	0.62	0.39	0.39
3	1.30	0.80	1.14	1.03	1.09	0.74	0.86	0.40
4	1.30	0.80	1.14	1.03	1.09	0.74	0.86	0.40

Table 6.4.2.12 European anchovy in GSAs 9, 10 & 11. Stock summary Fbar ages 1-3, Recruitment (* 1000) and SSB catch and total biomass (tons) from final assessment.

	Fbar (1-3)	Recruitment (thousands)	SSB (t)	Catch (t)	Total Biomass (t)
2009	0.54689	5293672	29145	7154.9	61036
2010	0.46291	6254804	30925	8538	66679
2011	0.7561	6037315	25758	11756.7	64354
2012	0.71306	5587597	24051	11286.5	59137
2013	0.74009	6997280	21339	9879.5	57150
2014	0.50112	7648074	24851	6647.1	61076
2015	0.44866	6077207	33738	7332	70406
2016	0.33589	6150093	39011	8931.1	75750

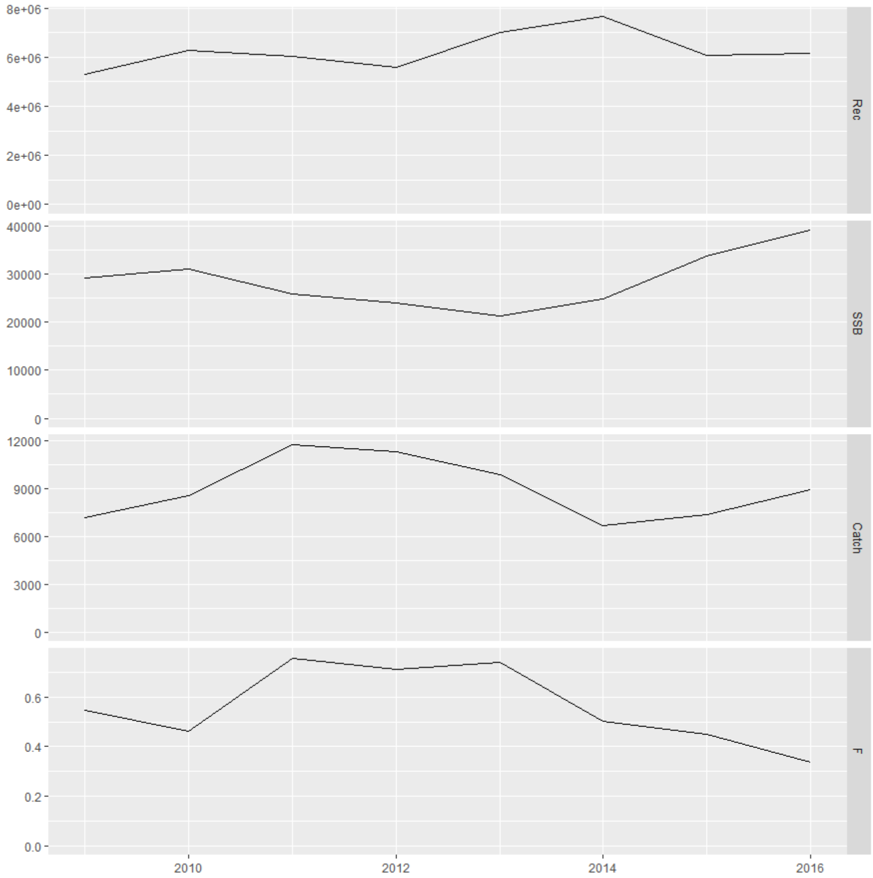


Figure 6.4.2.5. European anchovy in GSAs 9, 10 & 11. Summary of final run results.

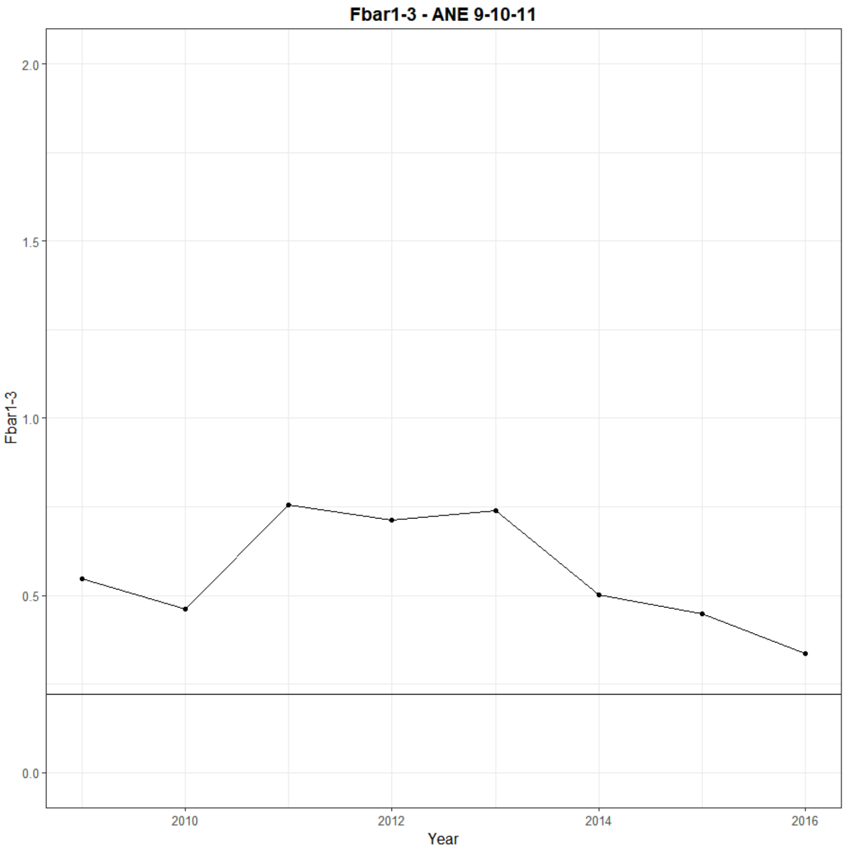


Figure 6.4.3.1. European anchovy in GSAs 9, 10 & 11. Fbar by year compared to the level of F corresponding to E=0.4 (0.22).

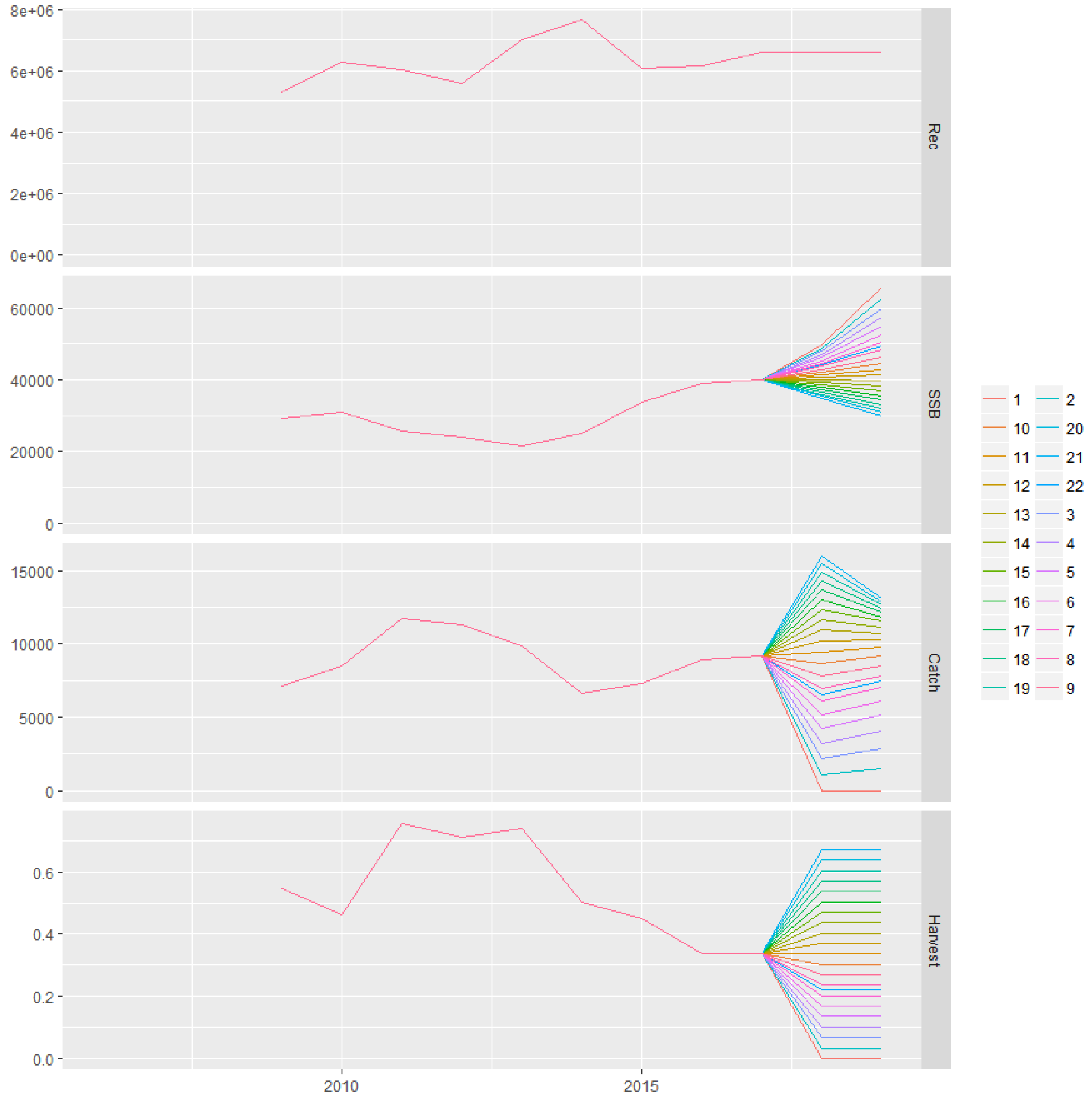


Figure 6.4.4.1. European anchovy in GSAs 9, 10 & 11. Short term forecast for anchovy in GSA 9, 10 and 11.

The analysis showed that fishing at E=0.4 would increase the SSB (from 2018 to 2019) and decrease the catch (from 2016 to 2018) of about 12%, while fishing at the status quo level would increase the SSB of the 3.5% and the catch of about 6%. The reduction of the 30% of the fishing mortality would reduce the catch of about 22 %, while would increase the SSB of about the 11%.

The EWG 17-09 advices to not increase the catch over the 6578 tons in 2018.

6.4.3 Reference Points

The reference point used to evaluate the status of the stock is the F corresponding to the exploitation rate E (=F/Z) equal to 0.4 (Patterson, 1992). The M used to estimate the Z has been weighted by the selectivity in the age classes and is equal to 0.33. The F corresponding to the E=0.4 is 0.22.

Considering that the F estimated by the model for 2016 is 0.27, the stock resulted slightly overexploited.

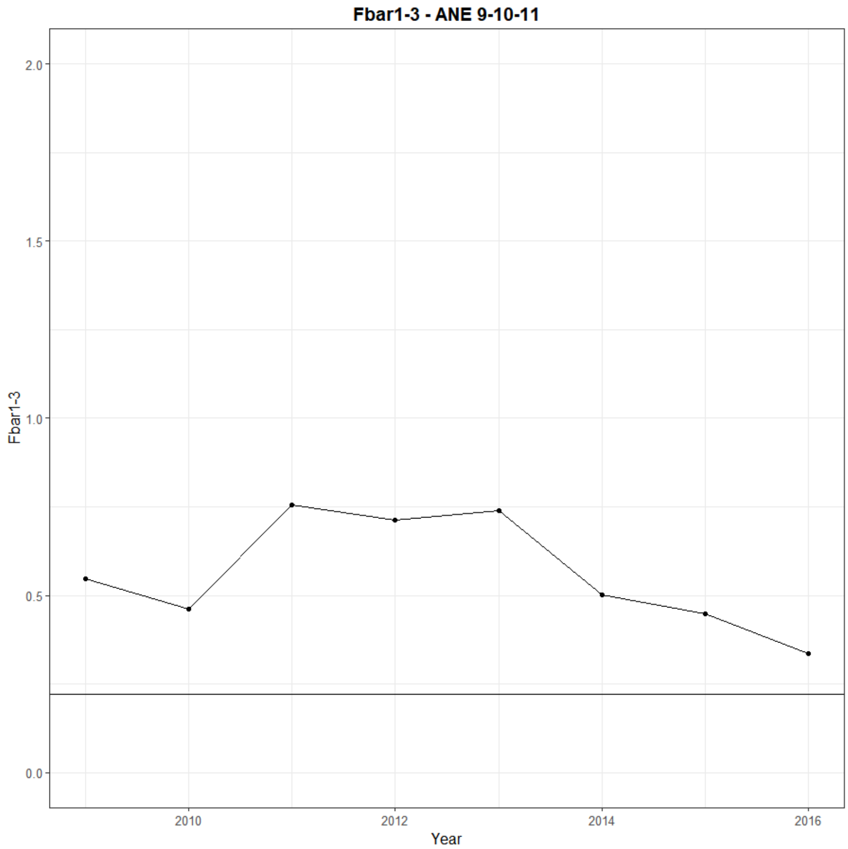


Figure 6.4.3.1 European anchovy in GSAs 9, 10 & 11. Fbar by year compared to the level of F corresponding to E=0.4 (0.22).

6.4.4 Short Term Forecast and Catch Options

Short term forecast was carried out using the routine made available by JRC. The reference point used for the analysis is F=0.22 corresponding to E=0.4. The recruitment from 2017 to 2019 was assumed equal to the geometric mean of the last three years (2014-2016). 22 different F scenarios were simulated in order to evaluate the change in SSB and in the catch in the short term (Table 6.4.4.1 and Figure 6.4.3.1).

Table 5.4.4.1. European anchovy in GSAs 9, 10 & 11. Catch (2017) = 9221 tons.

Rationale	Ffactor	Fbar	Catch 2018	Catch 2019	SSB 2018	SSB 2019	Change SSB 2018-2019 (%)	Change Catch 2016-2018 (%)
Zero catch	0	0	0	0	49742.06	65703.35	32.09	-100
High long term yield (Fmsy)	0.65	0.22	6577.8	7461.0	44087.3	49286.8	11.8	-26.3
Status quo	1.00	0.34	9447.6	9748.0	41417.1	42869.2	3.5	5.8
Different Scenarios	0.10	0.03	1113.6	1492.7	48825.5	62760.9	28.5	-87.5
	0.20	0.07	2185.0	2838.3	47928.7	59991.7	25.2	-75.5
	0.30	0.10	3216.3	4051.0	47051.4	57384.4	22.0	-64.0
	0.40	0.13	4209.1	5143.5	46193.1	54928.6	18.9	-52.9
	0.50	0.17	5165.1	6127.2	45353.2	52614.4	16.0	-42.2
	0.60	0.20	6086.0	7012.7	44531.5	50432.8	13.3	-31.9
	0.70	0.24	6973.3	7809.3	43727.4	48375.1	10.6	-21.9
	0.80	0.27	7828.4	8525.7	42940.6	46433.4	8.1	-12.3
	0.90	0.30	8652.7	9169.6	42170.6	44600.4	5.8	-3.1
	1.10	0.37	10214.3	10267.3	40679.7	41233.2	1.4	14.4
	1.20	0.40	10954.1	10733.1	39958.1	39686.6	-0.7	22.7
	1.30	0.44	11668.1	11150.8	39251.8	38223.7	-2.6	30.6
	1.40	0.47	12357.3	11525.0	38560.5	36839.2	-4.5	38.4
	1.50	0.50	13023.0	11859.9	37883.9	35528.4	-6.2	45.8
	1.60	0.54	13665.9	12159.6	37221.6	34286.6	-7.9	53.0
	1.70	0.57	14287.2	12427.3	36573.3	33109.5	-9.5	60.0
	1.80	0.60	14887.7	12666.4	35938.7	31993.4	-11.0	66.7
	1.90	0.64	15468.3	12879.7	35317.4	30934.3	-12.4	73.2
	2.00	0.67	16029.9	13069.6	34709.3	29928.9	-13.8	79.5

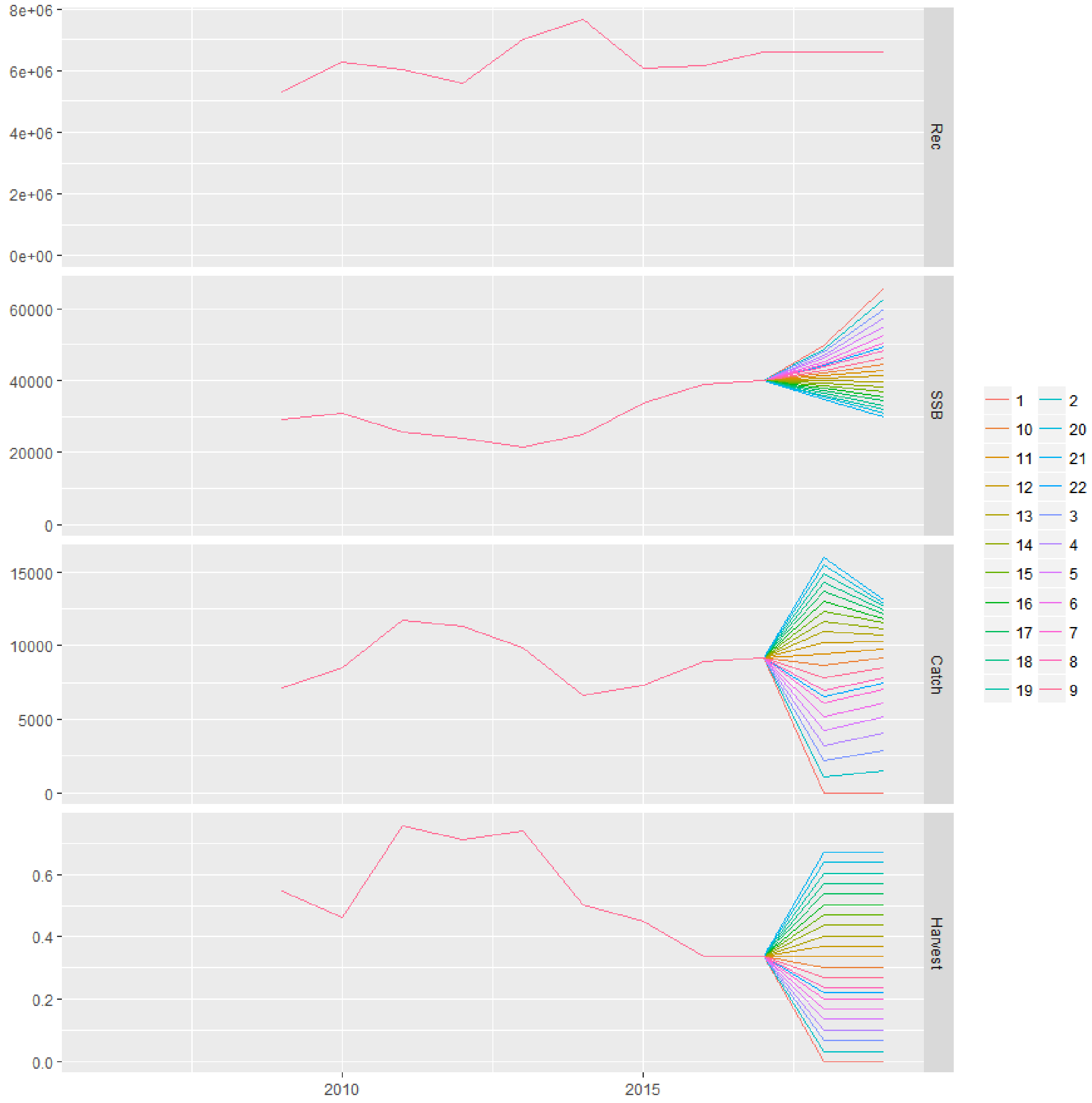


Figure 6.4.4.1 European anchovy in GSAs 9, 10 & 11. Short term forecast for anchovy in GSA 9, 10 and 11.

The analysis showed that fishing at E=0.4 would increase the SSB (from 2018 to 2019) and decrease the catch (from 2016 to 2018) of the about 7%, while fishing at the status quo level would increase the SSB of the 3% and the catch of the 12%. The reduction of the 30% of the fishing mortality would reduce the catch of about 18 %, while would increase the SSB of about the 10%.

6.4.5 Data Deficiencies

The data used for the analyses come from the last DCF official data call (2017). Some deficiencies have been detected and the detailed list is reported in section 7 (Data quality and deficiencies by stock).

6.5 STOCK ASSESSMENT ON SARDINE IN GSAS 9, 10 & 11

Stock Identity and biology

STECF 17-09, after analysing the results of the STOCKMED project, concluded that the region represented by the GSAs 8, 9, 10 and 11, corresponding to the Tyrrhenian Sea, is considered inhabited by a unique stock unit. Considering that no data are available for GSA 8, the present assessment covers the areas 9, 10 and 11.

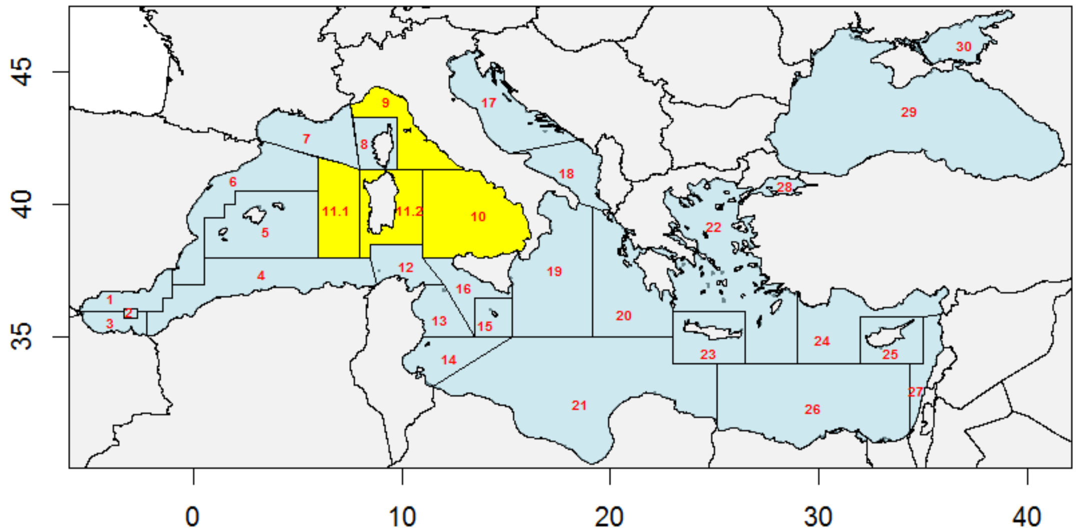


Figure 6.5.1 Geographical location of GSAs 9, 10 and 11.

Growth

The von Bertalanffy parameters from the official Data call by GSA are reported in table 6.5.1.

The experts re-estimated a von Bertalanffy curve for sex combined, based on age readings data from GSA 9 and 10, according to the recommendations of STECF EWG17-07, i.e. constraining t_0 parameter to be higher or equal to -0.2. This combined curve is reported in table 6.5.1. This curve has a growth pattern quite similar to the one of the VBGF estimated for GSA10, at least for ages 1, 2 and 3 which represent generally the bulk of the population.

The comparison of the three curves is reported in the figure 6.5.2.

Table 6.5.1. Sardine in GSAs 9, 10 & 11. Von Bertalanffy growth parameters for sardine by GSAV

GSA	L_{inf} (cm)	K	t_0
9	17.7	0.46	-0.195
10	24	0.305	-0.52
11	23	0.33	0
9-10	19	0.57	-0.2

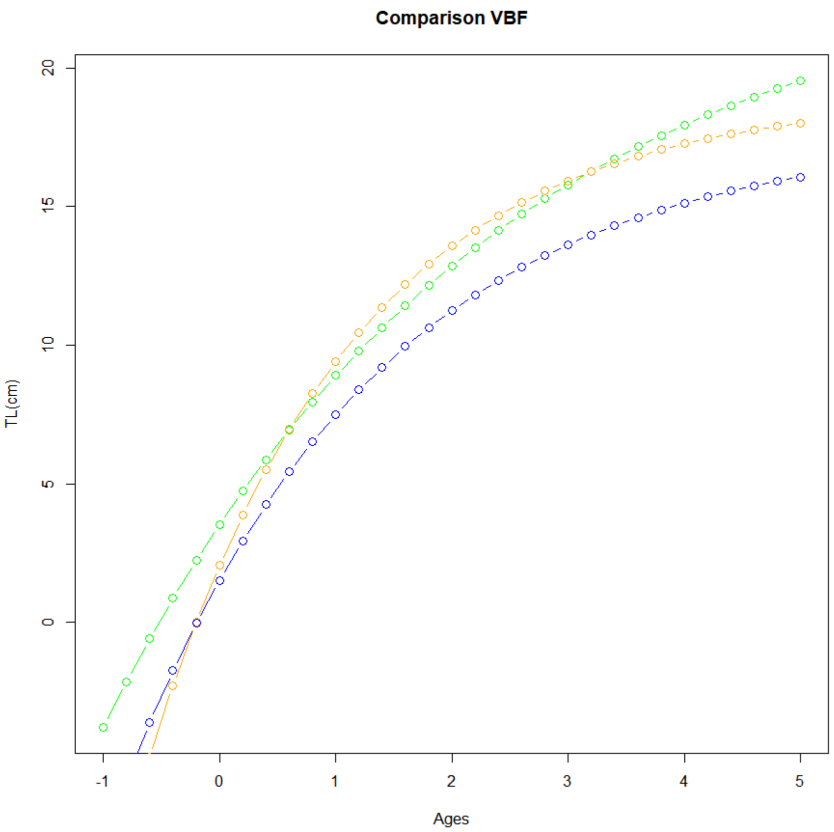


Figure 6.5.2 Sardine in GSAs 9, 10 & 11. Von Bertalanffy growth functions for GSA 9 (blue), GSA 10 (green) and combined GSA9 and 10 (orange).

Maturity

Maturity vector by length and by age is available for GSA 9, 10 and 11. The size at first maturity for this species in this area is about 11.5 cm. The maturity at age vector was obtained according to the re-estimated set of von Bertalanffy parameters and reported in table 6.5.1.1.2.

Table 6.5.2 Sardine in GSAs 9, 10 & 11. Maturity at age of sardine in GSA 9, 10 and 11.

Maturity	Age
0	0
1	0.34
2	0.92
3	1
4+	1

Natural mortality

The natural mortality vector by length was obtained using the Gislason method. The natural mortality by age was derived accordingly to the new set of von Bertalanffy parameters and reported in table 6.5.3.

Table 6.5.3 Sardine in GSAs 9, 10 & 11. Natural mortality at age of sardine in GSA 9, 10 and 11.

M	Age
0	1.236
1	0.795
2	0.694
3	0.619
4+	0.513

6.5.1 Data

6.5.1.1 Catch (landings and discards)

Landing and discard data in weight are reported in the official Data call for the three GSAs from 2002. The length and the age structures of landing and discard are also reported. The landing data showed that the amount of sardine landed in GSA 11 is negligible as well as the discard in the three GSAs. Only one high value of discard is reported for 2011 in GSA 10. The discard was however reconstructed for the years in which its collection was not mandatory and included in the assessment for completeness. The high value of 2011 in GSA10 has been considered as an outlier and thus but it was not further considered.

Table 6.5.1.1.1 Sardine in GSAs 9, 10 & 11. Catch of sardine in GSA 9, 10 and 11 by year. Weights are in tons.

Years/GSA	Landings 9	Landings 10	Landings 11	Discard all the GSAs	TOTAL
2006	4390	1812		107	6309
2007	5153	1506		89	6749
2008	2324	1156		69	3549
2009	5726	3069		182	8977
2010	4507	2452		145	7103
2011	2574	4835	0.15	92	7501
2012	1735	594	0.03	35	2364
2013	1320	630		1	1951
2014	1802	846		99	2747
2015	789	790		47	1626
2016	1186	785		47	2018

The length-frequency distributions for the three GSAs show that the bulk of the catches are between 12 cm and 16 cm.

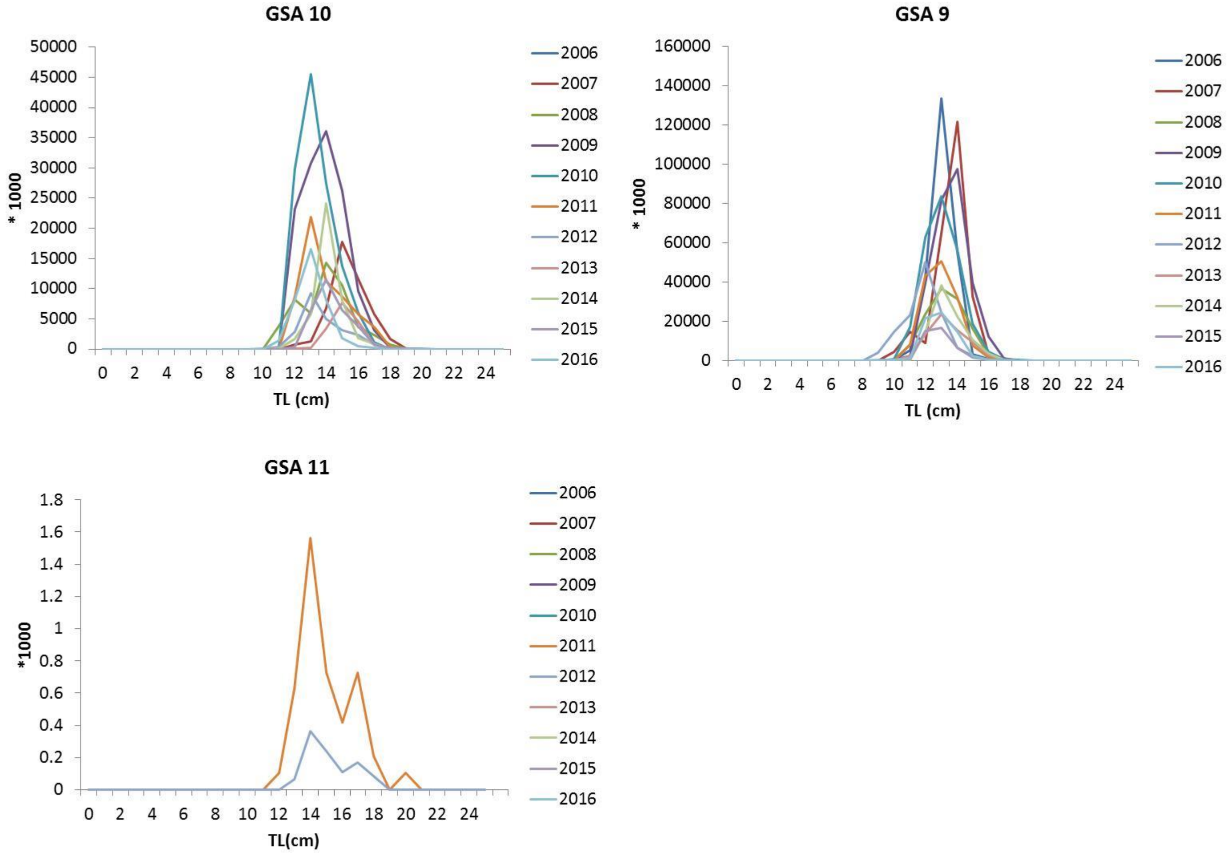


Figure 6.5.1.1.1 Sardine in GSAs 9, 10 & 11. Length-frequency distributions of the commercial catch for the GSA 9, 10 and 11.

6.5.1.2 Effort

The effort data are available for GSA9, 10 and 11. In table 6.5.1.2.1 is reported the nominal effort for the gear targeting this species.

Table 6.5.1.2.1 Sardine in GSAs 9, 10 & 11. Nominal effort in GSA 9, 10 and 11 of the gear targeting sardine in the same area.

Gear Fishery	GND SPF	GNS -1	DEMSP	SLPF	OTM MDPSP	PS -1	SPF	PTM SPF	Total
2002		6504001				1971827			3482552
2003		6925653				2131812			3729759
2004	33051		470584	8321			197055	3087	245597
2005	14704		491883	40677			183408		264619
2006	48989		206888	15803			151326	2300	149210
2007	41274		186348	24466			188900		146150
2008	41390		165415	5810			146375		121753
2009	33873		185829	8188			97204		112135
2010	12754		169039	8531			79166	100	96249
2011	5246		215673	18224			92535		111663
2012	13436		151782	6443			90075	902	88714
2013	7667		108838	11197			84920		75691
2014	7669		131454	10283	95902		79945		84384

2015	2991	103917	21182	114496	96328	83473
2016	8221	134261	13997		102839	93157

6.5.1.3 Survey data

Acoustic survey data are available from the official Data call only for GSA 10 and 9. No data on biomass or abundance were available in GSA 10 and GSA9 for the years 2010 and 2012. Also for GSA9 no data on biomass or abundance was available for 2013. No data were available before 2009.

Length structures from MEDITS data are available since 2011 for GSA9 and since 2012 for GSA10 and GSA11.

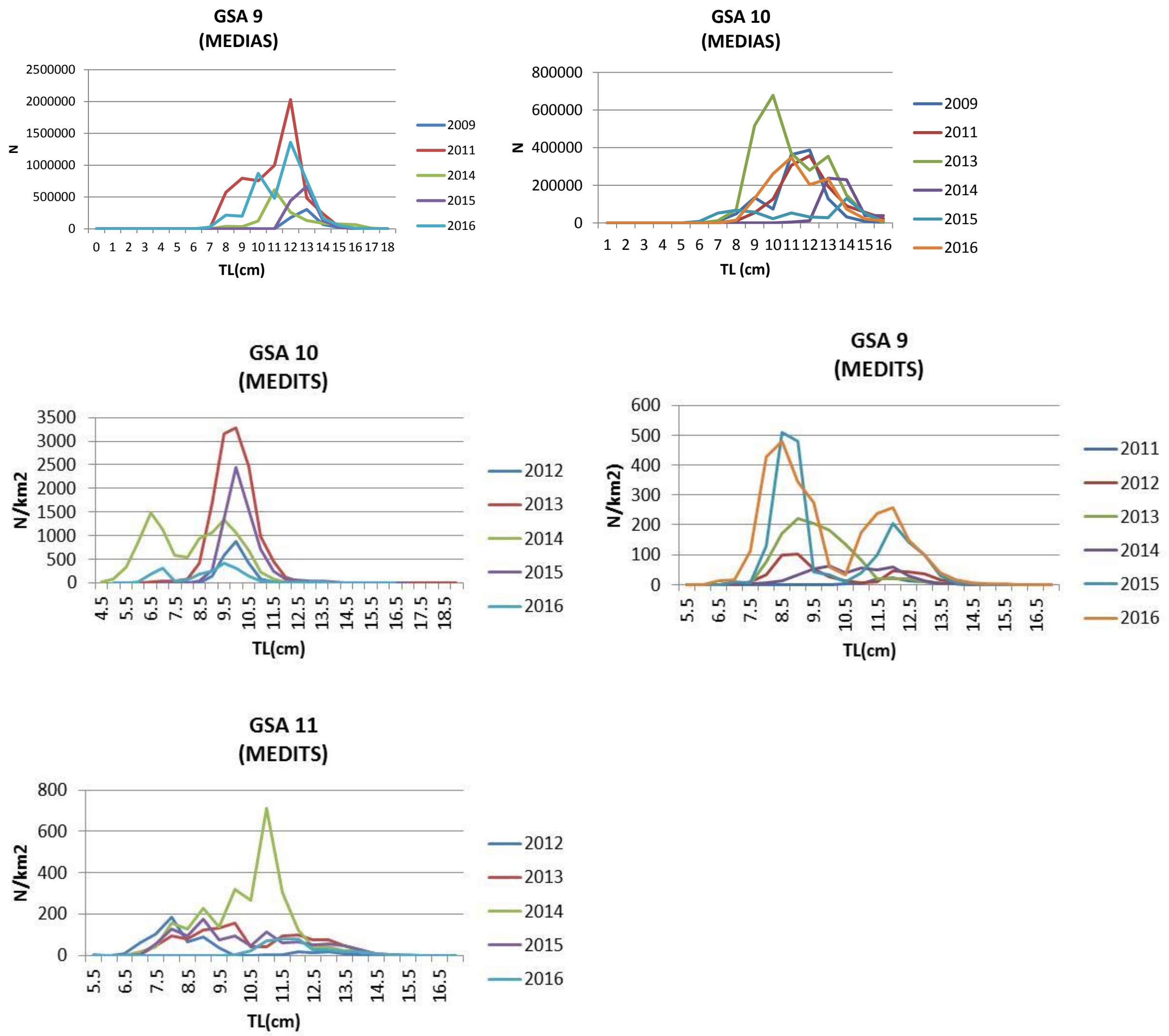


Figure 6.5.1.3.1 Sardine in GSAs 9, 10 & 11. Length-frequency distributions from the acoustic survey MEDIAS and from the MEDITS trawl survey for the GSA 9, 10 and 11.

6.5.2 STOCK ASSESSMENT

Methods: XSA (Extended Survival Analysis)

During the STECF-14-08 the sardine stock of GSA 9 was assessed by a separable VPA, being lacking the acoustic survey data. No previous assessment related to the GSA9, 10 and 11 combined was carried out.

FLR libraries were employed in order to carry out an XSA based assessment. The major assumption of the method is the flat selectivity for the oldest ages (selectivity as classical ogive), that for this species was considered plausible. The method performs a tuning by survey index by age and was applied using the age data obtained by the slicing of the length frequency distributions of the catch and survey data.

Input data

Two runs have been carried out, differing only in the slicing method for deriving the catch at age matrices (for commercial catch and for survey):

1) The length frequency distributions of GSA 9, both for the surveys and for the commercial catches, were sliced according the age-length keys estimated for GSA 9 using an ALK stabilised over the years. An analogous procedure was applied for GSA 10 using the stabilised ALK estimated for this GSA. The length frequency distributions of GSA 11 were sliced with a combined (GSA9 and 10) age-length key, lacking specific information on age-length key for GSA 11;
2) The length frequency distributions of all GSAs were sliced by deterministic age slicing (LFDA algorithm) using the re-estimated von Bertalanffy parameters on the basis of the age-length data from GSA 9 and 10 provided by the experts (see Table 6.5.1).

The catch at age matrices for the two runs are reported in table 6.5.2.1. SoP corrections were not applied, being the differences among the observed catch and the SoP on average less of 4.5% and 6 respectively for ALK and age slicing runs. These have a negligible impact on the assessment, and as short term forecasts are not used do not influence the results.

Table 6.5.2.1 Sardine in GSAs 9, 10 & 11. Catch at age matrices derived from age-length key and from deterministic age slicing.

ALK	0	1	2	3	4+
2006	721	61633	176468	92894	1350
2007	3431	26704	139530	123391	3708
2008	654	34224	82593	51159	1894
2009	494	66347	197700	134562	5089
2010	1551	91856	183550	90097	2485
2011	550	46050	103063	52679	1240

2012	15017	48479	68072	20263	314
2013	117	10777	42242	28915	1403
2014	127	21628	68477	40880	1378
2015	374	16503	39164	18522	674
2016	647	29443	52092	22108	228

Age slicing	0	1	2	3	4+
2006	60	196494	112879	11757	3738
2007	60	88772	184327	16538	5744
2008	60	82860	75960	7386	2277
2009	60	168022	209101	23367	2925
2010	60	228719	127388	11210	1212
2011	60	126513	65830	8561	2693
2012	2428	123551	18644	2727	575
2013	60	37554	37441	7557	854
2014	60	52867	67065	5843	808
2015	60	37766	28841	4561	917
2016	130	69945	30218	930	91

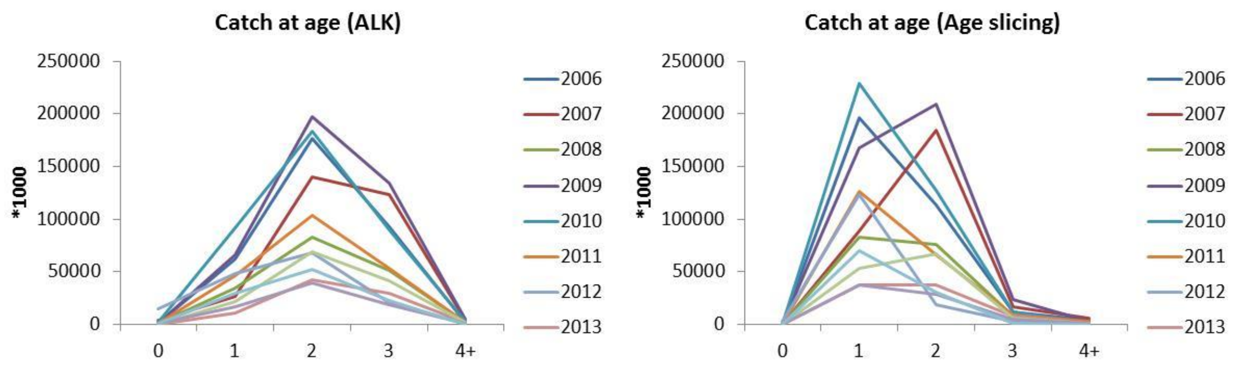


Figure 6.5.2.1 Sardine in GSAs 9, 10 & 11. Catch at age matrices derived from age-length key and from deterministic age slicing.

The catch at age plots show a different pattern: indeed, using ALK the bulk of the catches is at ages 2 and 3, while using age slicing the most part of individuals are from ages 1 and 2.

Table 6.5.2.2 Sardine in GSAs 9, 10 & 11. Catch (discards + landings in weight) data used for both runs. Weights are in tons.

Year	**Catch**
2006	6309
2007	6749
2008	3549
2009	8977

2010	7103
2011	7501
2012	2364
2013	1951
2014	2747
2015	1626
2016	2018

The individual weight at age in catches and in the stock are reported in table 6.5.2.3.

Table 6.5.2.3 Sardine in GSAs 9, 10 & 11. Individual weight at age in the catches and in the stock for the ALK and age slicing runs. Weights in kg.

	0	**1**	**2**	**3**	**4+**
Catch in weight (ALK)	0.006	0.014	0.02	0.029	0.042
Stock in weight (ALK)	0.002	0.013	0.028	0.035	0.046
Catch in weight (Age slicing)	0.007	0.019	0.029	0.042	0.051
Stock in weight (Age slicing)	0.002	0.013	0.028	0.035	0.046

The maturity at age vector and the natural mortality vector for the two runs is reported in table 6.5.2.4.

Table 6.5.2.4 Sardine in GSAs 9, 10 & 11. Maturity and natural mortality at age for the ALK and age slicing runs.

	0	**1**	**2**	**3**	**4+**
Maturity (ALK)	0	0.34	0.92	1	1
Natural mortality (ALK)	1.236	0.795	0.694	0.619	0.513
Maturity (Age slicing)	0	1	1	1	1
Natural mortality (Age slicing)	1.880	0.930	0.610	0.510	0.440

The MEDITS indices by length were re-estimated treating the three GSAs as a unique area, starting from the TC files (Table 6.5.2.5) and re-stratifying the single hauls in the TA files of the three GSAs. The aggregated indices from acoustic surveys MEDIAS were derived summing up the GSA 9 and 10, being absolute numbers.

Table 6.5.2.5 Sardine in GSAs 9, 10 & 11. Survey (MEDIAS and MEDITS) indices by age for ALK and Age slicing runs.

MEDITS (ALK)	**0**	**1**	**2**	**3**	**4+**

2012	549	167	165	53	2
2013	4167	1283	597	160	5
2014	671	822	1311	435	4
2015	6763	673	782	243	6
2016	2143	638	680	189	5
MEDITS (Age slicing)	**0**	**1**	**2**	**3**	**4+**
2012	237	610	77	8	3
2013	1109	4803	259	37	4
2014	267	2292	639	42	6
2015	6100	1995	325	42	6
2016	1650	1716	246	31	16
MEDIAS survey (ALK)	**0**	**1**	**2**	**3**	**4+**
2009	433419	1125882	823859	228733	14979
2010	NA	NA	NA	NA	NA
2011	12049	300354	591498	245629	4087
2012	NA	NA	NA	NA	NA
2013	NA	NA	NA	NA	NA
2014	204935	375743	850079	359577	3546
2015	3055100	2419945	2363995	544971	2643
2016	1403655	1721328	1794524	507007	4839
MEDIAS survey (Age slicing)	**0**	**1**	**2**	**3**	**4+**
2009	197572	2125411	225699	72511	5680
2010	NA	NA	NA	NA	NA
2011	6402	692750	405112	46070	3282
2012	NA	NA	NA	NA	NA
2013	NA	NA	NA	NA	NA
2014	162278	1209826	405540	14567	1712
2015	1437263	6412378	533445	2316	1378
2016	449980	4560058	396558	23796	990

Results

Sensitivity analyses were conducted to assess the effect of the main parameters. Setting rage value=0 and 1, qage=1 and 2, shk.years=3 and shk.ages=3, values ranging from 0.5 to 3 (0.5 increasing) have been tested.

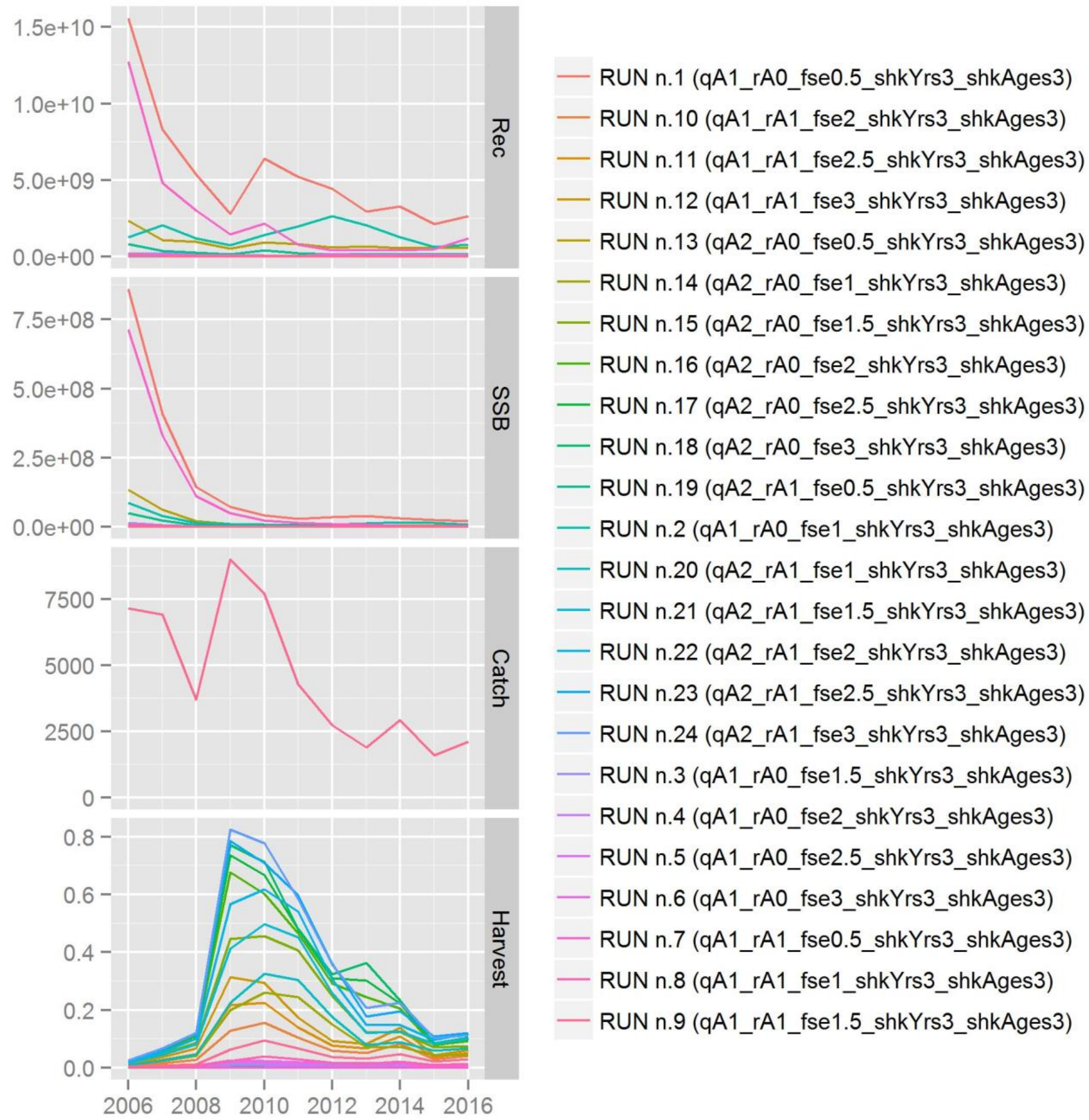


Figure 6.5.2.2 Sardine in GSAs 9, 10 & 11. Sensitivity of settings and shrinkages for ALK run.

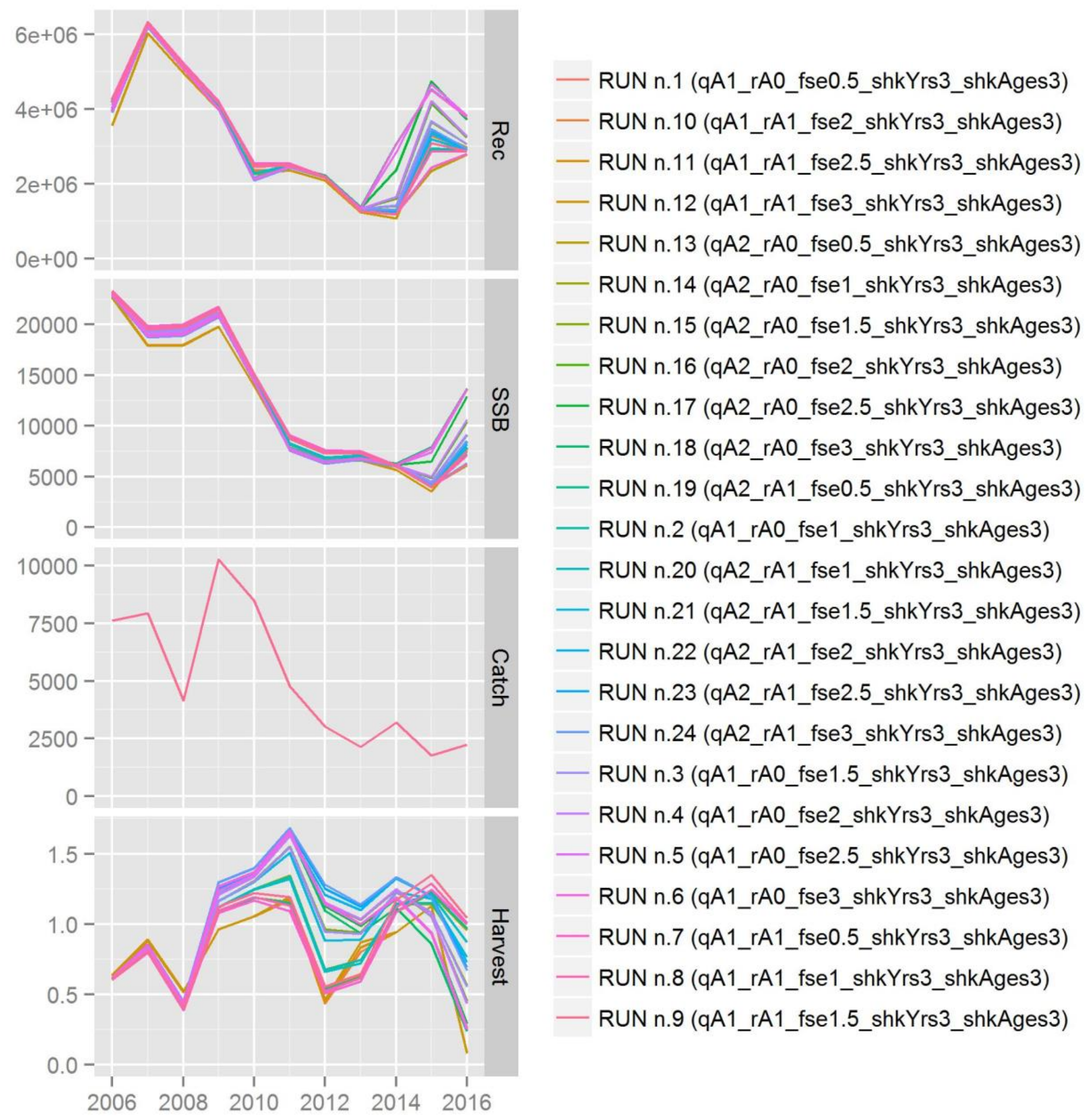


Figure 6.5.2.3 Sardine in GSAs 9, 10 & 11. Sensitivity of settings and shrinkages for Age slicing run.

The ALK run results show a very low value of fishing mortality (around 0.1), while in the other hand a decrease in SSB until a quite high value in 2016 (about 30000 tons) respect to the total catch. Conversely, in the age slicing run shows a higher level of fishing mortality (around 0.6 in 2016), a decreasing pattern in SSB with a very low value in 2016 (about 9000 tons) compared to the total catch.

In Table 6.5.2.6 the residuals of the models with ALK for the different settings are presented.

Table 6.5.2.6 Sardine in GSAs 9, 10 & 11. Residuals of the models with ALK for the different settings.

run	rAGES	qAGES	FSE	shk_yrs	shk_ages	min	max	avg_abs_values	median_abs_values
RUN n.1 (qA1_rA0_fse0.5)	0	1	0.5	3	3	-1.70	1.25	0.55	0.49
RUN n.2 (qA1_rA0_fse1)	0	1	1	3	3	-1.53	1.30	0.59	0.49
RUN n.3 (qA1_rA0_fse1.5)	0	1	1.5	3	3	-0.77	2.03	0.44	0.14
RUN n.4 (qA1_rA0_fse2)	0	1	2	3	3	-0.72	2.09	0.53	0.35
RUN n.5 (qA1_rA0_fse2.5)	0	1	2.5	3	3	-0.72	2.12	0.53	0.34
RUN n.6 (qA1_rA0_fse3)	0	1	3	3	3	-0.71	2.13	0.54	0.34
RUN n.7 (qA1_rA1_fse0.5)	1	1	0.5	3	3	-17.07	3.54	8.07	8.39
RUN n.8 (qA1_rA1_fse1)	1	1	1	3	3	-12.67	0.01	5.62	5.15
RUN n.9 (qA1_rA1_fse1.5)	1	1	1.5	3	3	-11.79	0.01	5.21	4.76
RUN n.10 (qA1_rA1_fse2)	1	1	2	3	3	-11.22	0.02	4.95	4.37
RUN n.11 (qA1_rA1_fse2.5)	1	1	2.5	3	3	-10.91	0.02	4.81	4.20
RUN n.12 (qA1_rA1_fse3)	1	1	3	3	3	-10.66	0.03	4.71	4.05
RUN n.13 (qA2_rA0_fse0.5)	0	2	0.5	3	3	-1.57	0.95	0.49	0.26
RUN n.14 (qA2_rA0_fse1)	0	2	1	3	3	-1.27	1.03	0.43	0.35
RUN n.15 (qA2_rA0_fse1.5)	0	2	1.5	3	3	-1.20	1.01	0.43	0.33
RUN n.16 (qA2_rA0_fse2)	0	2	2	3	3	-0.92	0.81	0.35	0.29
RUN n.17 (qA2_rA0_fse2.5)	0	2	2.5	3	3	-0.92	0.82	0.36	0.29
RUN n.18 (qA2_rA0_fse3)	0	2	3	3	3	-0.92	0.89	0.37	0.27
RUN n.19 (qA2_rA1_fse0.5)	1	2	0.5	3	3	-1.97	1.15	0.40	0.08
RUN n.20 (qA2_rA1_fse1)	1	2	1	3	3	-0.93	0.91	0.33	0.19
RUN n.21 (qA2_rA1_fse1.5)	**1**	**2**	**1.5**	**3**	**3**	**-0.90**	**0.85**	**0.16**	**0.03**
RUN n.22 (qA2_rA1_fse2)	1	2	2	3	3	-0.90	0.85	0.16	0.02
RUN n.23 (qA2_rA1_fse2.5)	1	2	2.5	3	3	-1.66	1.71	0.55	0.26
RUN n.24 (qA2_rA1_fse3)	1	2	3	3	3	-2.14	1.59	0.47	0.23

In Table 6.5.2.7 the residuals of the models with age slicing for the different settings are presented.

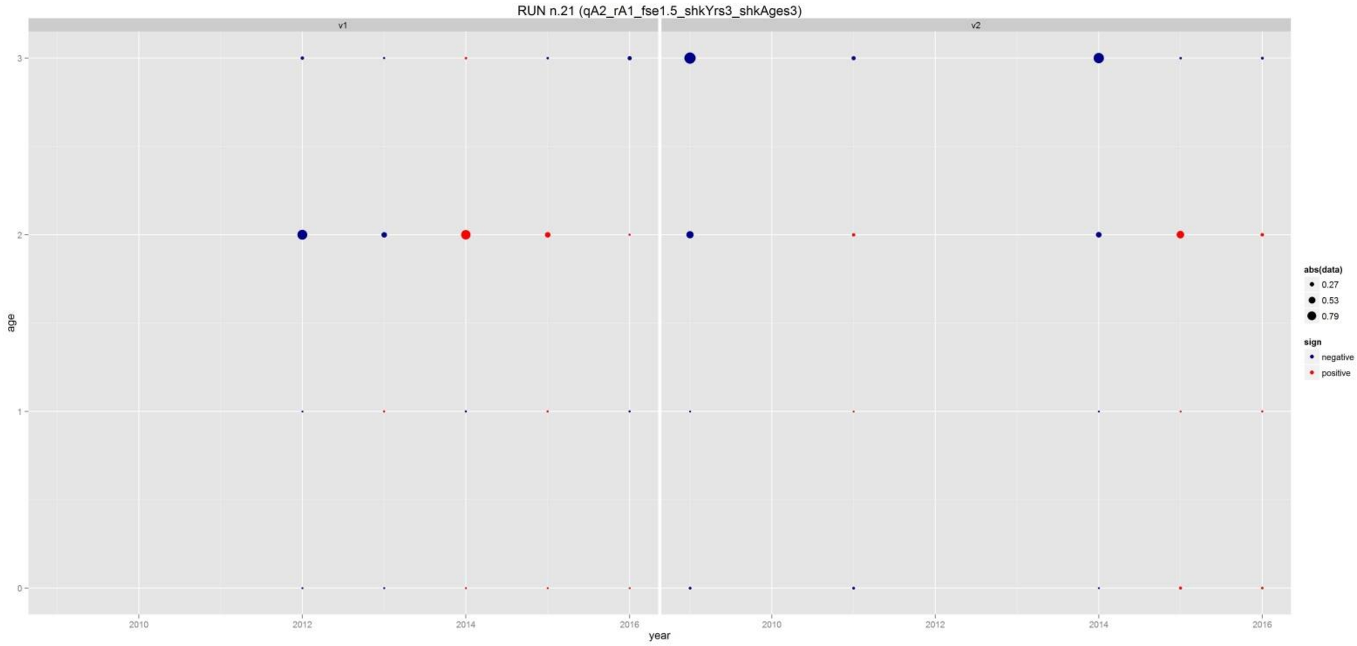
Table 6.5.2.7 Sardine in GSAs 9, 10 & 11. Residuals of the models with age slicing for the different settings.

run	rAGES	qAGES	FSE	shk_yrs	shk_ages	minimum	maximux	average_abs_values	median_abs_values
RUN n.1 (qA1_rA0_fse0.5)	0	1	0.5	3	3	-2.37	1.04	0.75	0.58
RUN n.2 (qA1_rA0_fse1)	0	1	1	3	3	-1.8	0.94	0.61	0.46
RUN n.3 (qA1_rA0_fse1.5)	**0**	**1**	**1.5**	**3**	**3**	**-1.37**	**0.82**	**0.48**	**0.37**
RUN n.4 (qA1_rA0_fse2)	0	1	2	3	3	-1.23	0.87	0.44	0.34
RUN n.5 (qA1_rA0_fse2.5)	0	1	2.5	3	3	-1.3	0.97	0.54	0.58
RUN n.6 (qA1_rA0_fse3)	0	1	3	3	3	-1.39	0.98	0.58	0.71
RUN n.7 (qA1_rA1_fse0.5)	1	1	0.5	3	3	-9.92	2.41	4.32	4.37
RUN n.8 (qA1_rA1_fse1)	1	1	1	3	3	-9.88	2.77	4.35	4.57
RUN n.9 (qA1_rA1_fse1.5)	1	1	1.5	3	3	-9.78	3.05	4.35	4.71
RUN n.10 (qA1_rA1_fse2)	1	1	2	3	3	-9.42	3.9	4.48	4.99
RUN n.11 (qA1_rA1_fse2.5)	1	1	2.5	3	3	-9.35	3.98	4.49	5.04
RUN n.12 (qA1_rA1_fse3)	1	1	3	3	3	-9.28	4.03	4.48	5.07
RUN n.13 (qA2_rA0_fse0.5)	0	2	0.5	3	3	-2.26	1.14	0.74	0.6
RUN n.14 (qA2_rA0_fse1)	0	2	1	3	3	-1.74	0.98	0.61	0.44
RUN n.15 (qA2_rA0_fse1.5)	0	2	1.5	3	3	-1.34	0.84	0.47	0.37
RUN n.16 (qA2_rA0_fse2)	0	2	2	3	3	-1.22	0.88	0.44	0.33
RUN n.17 (qA2_rA0_fse2.5)	0	2	2.5	3	3	-1.05	0.97	0.48	0.4
RUN n.18 (qA2_rA0_fse3)	0	2	3	3	3	-1.25	1	0.57	0.69
RUN n.19 (qA2_rA1_fse0.5)	1	2	0.5	3	3	-2.28	2.42	0.84	0.6
RUN n.20 (qA2_rA1_fse1)	1	2	1	3	3	-2.54	2.81	0.79	0.42
RUN n.21 (qA2_rA1_fse1.5)	1	2	1.5	3	3	-2.95	3.14	0.7	0.27
RUN n.22 (qA2_rA1_fse2)	1	2	2	3	3	-3.19	3.34	0.64	0.27
RUN n.23 (qA2_rA1_fse2.5)	1	2	2.5	3	3	-3.22	3.35	0.62	0.27
RUN n.24 (qA2_rA1_fse3)	1	2	3	3	3	-3.21	3.33	0.61	0.27

In the ALK run the settings minimizing the residuals and the mean diagnostics output also in term of retrospective analysis corresponded to: *rage=1, qage=2, shrinkage years=3, shrinkage ages=3*, with an intermediate weight of the survey *(fse=1.5)* (run 21 of figure 6.5.2.2).

In the age slicing run the settings minimizing the residuals and the mean diagnostics output also in term of retrospective analysis corresponded to *rage=0, qage=1, shrinkage years=3, shrinkage ages=3*, assigning an intermediate weight to the survey *(fse=1.5)* (run 3 of figure 6.5.2.3).

The residuals of the MEDITS trawl survey and MEDIAS survey did not show any particular trend and are shown in Figure 6.5.2.4.



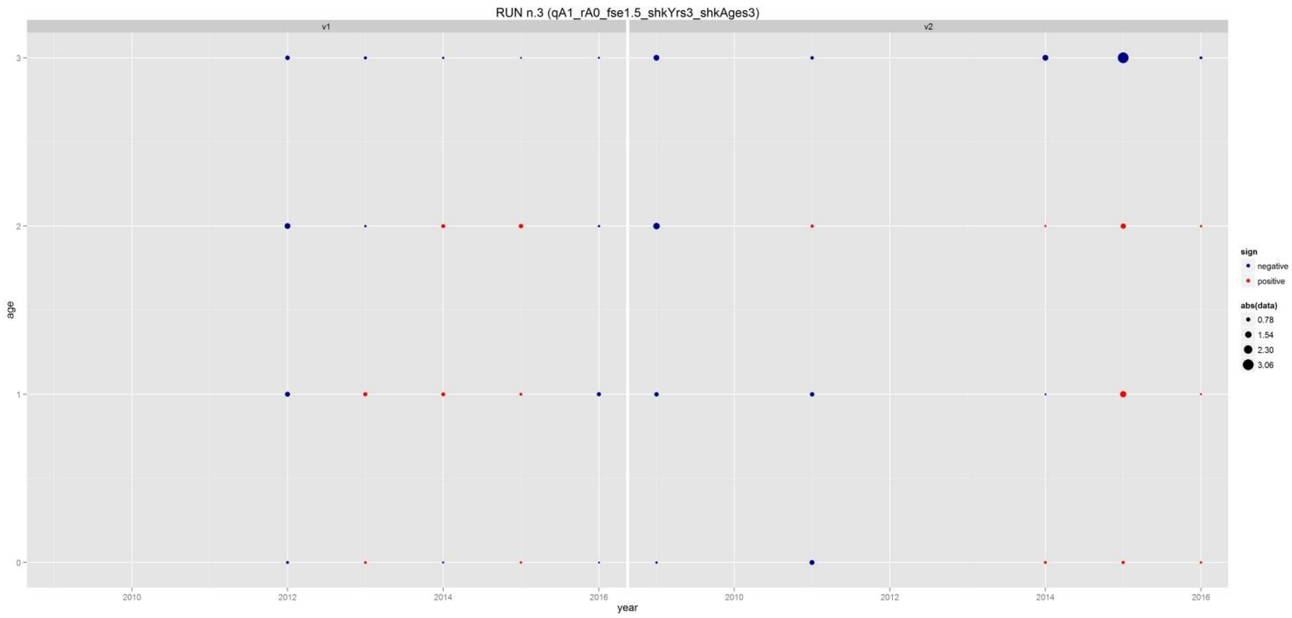


Figure 6.5.2.4 Sardine in GSAs 9, 10 & 11. Residuals for sardine GSA9, 10 and 11 for MEDITS (left) and acoustic survey, for the ALK run (up) and Age slicing run (down).

The results of the retrospective analysis are shown in Figure 6.5.2.5.

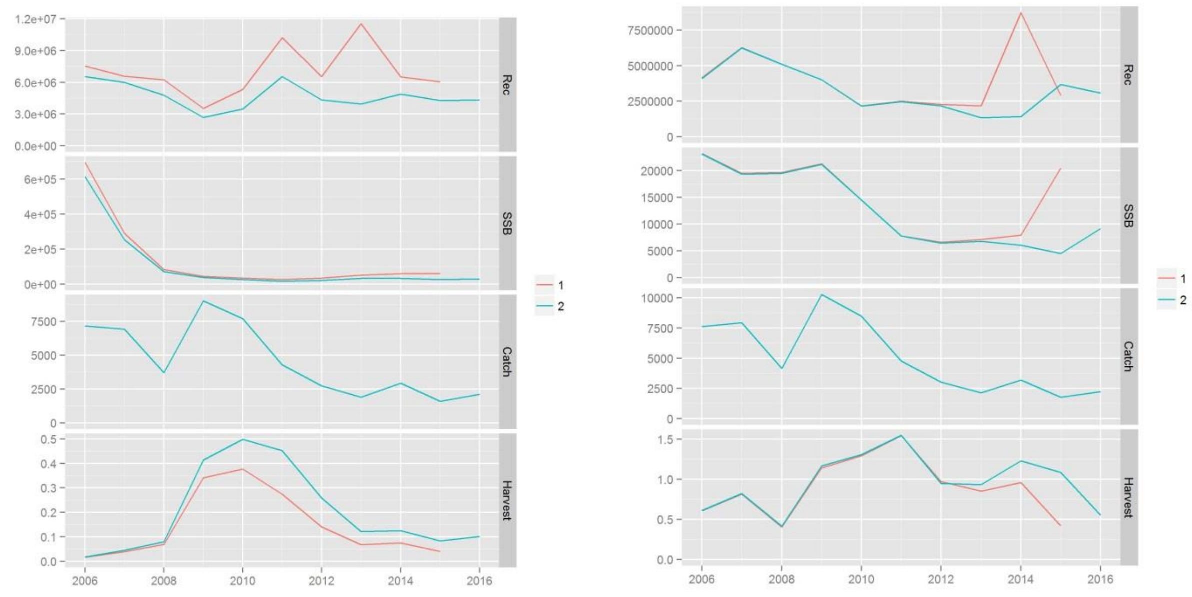


Figure 6.5.2.5 Sardine in GSAs 9, 10 & 11. Retrospective for sardine GSA9,10 and 11 for the ALK run (left) and Age slicing run (right).

Nevertheless, for both runs the retrospective analysis showed a certain level of instability especially for recruitment and harvest.

Despite the same increasing signal in MEDIAS and MEDITS surveys, the final results obtained by the two assessment runs are conflicting. The ALK run showed a high value of SSB with a very low value of F. The value of F is too low to allow the estimation of a reliable estimate, in this case about 10% of M. On the other hand, the age slicing run showed higher absolute residuals respect to the ALK run; moreover, the F is high and the SSB seems inexplicably low compared to the total catch, which is small. Overall it was concluded that neither run could be used as an assessment, however, with the better diagnostics the run showing that the stock is lightly exploited seems most plausible, it better fits the data and better reflect the fishery which is thought to be intermittent and at a low level.

The results of the XSA for the two runs are shown in the following figure and tables.

Table 6.5.2.8 Sardine in GSAs 9, 10 & 11. Stock in numbers for sardine in GSA 9-10-11 for the ALK run.

	year					
age	2006	2007	2008	2009	2010	2011
0	6531626	5996128	4778825	2685578	3466522	6534066
1	5739386	1897337	1740290	1388107	780012.5	1006341
2	10067571	2550382	838856.6	762883.9	582257.6	290511.8
3	9075685	4904766	1175483	360693.6	241381.3	161146.8
4	129732.8	144821.7	42692.6	12955.7	6322.4	3624.8

age	2012	2013	2014	2015	2016
0	4332275	3956257	4887096	4269739	4322631
1	1898137	1250622	1149404	1419848	1240346
2	423499.4	824585.2	557515.8	504515.4	630087
3	72286.3	163455.8	382084.6	230120.5	224361.3
4	1074.8	7694.9	12573.7	8195.4	2256.9

Table 6.5.2.9 Sardine in GSAs 9, 10 & 11. Stock in numbers for sardine in GSA 9, 10 & 11 for the age slicing run.

	year					
age	2006	2007	2008	2009	2010	2011
0	4095093	6253538	5096461	4013108	2148712	2455156
1	1111170	624847.3	954204.6	777646.1	612337.2	327848.8
2	237292.7	314991.7	190774.8	324437.9	201282.9	97933.77
3	40674.29	45727.66	35279.09	47666.07	22150.65	15466.53
4	12546.97	15303.32	10615.32	5663.36	2268.97	4573.37

age	2012	2013	2014	2015	2016
0	2177992	1327600	1417779	3671325	3063191
1	374609.1	331391.7	202555.1	216315.7	560184.4
2	49886.52	70196.8	107163.1	46711.11	61626.24
3	4687.88	13362.85	10542.74	8792.19	4121.24
4	923.83	1416.48	1370.36	1671.28	394.69

Table 6.5.2.10 Sardine in GSAs 9, 10 & 11. Fishing mortality by age and f_{bar} (1-3) for sardine in GSA 9, 10 & 11 for ALK run.

age	2006	2007	2008	2009	2010	2011
	year					
0	0.00	0.00	0.00	0.00	0.00	0.00
1	0.02	0.02	0.03	0.07	0.19	0.07
2	0.03	0.08	0.15	0.46	0.59	0.70
3	0.01	0.03	0.06	0.71	0.71	0.59
4	0.01	0.03	0.06	0.71	0.71	0.59
fbar(1-3)	**0.02**	**0.05**	**0.08**	**0.41**	**0.50**	**0.45**
age	2012	2013	2014	2015	2016	
0	0.01	0.00	0.00	0.00	0.00	
1	0.04	0.01	0.03	0.02	0.04	
2	0.26	0.08	0.19	0.12	0.12	
3	0.48	0.28	0.16	0.12	0.14	
4	0.48	0.28	0.16	0.12	0.14	
fbar(1-3)	**0.26**	**0.12**	**0.13**	**0.08**	**0.10**	

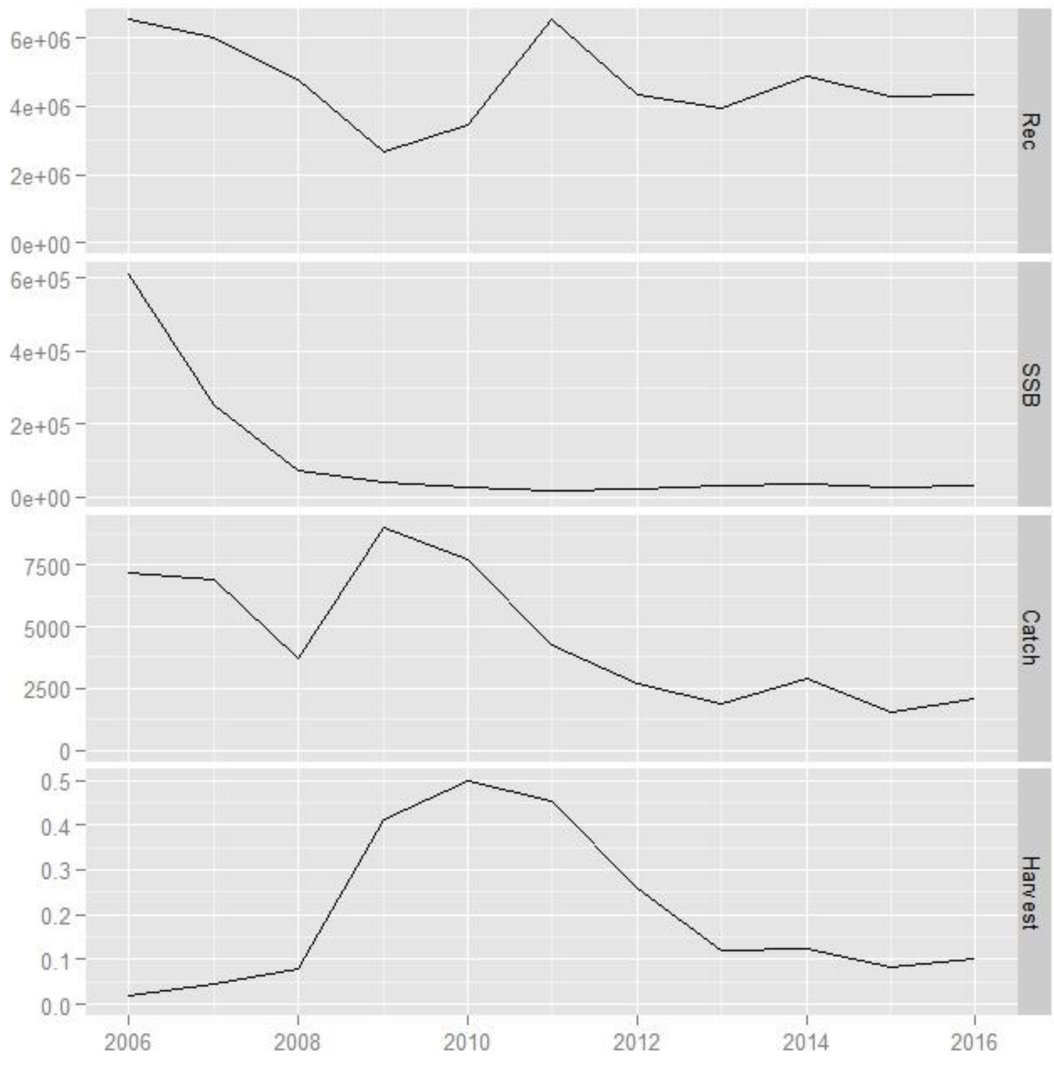
Table 6.5.2.11 Sardine in GSAs 9, 10 & 11. Fishing mortality by age and f_{bar} (1-3) for sardine in GSA 9-10-11 for age slicing run.

age	2006	2007	2008	2009	2010	2011
	year					
0	0.00	0.00	0.00	0.00	0.00	0.00
1	0.33	0.26	0.15	0.42	0.90	0.95
2	1.04	1.58	0.78	2.07	1.96	2.43
3	0.47	0.63	0.31	1.00	1.06	1.25
4	0.47	0.63	0.31	1.00	1.06	1.25
fbar(1-3)	**0.61**	**0.82**	**0.41**	**1.17**	**1.31**	**1.54**
age	2012	2013	2014	2015	2016	
0	0.00	0.00	0.00	0.00	0.00	
1	0.74	0.20	0.54	0.33	0.22	
2	0.71	1.29	1.89	1.82	1.09	
3	1.39	1.31	1.26	1.11	0.34	
4	1.39	1.31	1.26	1.11	0.34	
fbar(1-3)	**0.95**	**0.93**	**1.23**	**1.08**	**0.55**	

Table 6.5.2.12 Sardine in GSAs 9, 10 & 11. Recruitment (* 1000) and SSB (tons) times series for sardine in GSA 9-10-11 for the ALK and age slicing runs.

	SSB (ALK)	**SSB (Age slicing)**	**Rec (ALK)**	**Rec (Age slicing)**
2006	612653	23125	6531626	4095093
2007	254008	19323	5996128	6253538
2008	72833	19495	4778825	5096461

2009	39261	21196	2685578	4013108
2010	27376	14515	3466521	2148712
2011	17833	7775	6534065	2455156
2012	21980	6474	4332275	2177992
2013	33077	6817	3956257	1327600
2014	33599	6091	4887096	1417779
2015	27863	4512	4269738	3671325
2016	29863	9168	4322631	3063191



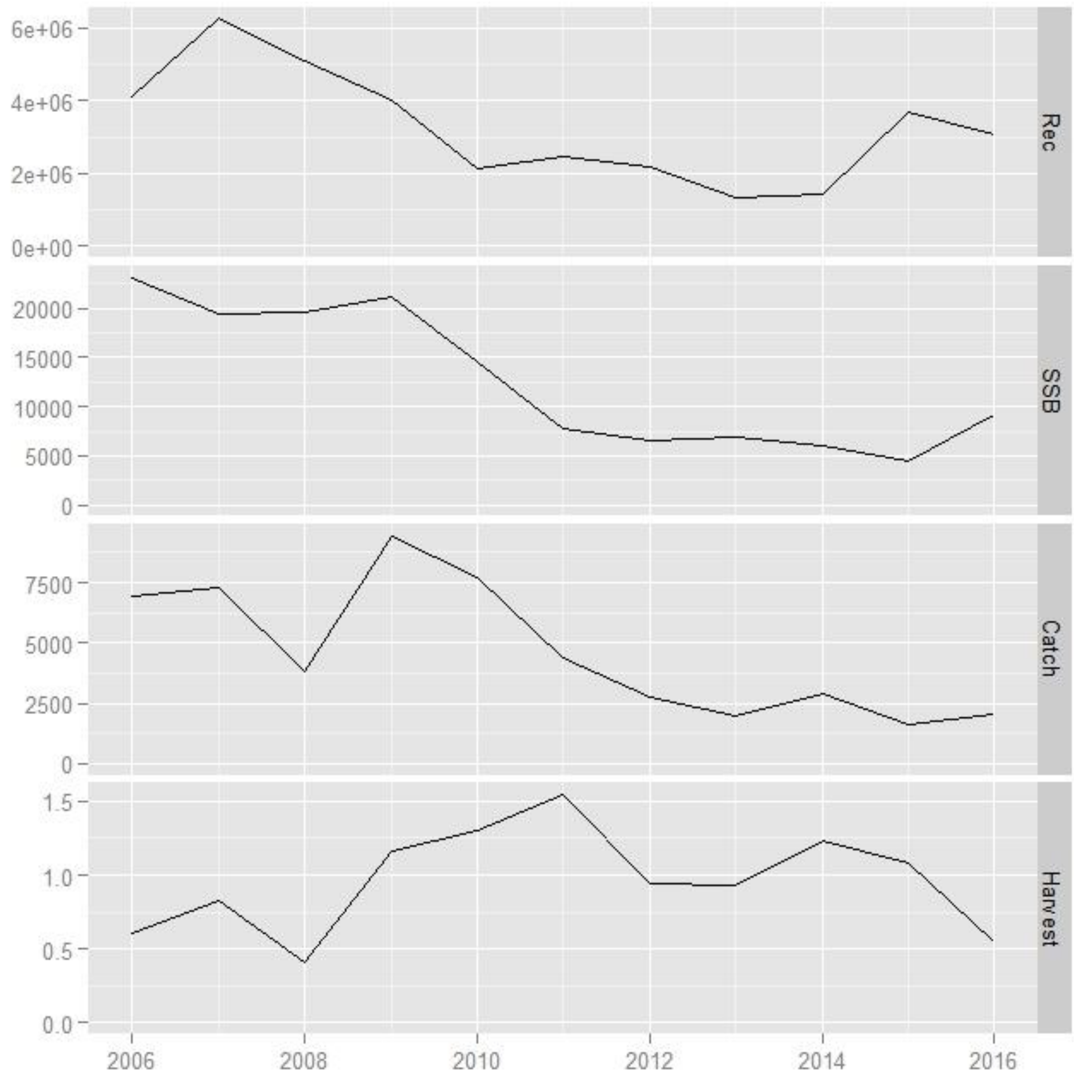


Figure 6.5.2.6 Sardine in GSA 9, 10 & 11. Summary of results for ALK (up) and age slicing results (down).

6.5.3 Reference Points

Considering the conflicting output in the two carried out analyses, it was no possible to establish a reference point for this stock.

6.5.4 Short term Forecast and Catch Options

6.5.4 Short term Forecast and Catch Options

Following the ICES approach on data limited stocks recent stock trends are inferred from an acoustic survey biomass index (Fig 5.5.1.1).

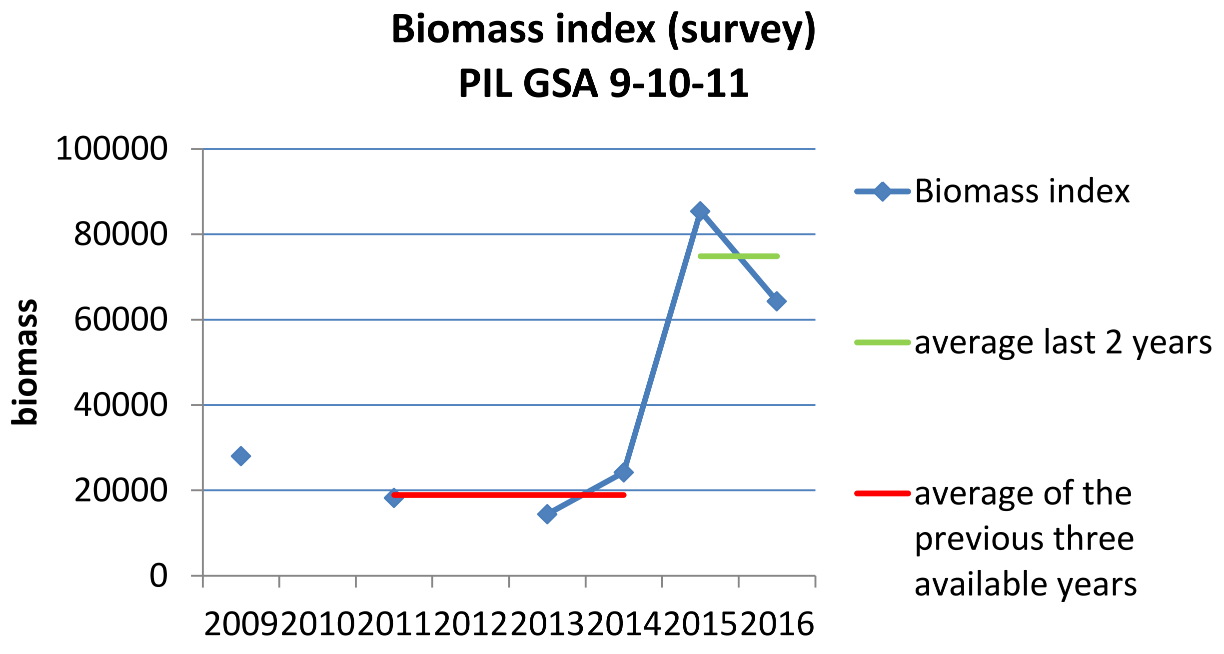


Figure 6.5.4.1 Sardine in GSA 9-10-11. Biomass index from MEDIAS survey. In green the mean of the last two years compared to the previous three years available (red, 2014-2013-2011).

Following the ICES procedures for data limited stocks the change in biomass over the last five years was used to provide an index for change (3.95, Figure 5.5.1.1). As this index is much higher than 1.2, this value is used to multiply the catch to provide an initial catch advice. The exploitation of the stock has been evaluated with a length indicator, this shows that for the last 15 years L_{fem}/L_{mean} has been greater than 1.0, supporting their view the stock is exploited at less than or equal to MSY. In this case it is not necessary to apply a precautionary buffer. The resulting catch advice referred to the average of the last three years (2130 t) is 2556.

Length Indicator Analysis

The length indicator analysis (See details in annex 1 to this report) was carried out for most stocks including sardine in GSA 9, 10 and 11 the results by year are given in Figure 6.5.4.2 and summarised over years in Figure 6.5.4.3. The exploitation rate indicator L_{fem}/L_{mean} is seen to be above 1.0 for the whole time series.

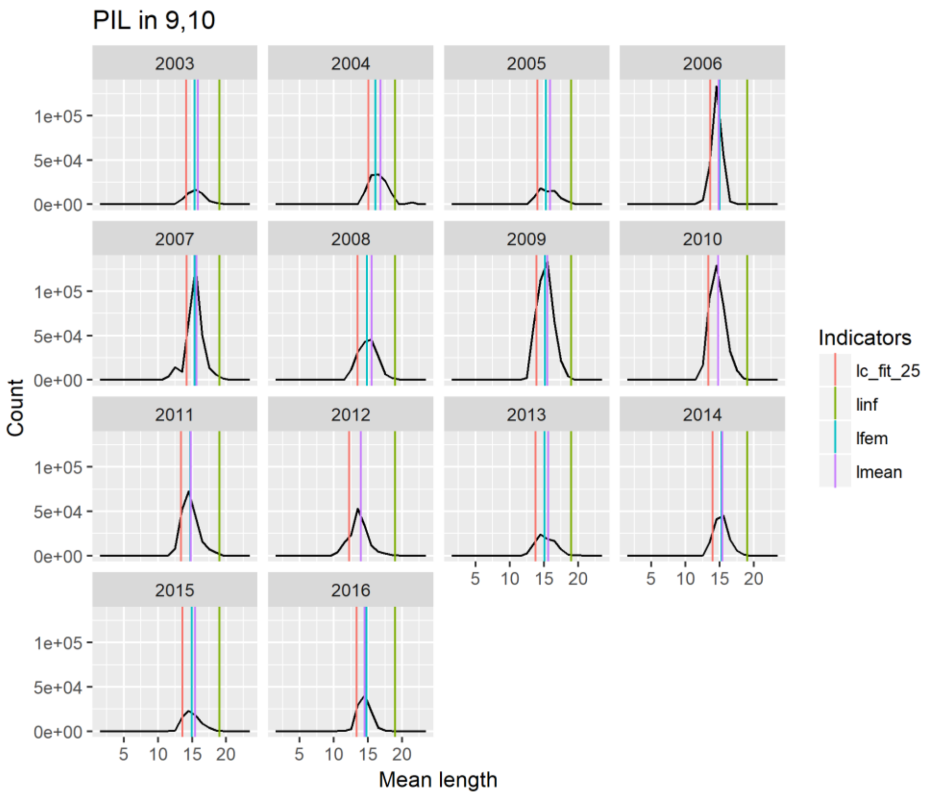


Figure 6.5.4.2, Results of year by year length indicator analysis showing distribution of length in the catch, and the L_{fem} and L_{mean} that are used to evaluate exploitation relative to MSY.

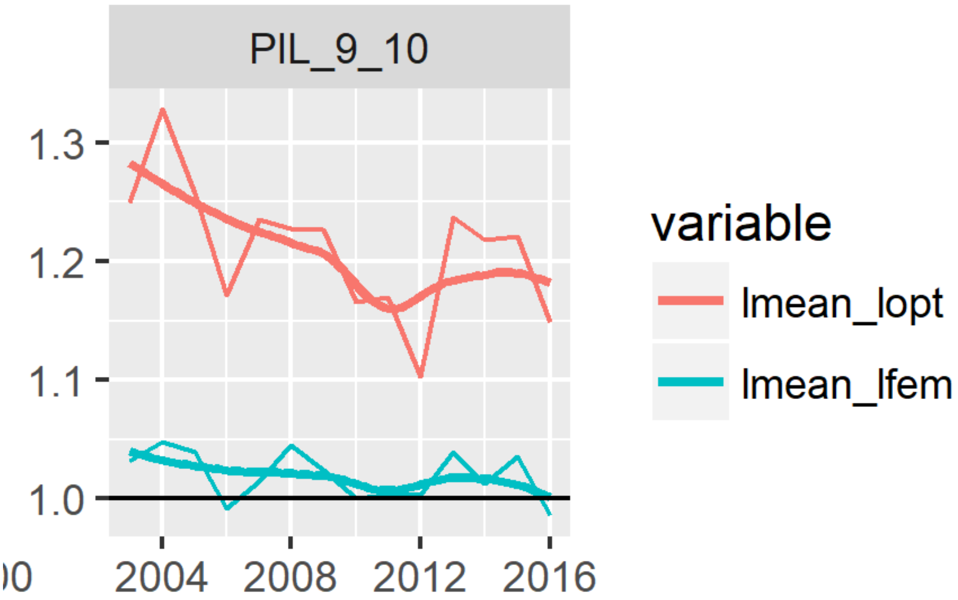


Figure 6.5.4.3, Summary of length indicator analysis showing distribution of length in the catch, and the L_{fem} and L_{mean} that are used to evaluate exploitation relative to MSY.

6.5.5 Data Deficiencies

The data used for the analyses come from the last DCF official data call (2017). Some deficiencies have been detected and the detailed list is reported in section 7 (Data quality and deficiencies by stock).

6.6 STOCK ASSESSMENT ON ATLANTIC HORSE MACKEREL IN GSAS 9, 10 & 11

Stock Identity and biology

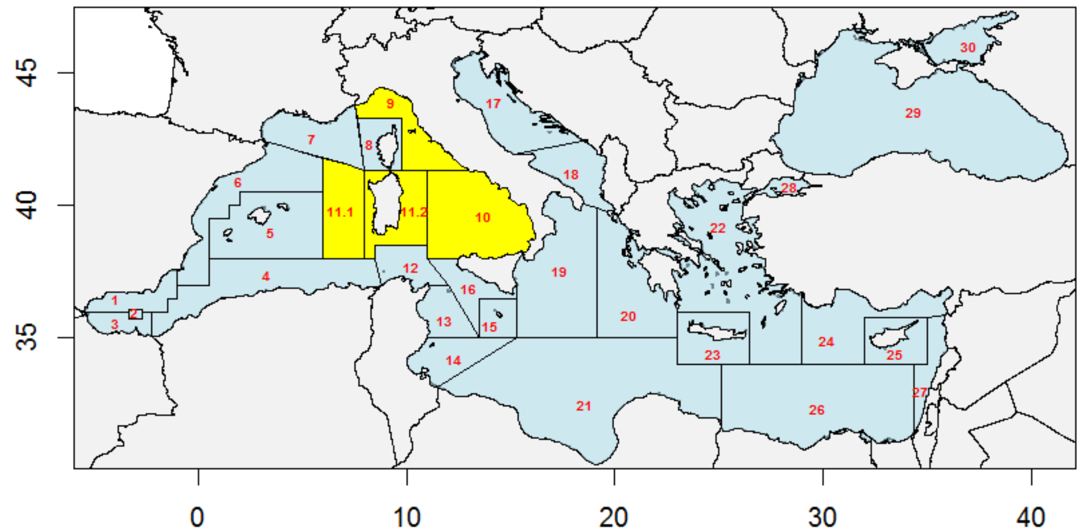


Figure 6.6.1 Geographical location of GSAs 9, 10 and 11.

6.6.1 Data

6.6.1.1 Catch (landings and discards)

Landings

As reported on the DCF data call total landings (tonnes) area available since 2003 in GSA 9, but since 2009 only in all the 3 GASs of the analysed region (Figure 6.6.1.1.1). Landings belong mainly to OTB and PS and other gears and show the lowest values in GSA 11 (Figure 6.6.1.1.2, Tables 6.6.1.1.1 and 6.6.1.1.2).

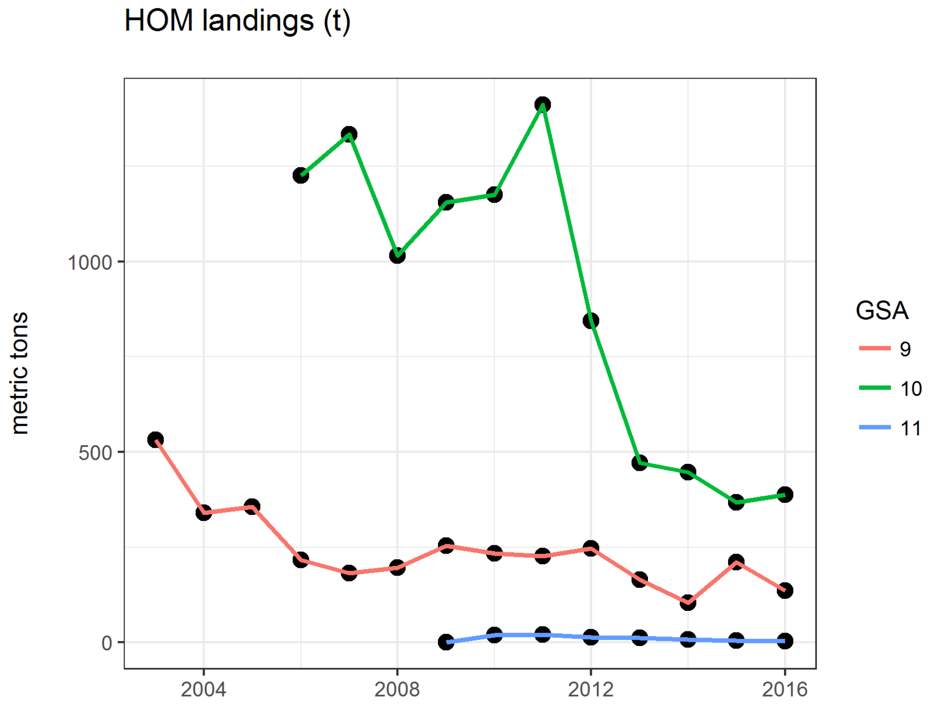


Figure 6.6.1.1.1 Atlantic horse mackerel in GSAs 9, 10 & 11. Trend of total landings by GSA.

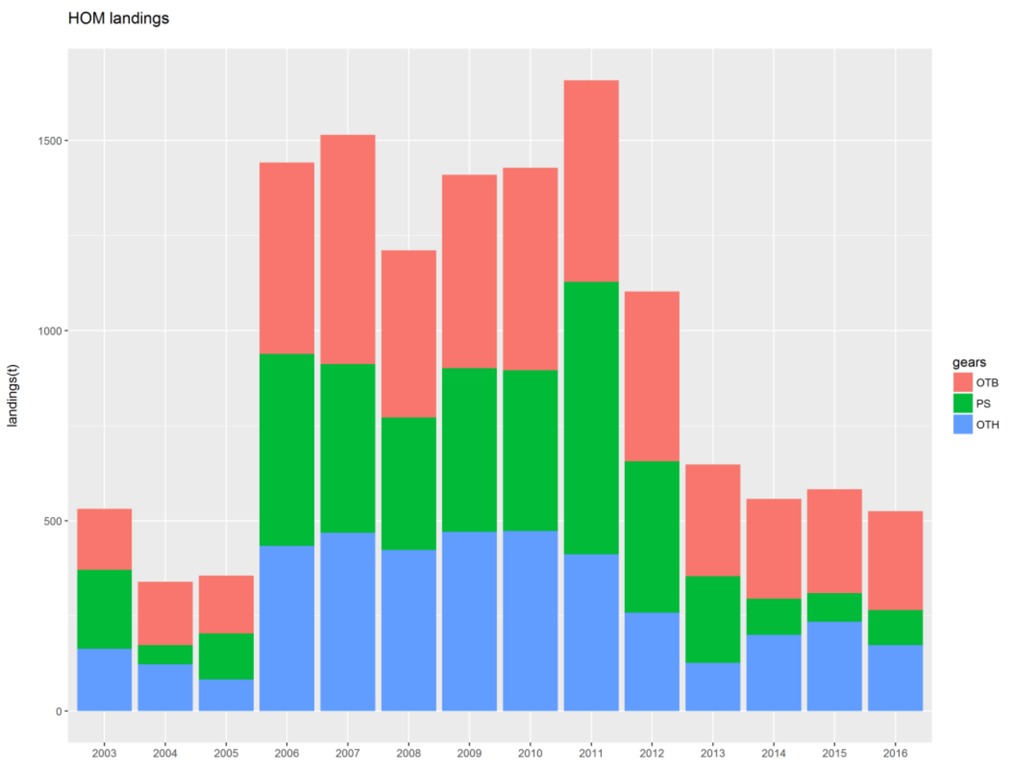


Figure 6.6.1.1.2 Atlantic horse mackerel in GSAs 9, 10 & 11. Total landings by year and main fishing gear in the region.

Table 6.6.1.1.1 Atlantic horse mackerel in GSAs 9, 10 & 11. Year trend on total landings and percent contribution by main gear in the region.

year	OTB	PS	OTH	Total	% OTB	% PS	% OTH
2003	160.7	207.5	163.6	531.8	30.2	39.0	30.8
2004	166.8	50.6	122.4	339.8	49.1	14.9	36.0
2005	151.9	121.6	82.7	356.2	42.6	34.1	23.2
2006	503.5	504	434.4	1441.9	34.9	35.0	30.1
2007	602.6	443.2	468.6	1514.4	39.8	29.3	30.9
2008	439.4	348.4	423.1	1210.9	36.3	28.8	34.9
2009	508.1	430	471	1409.1	36.1	30.5	33.4
2010	532.5	422.4	473.3	1428.2	37.3	29.6	33.1
2011	530	715.9	412	1657.9	32.0	43.2	24.9
2012	446.5	398	258.6	1103.1	40.5	36.1	23.4
2013	293.7	227.8	126.8	648.3	45.3	35.1	19.6
2014	262.5	95	200.4	557.9	47.1	17.0	35.9
2015	272.9	75.3	234.7	582.9	46.8	12.9	40.3
2016	260.4	91.9	173.2	525.5	49.6	17.5	33.0

Landings at length were available from 2007 and reported by main fishing gear (Table 6.6.1.1.2, Fig. 6.6.1.1.3-4). In some GSAs the information by years shows gaps for some gears and some inconsistency along the time series (GSA11, other gears in 2010).

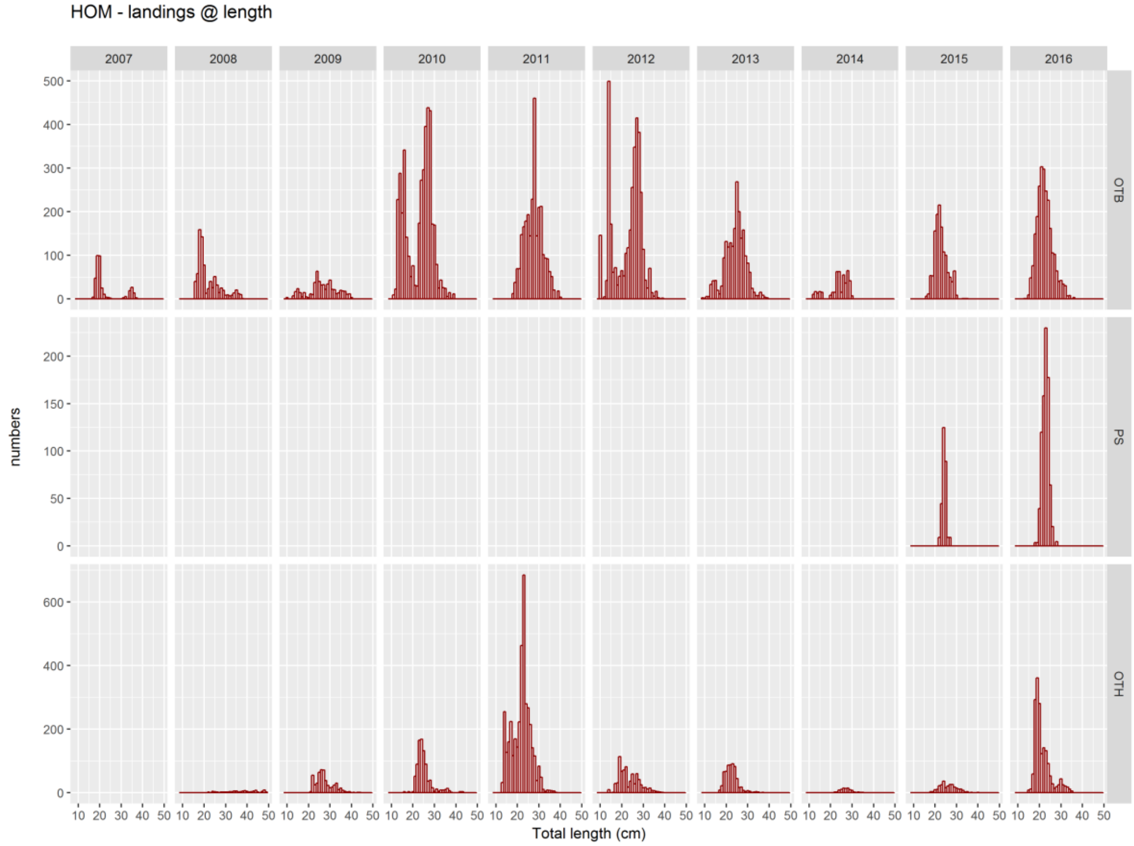


Figure 6.6.1.1.3 Atlantic horse mackerel in GSAs 9, 10 & 11. Length at age distribution by year and main fishing gear in the region (GSAs 9, 10, 11)

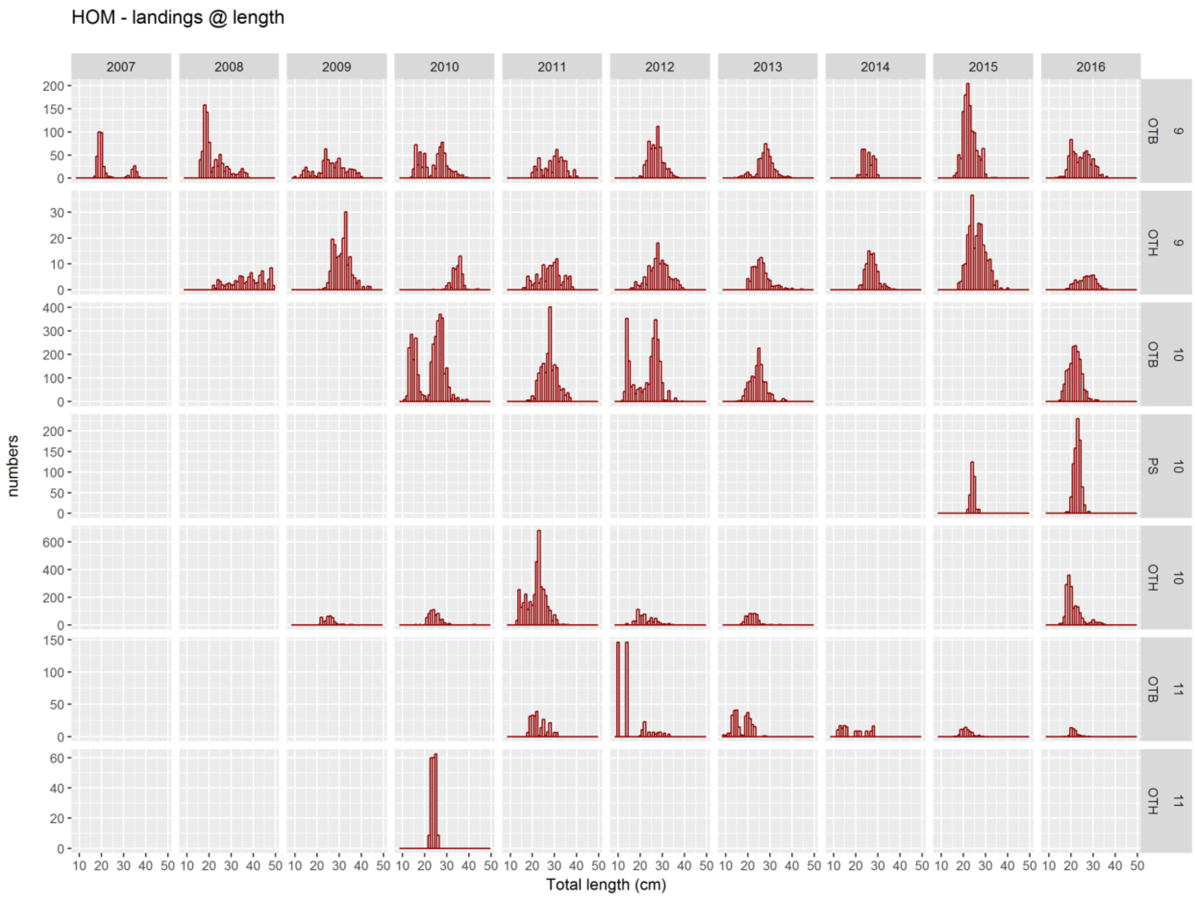


Figure 6.6.1.1.4 Atlantic horse mackerel in GSAs 9, 10 & 11. Landings at length distribution by year, main fishing gear and GSA in the region (GSAs 9, 10, 11) Note that scales differ among the categories.

Table 6.6.1.1.2 Atlantic horse mackerel in GSAs 9, 10 & 11. Landings at length by year and main gear in the region (GSAs 9, 10, 11).

gear	len	2003	2004	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
OTB	6	17.58	0	0	0	0	0	0	0	0	0	0	0
OTB	7	11.72	0	0	0	0	0	0	0	0	0	0	0
OTB	8	11.72	0	0	0	0	0	0	0	0	0	0	0
OTB	9	11.72	0	0	0	0	0	0	0	2.327	0	0	0
OTB	10	29.31	78.37	0	0	3.288	0	0	146.2	1.806	0	0	0
OTB	11	64.48	285.7	0	0	0	9.212	0	0	5.419	0	0	0
OTB	12	76.2	442	0	0	0	23.03	0	4.705	5.036	10.61	0	0
OTB	13	76.2	281.5	0	0	7.002	228	0	42.35	33.34	16.97	0	1.005
OTB	14	76.2	272.9	0	0	16.34	287.8	0	499.1	41.48	12.73	0	0.67
OTB	15	58.62	578.5	0	0	23.34	197.3	0	171.7	42.22	16.97	0	9.255
OTB	16	41.03	468.4	0	40.12	14.36	341.3	0	61.17	19.93	14.85	5.888	48.16
OTB	17	41.03	445.5	3.59	58.04	5.021	141.6	0	71.3	11.25	0	11.78	76.39
OTB	18	70.34	579.3	47.59	158.4	14.53	97.7	12.22	31.76	29.11	0	53.19	149.3

gear	len	2003	2004	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
OTB	19	123.1	143.3	99.66	142.5	4.668	51.1	37.65	51.76	93.93	0	53.11	188.7
OTB	20	58.62	35.88	98.39	77.38	2.119	76.37	69.18	64.96	131.7	8.21	155.9	258.5
OTB	21	52.75	1.646	24.65	12.72	11.7	30.65	69.14	52.85	119.2	15.12	194.3	303.3
OTB	22	46.89	6.584	10.29	23.46	10.21	29.51	147.1	104.2	128.5	15.12	215	297.8
OTB	23	193.4	16.46	3.622	40.13	38.04	173.4	165.4	117.5	120.7	62.23	164.4	247.6
OTB	24	275.5	26.34	3.083	26.01	63.08	272.2	177.9	158.3	161.5	62.23	107.8	226.1
OTB	25	164.1	13.17	1.542	50.87	39.61	296.4	193.6	255.9	268.5	15.12	100.1	161.7
OTB	26	129	8.231	0	31.94	31.52	395.5	144.6	347.7	200.1	55.32	60.04	105.6
OTB	27	58.62	8.231	0	14.73	32.35	438.1	228.9	415.2	139	35.87	49.83	102
OTB	28	46.89	14.81	0	24.68	22.3	431.6	459.8	381.8	158	64.83	39.43	64.15
OTB	29	23.45	13.17	0	19.91	34.3	171.5	144.1	244.2	98.32	41.49	63.79	40.2
OTB	30	17.58	24.52	0	8.628	43.03	169	210.1	113.9	81.78	6.915	8.474	42.24
OTB	31	0	35.86	2.632	9.38	21.64	79.3	211.8	43.11	61.12	0	0	34.11
OTB	32	0	8.231	5.264	6.902	21.53	24.85	101.7	24.72	24.54	0	0.282	29.98
OTB	33	0	17.93	0	8.628	11.81	42.87	92.98	69.8	15.49	0	1.13	6.848
OTB	34	0	6.584	19.15	13.7	13.54	25.58	91.6	14.7	7.362	0	0.565	7.445
OTB	35	0	4.938	26.5	20.66	19.59	24.27	62.8	6.144	7.443	0	0.565	0.447
OTB	36	0	16.29	13.89	12.03	18.53	5.617	51.09	17.33	15.38	0	0	3.463
OTB	37	0	4.938	2.632	10.25	17.47	14.1	20.07	2.739	8.072	0	0	0
OTB	38	0	0	0	0.767	10.89	0.936	0	0.521	4.207	0	0.282	0
OTB	39	0	0	0	0	11.07	11.08	17.84	1.697	2.103	0	0	0.447
OTB	40	0	0	0	0	3.288	0	3.959	0	0	0	0	0
OTB	44	5.862	0	0	0	0	0	0	0	0	0	0	0
PS	18	0	0	0	0	0	0	0	0	0	0	0	3.183
PS	19	0	0	0	0	0	0	0	0	0	0	0	3.183
PS	20	0	0	0	0	0	0	0	0	0	0	0	39.26
PS	21	0	0	0	0	0	0	0	0	0	0	0	119.9
PS	22	0	0	0	0	0	0	0	0	0	0	8.898	158.3
PS	23	0	0	0	0	0	0	0	0	0	0	44.49	229.6
PS	24	0	0	0	0	0	0	0	0	0	0	124.6	177.6
PS	25	0	0	0	0	0	0	0	0	0	0	88.98	64.09
PS	26	0	0	0	0	0	0	0	0	0	0	8.898	20.37
PS	27	0	0	0	0	0	0	0	0	0	0	8.898	0
PS	28	0	0	0	0	0	0	0	0	0	0	0	4.244
OTH	13	0	0	0	0	0	0	31.81	0	0	0	0	0
OTH	14	0	0	0	0	0	0	254.5	9.231	0	0	0	0
OTH	15	0	0	0	0	0	0	127.2	0	0	0	0	8.742
OTH	16	0	0	0	0	0	3.014	160.1	0.692	0	0	0	11.71
OTH	17	0	0	0	0	0	0	223.5	29.03	8.195	0	0	58.75
OTH	18	0	0	0	0	0	3.014	116.6	30.81	21.85	0	2.697	293.4
OTH	19	0	0	0	0	0	0	169.5	113.8	65.56	0	3.267	361.3
OTH	20	0	0	0	0	0	3.014	143.2	67.3	67.13	0	9.526	280.2
OTH	21	0	0	0	0	2.847	51.24	222.8	71.01	86.54	0.156	10.07	122.9
OTH	22	0	0	0	1.776	54.38	90.02	463.3	82.04	88.05	1.756	21.36	141.5
OTH	23	0	0	0	0.493	24.46	165.5	684.9	17.13	90.9	1.928	24.83	131.7
OTH	24	0	0	0	3.946	29.96	168.6	279.6	36.15	82.54	7.903	36.54	91.4

gear	len	2003	2004	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
OTH	25	0	0	0	3.255	63.73	131.8	267.4	59.13	44.44	10.13	16.05	52.17
OTH	26	0	0	0	1.875	72.25	90.02	214.5	27.51	16.56	15.01	20.85	27.61
OTH	27	0	0	0	1.382	71.25	36.22	141	60.04	17.18	13.68	25.71	13.5
OTH	28	0	0	0	2.17	38.64	39.34	115.2	41.71	7.766	14.09	25.38	18.14
OTH	29	0	0	0	2.565	23.07	15.38	38.52	25.18	4.229	9.789	17.36	24.74
OTH	30	0	0	0	1.875	15.73	4.699	83.15	15.91	6.367	7.065	14.51	43.33
OTH	31	0	0	0	1.875	17.87	11.77	48.49	16.53	4.104	2.453	11.28	24.6
OTH	32	0	0	0	3.55	23.92	4.035	10.1	11.52	1.372	1.281	11.75	20.32
OTH	33	0	0	0	3.058	30.11	8.423	4.48	14.04	1.64	2.238	7.391	17.5
OTH	34	0	0	0	5.427	9.545	7.912	8.319	7.347	3.11	1.377	1.789	11.59
OTH	35	0	0	0	5.13	14.09	9.209	7.738	5.863	2.539	0.772	3.534	5.407
OTH	36	0	0	0	2.366	7.069	13	5.829	4.245	0.143	0.188	0	0.249
OTH	37	0	0	0	3.058	4.578	6.054	5.752	3.691	0.727	0.345	0.718	0.042
OTH	38	0	0	0	4.933	2.599	1.603	1.123	2.582	0.376	0.156	0	0.056
OTH	39	0	0	0	6.608	3.608	0.102	0.433	0.782	0	0	0	0
OTH	40	0	0	0	3.75	0	0.153	0.045	0.173	0.558	0	0.675	0
OTH	41	0	0	0	2.565	1.203	0.051	0	0	0	0	0	0
OTH	42	0	0	0	2.86	0	3.065	0	0	0	0	0	0
OTH	43	0	0	0	5.623	1.397	3.116	0	0	0	0	0	0
OTH	44	0	0	0	7.299	1.203	0.255	0.045	0	0.234	0	0	0.056
OTH	45	0	0	0	2.366	0	0.051	0	0	0.117	0	0	0
OTH	47	0	0	0	4.043	0	0.051	0	0	0	0	0	0
OTH	48	0	0	0	8.481	0	0.051	0	0	0	0	0	0
OTH	49	0	0	0	1.677	0	0.051	0	0	0	0	0	0

Discards

Discards area available since 2009 and belongs mainly to OTB except for GSA 9 (Table 6.6.1.1.3, Fig. 6.6.1.1.5). In 2014, discards on OTB are null then discards from other gears (OTH) are mostly by GNS and represent the 100 % of the total amount (Table 6.6.1.1.3).

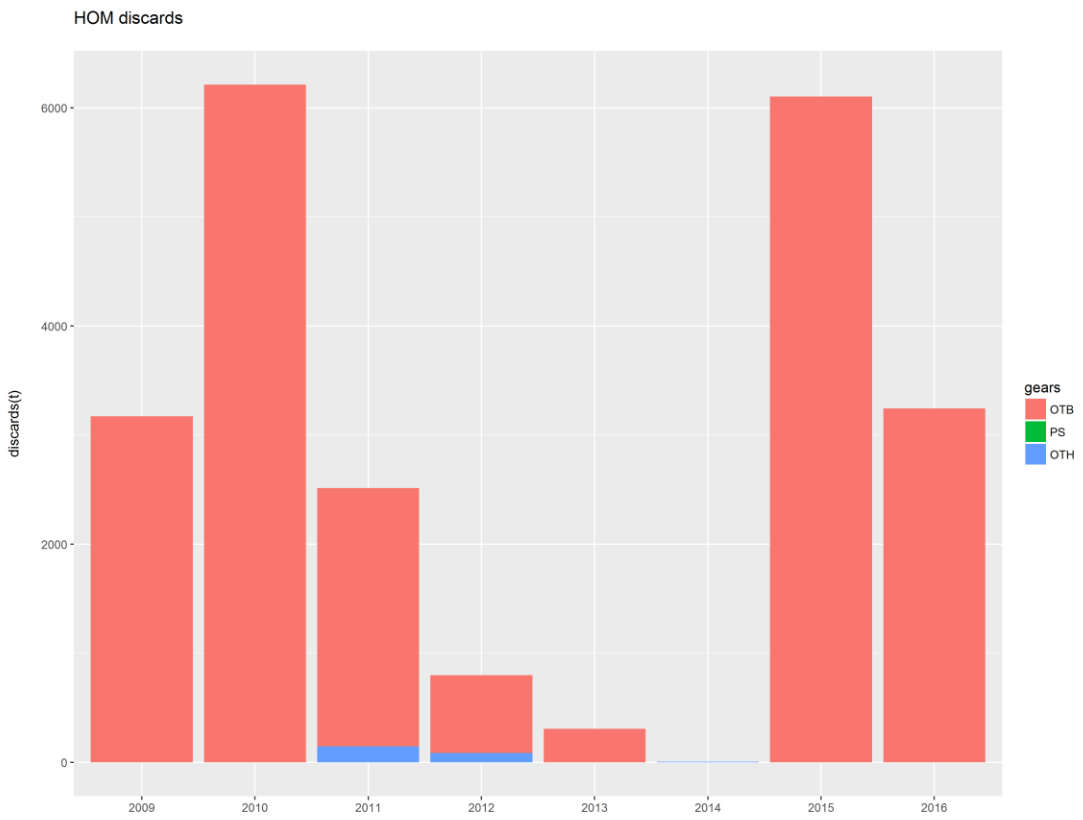


Figure 6.6.1.1.5 Atlantic horse mackerel in GSAs 9, 10 & 11. Total discards by year, GSA and main fishing gear in the region.

Table 6.6.1.1.3 Atlantic horse mackerel in GSAs 9, 10 & 11. Total discards by year and main fishing gear in the region.

year	OTB	PS	OTH	Total	% OTB	% PS	% OTH
2009	3173.9	0	0	3173.9	100.0	0.0	0.0
2010	6213.3	0	0	6213.3	100.0	0.0	0.0
2011	2369.4	0	146.2	2515.6	94.2	0.0	5.8
2012	712.5	0	85.6	798.1	89.3	0.0	10.7
2013	306.4	0	0	306.4	100.0	0.0	0.0
2014	0	0	6.5	6.5	0.0	0.0	100.0
2015	6106	0	0	6106	100.0	0.0	0.0
2016	1077.3	0	0	1077.3	100.0	0.0	0.0

Discards at length were available from 2009 for OTB and only for 2011, 2012 and 2014 for GNS, indicated as OTH in Fig. 6.6.1.1.6. and Table 6.6.1.1.4

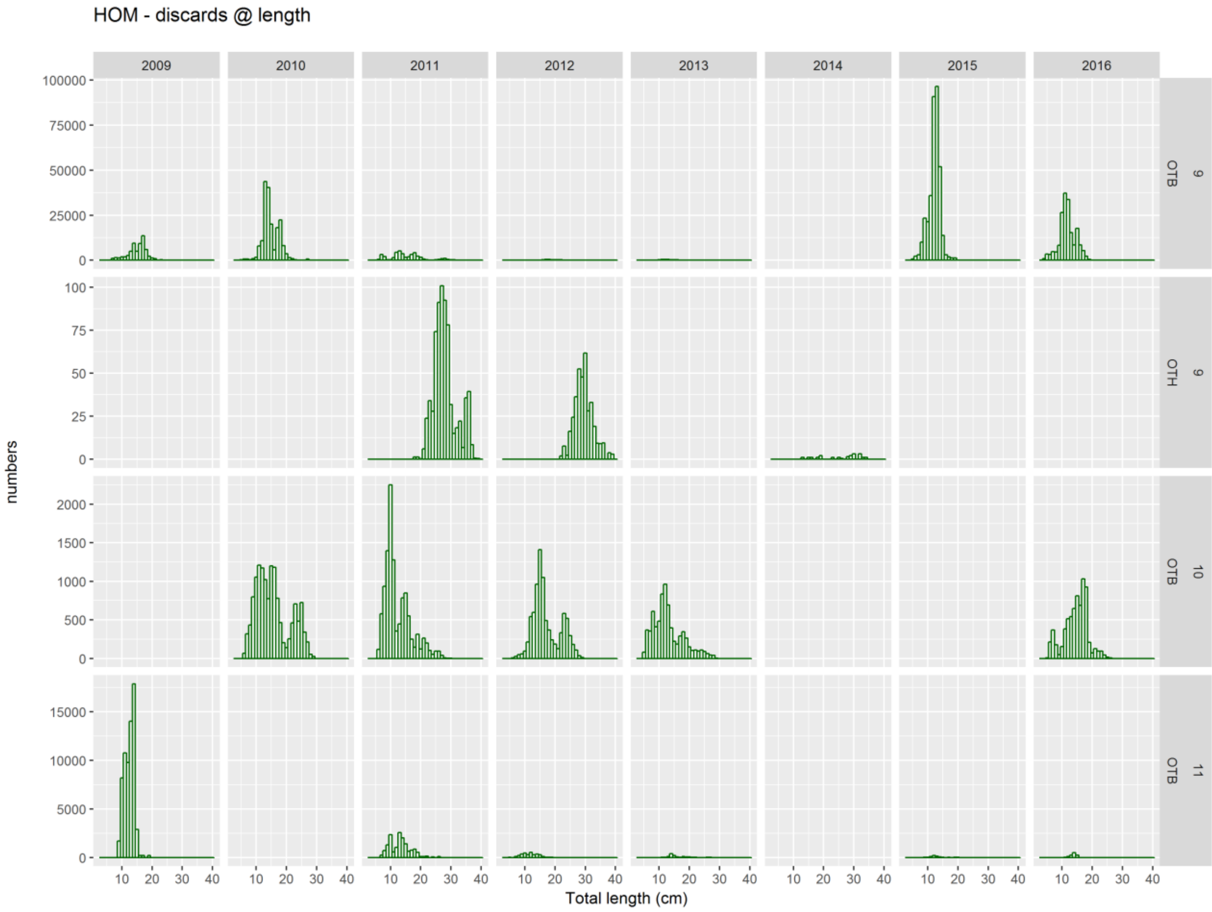


Figure 6.6.1.1.6 Atlantic horse mackerel in GSAs 9, 10 & 11. Discards at length by year, GSA and main fishing gear in the region.

Table 6.6.1.1.4 Atlantic horse mackerel in GSAS 9, 10 & 11. Discards at length by year and main gear in the region (GSAs 9, 10, 11).

gear2	len	2009	2010	2011	2012	2013	2014	2015	2016
OTB	3	0	18.83	0	0	0	0	0	0
OTB	4	0	0	0	0	0	0	0	816.1
OTB	5	31.01	180.3	0	40.67	80.11	0	636	3374
OTB	6	167.9	782.2	550.2	8.289	368.5	0	2216	3453
OTB	7	993.1	1045	3925	104.8	358.3	0	2948	5194
OTB	8	1445	801.7	3669	259.3	676.5	0	9983	4752
OTB	9	2914	1705	2933	451.7	521.1	0	23459	8347
OTB	10	9952	2644	4954	565.3	666.4	0	21475	26583
OTB	11	12705	9102	3288	509.1	1223	0	36042	37554
OTB	12	12321	11978	5740	1081	1414	0	91038	34276
OTB	13	18943	44787	8214	905.3	1269	0	96561	16153
OTB	14	27305	41116	6321	1363	1136	0	51867	9681
OTB	15	7859	21175	3985	1847	745	0	13769	18783
OTB	16	9535	7020	3120	1387	422.6	0	3061	9162
OTB	17	13807	18800	4116	1066	466.4	0	1844	6371
OTB	18	5990	22821	5199	791.8	447	0	1281	3122

gear2	len	2009	2010	2011	2012	2013	2014	2015	2016
OTB	19	2451	8253	2988	509.1	392.2	0	1317	618.4
OTB	20	1203	3773	1913	536.2	220.5	0	120.4	97.61
OTB	21	866.9	1775	943.7	348.1	131.7	0	30.67	128.3
OTB	22	127.7	1321	590.2	569.2	126.4	0	41.61	120.7
OTB	23	353.2	894.5	172	724.5	102.3	0	0	95.71
OTB	24	42.44	609.3	95.51	676.7	120.4	0	49.79	42.9
OTB	25	74.59	789.3	365.5	415.7	99.76	0	41.61	16.5
OTB	26	45.46	378	658.5	234.6	68.18	0	0	6.6
OTB	27	33.99	786.7	985	142.9	50.05	0	0	0
OTB	28	7.294	62.67	1061	83.76	40.05	0	0	0
OTB	29	4.862	26.05	530.9	38.85	3.641	0	0	0
OTB	30	0	0	321.3	19.84	0	0	0	0
OTB	31	0	0	220.3	13.9	0	0	0	0
OTB	32	0	0	8.357	13.9	0	0	0	0
OTB	33	0	0	11.34	13.9	0	0	0	0
OTB	34	1.216	0	6.566	13.9	0	0	0	0
OTB	35	2.431	0	4.775	0	0	0	0	0
OTB	36	6.078	0	3.581	0	0	0	0	0
OTB	37	6.078	0	1.791	0	0	0	0	0
OTB	38	3.647	0	0	0	0	0	0	0
OTB	39	1.216	0	0	0	0	0	0	0
OTH	13	0	0	0	0	0	1.027	0	0
OTH	15	0	0	0	0	0	1.027	0	0
OTH	16	0	0	0	0	0	1.027	0	0
OTH	18	0	0	1.353	0	0	1.027	0	0
OTH	19	0	0	1.353	0	0	2.054	0	0
OTH	20	0	0	0.301	0	0	0	0	0
OTH	21	0	0	6.031	0	0	0	0	0
OTH	22	0	0	23.85	1.944	0	0	0	0
OTH	23	0	0	34.08	7.592	0	1.027	0	0
OTH	24	0	0	28.06	2.353	0	0	0	0
OTH	25	0	0	74.31	16.22	0	1.027	0	0
OTH	26	0	0	91.21	24.4	0	0.522	0	0
OTH	27	0	0	101	36.29	0	0	0	0
OTH	28	0	0	92.54	52.62	0	1.549	0	0
OTH	29	0	0	78.14	47.84	0	2.054	0	0
OTH	30	0	0	31.95	61.84	0	3.08	0	0
OTH	31	0	0	14.98	28.16	0	0	0	0
OTH	32	0	0	18.24	33.03	0	3.08	0	0
OTH	33	0	0	22.22	19.24	0	1.027	0	0
OTH	34	0	0	6.775	9.285	0	1.027	0	0
OTH	35	0	0	35.71	9.154	0	0	0	0
OTH	36	0	0	39.42	9.6	0	0	0	0
OTH	37	0	0	8.439	0	0	0	0	0
OTH	38	0	0	0.752	3.848	0	0	0	0
OTH	39	0	0	0.451	2.876	0	0	0	0

gear2	len	2009	2010	2011	2012	2013	2014	2015	2016
OTH	40	0	0	0.15	0	0	0	0	0

By the comparison of landings and discards at length it is clear the different selection pattern (Fig. 6.6.1.1.7).

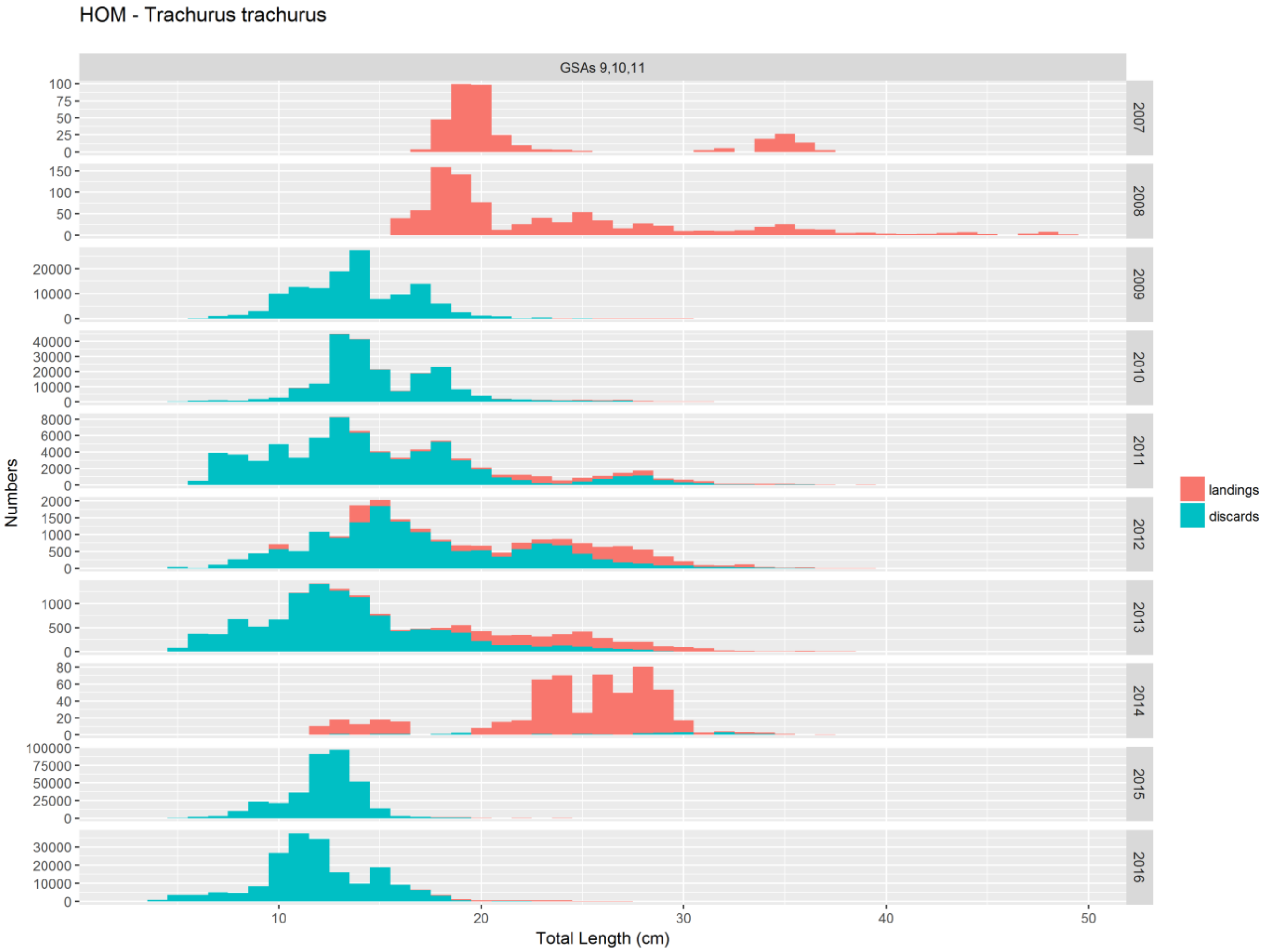


Figure 6.6.1.1.7. Atlantic horse mackerel in GSAs 9, 10 & 11. Landings and discards at length by year in the region.

6.6.1.2 Effort

Fishing effort data were reported to STECF EWG 17-09 through DCF. Fishing effort by country for GSAs 9, 10, 11 were present as nominal effort (Table 6.6.1.2.1), Gt days at sea, and days at sea by years and main gears which include OTB, PS and all other gears (OTH). Data are reported since 2002, however due to the absence of information for Gt days at sea, and days at sea in 2002 and 2003 figures are plotted from 2004 (Fig 6.6.1.2.1-3). After a period of decreasing trend, effort is generally unchanged in the most recent years.

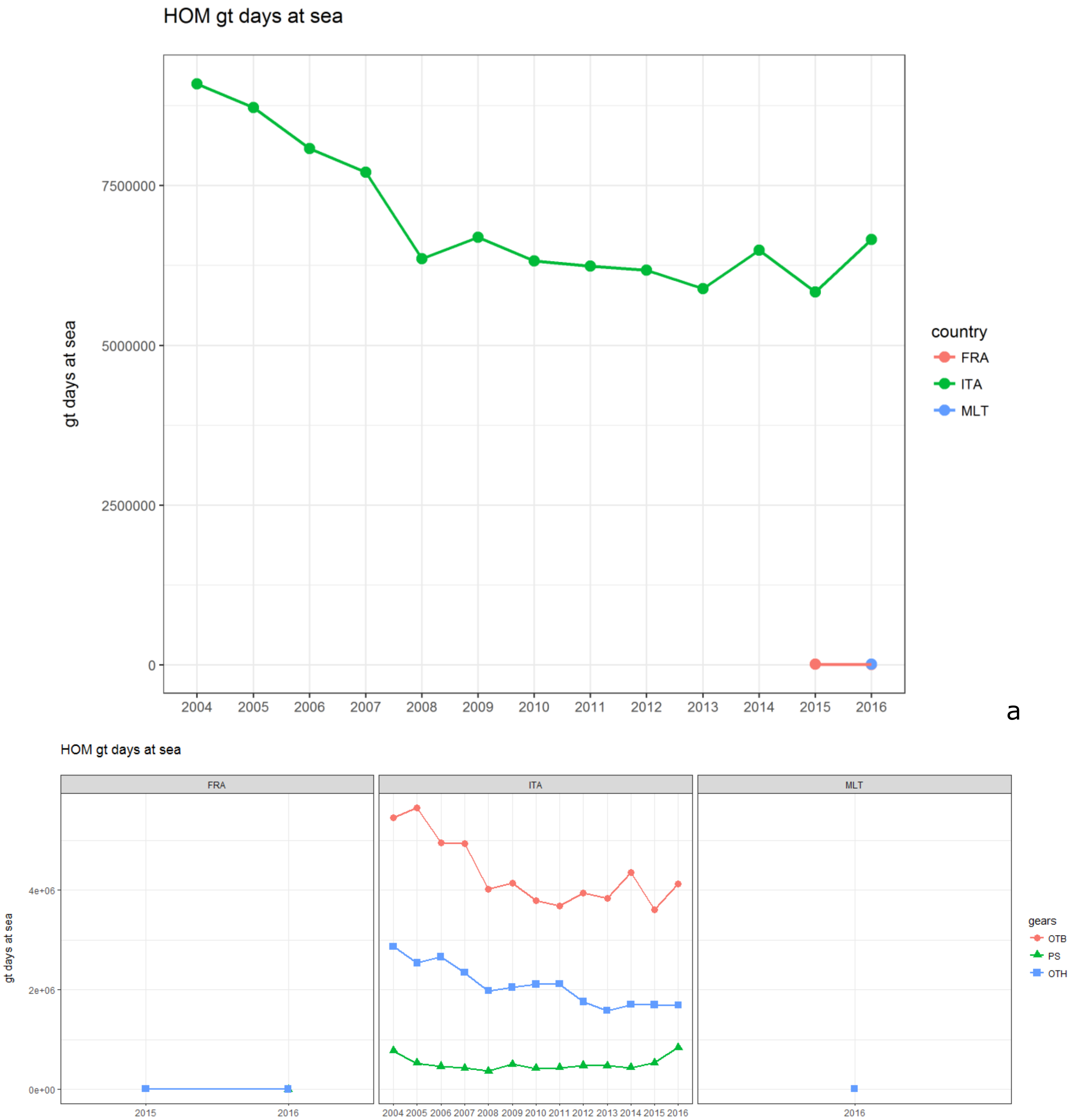
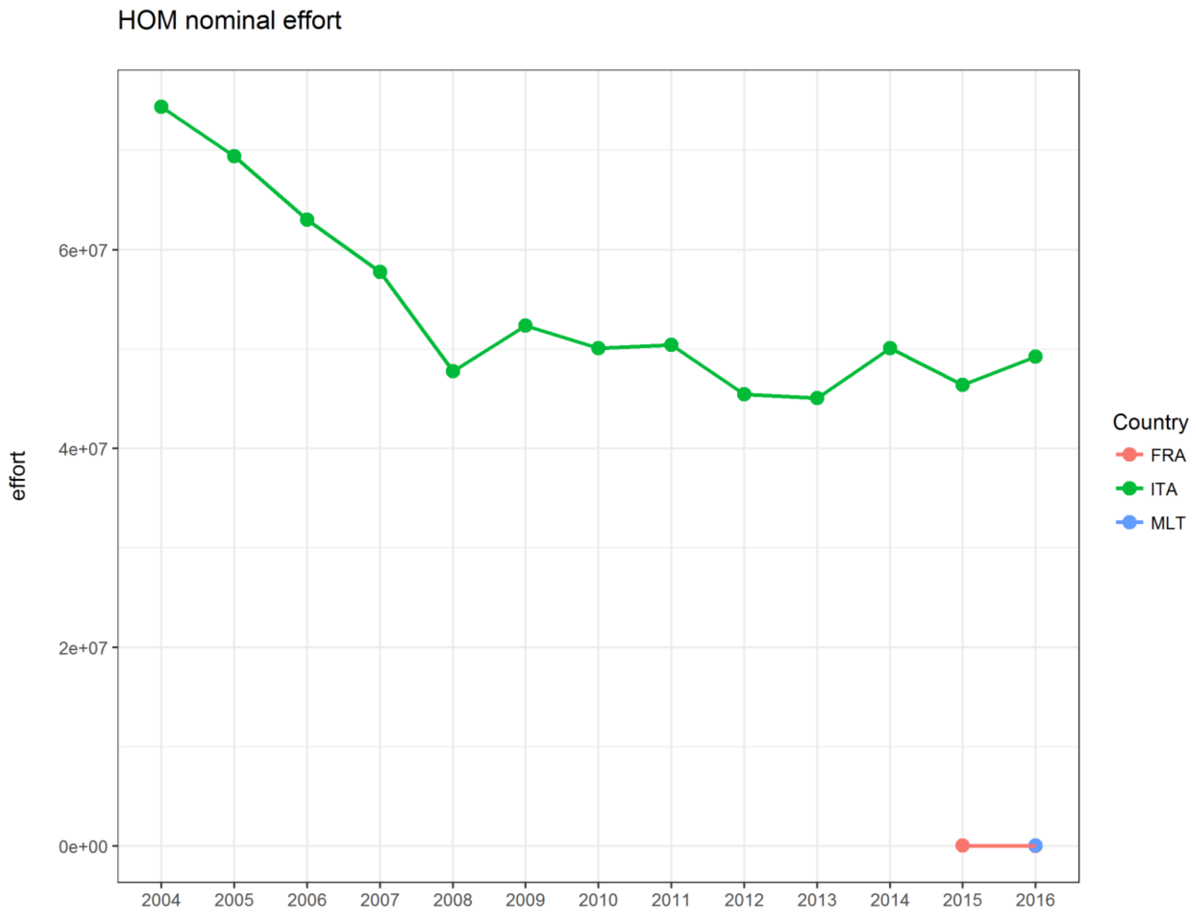
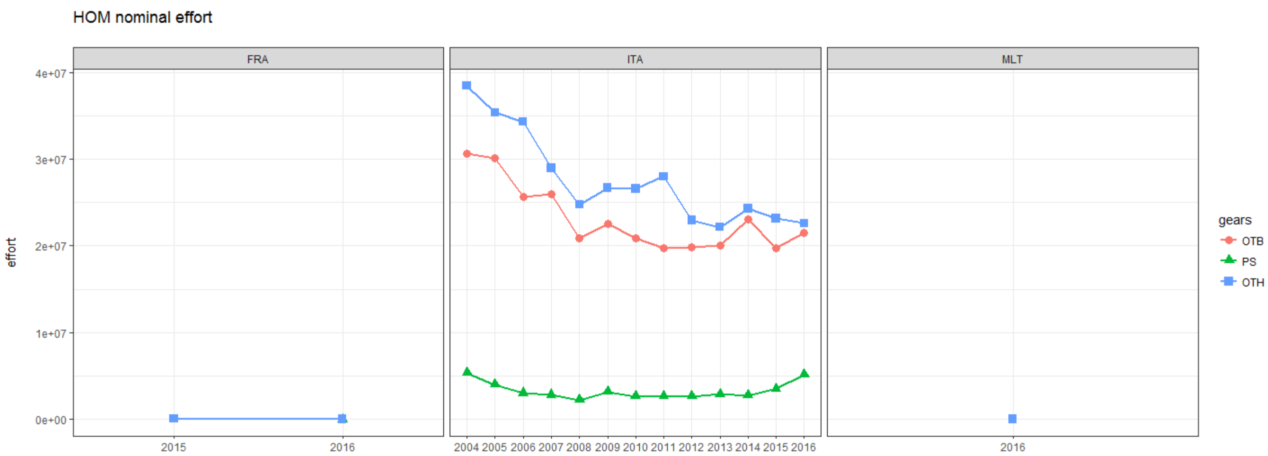


Figure 6.6.1.2.1 Atlantic horse mackerel in GSAs 9, 10 & 11. Fishing effort data in GT_Days at sea in the region by country (a) and by country and gear (b).



a



b

Figure 6.6.1.2.2. Atlantic horse mackerel in GSAs 9, 10 & 11. Nominal effort at sea in the region by country (a) and by country and gear (b).

a

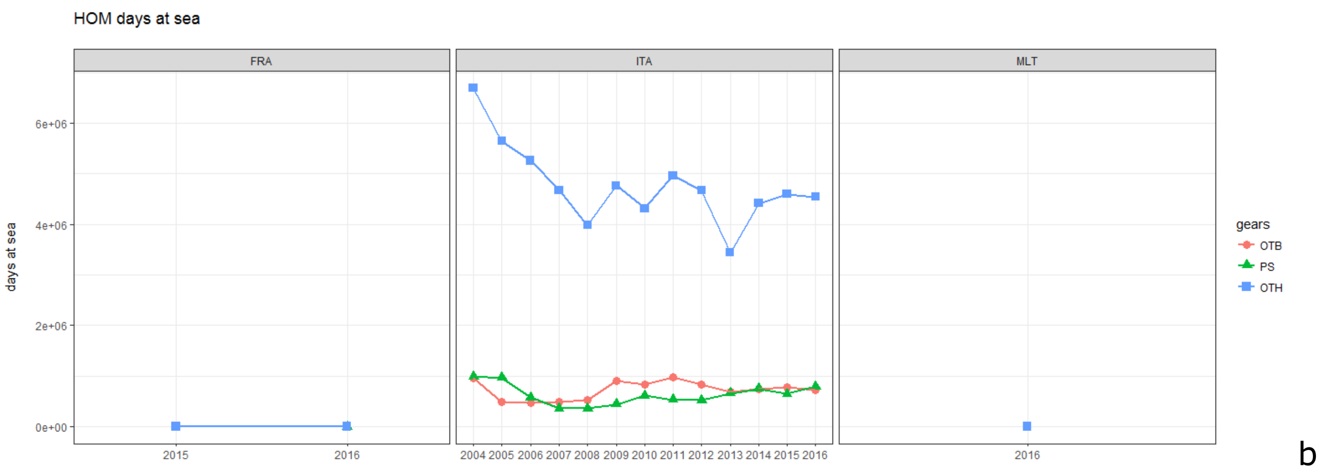


Figure 6.6.1.2.3. Atlantic horse mackerel in GSAs 9, 10 & 11. Fishing effort data in Days at sea in the region by country (a) and by country and gear (b).

Table 6.6.1.2.1. Atlantic horse mackerel in GSAs 9, 10 & 11. DCF data on effort in the region.

nominal_effort		gear												
country	year	DRB	FPO	FYK	GND	GNS	GTR	LLD	LLS	LTL	OTB	OTM	PS	PTM
ITA	2002	281809	0	0	0	6504001	14021521	0	0	0	25607249	0	3943654	0
	2003	365061	0	0	0	6925653	16373768	0	0	0	26555175	0	4263625	0
	2004	358139	42030	0	297458	8966066	13136951	1606449	6036498	0	30597146	0	5354735	6173
	2005	558741	391578	0	132337	9959696	12741736	2233868	3249513	0	30054689	0	3998928	0
	2006	531762	1119388	0	685851	6429324	15379181	2192747	3150160	13928	25657959	0	3037943	4599
	2007	374390	1498812	4639	454015	6693459	11551313	2198688	2463346	5408	25937181	0	2832784	0
	2008	619714	974343	0	496680	6001423	9383133	2019362	2092615	589	20826826	0	2220934	0
	2009	466159	1071094	0	440344	6788083	9610840	2421251	1717309	3169	22541273	0	3176208	0
	2010	438958	1069982	0	127540	6204823	10149344	3719195	1836022	0	20867779	0	2642790	100
	2011	416682	1776781	720	52457	7013899	10272814	3728507	2167023	20109	19718982	0	2696033	0
	2012	378111	1569018	0	53742	5144115	9376203	3258596	1621079	5658	19873334	0	2653745	902
	2013	225168	1398494	0	7667	3357838	12223851	2085043	1828631	28516	20017955	0	2889480	0
	2014	214676	1288003	0	38343	4765401	11588290	2066175	3179887	12334	23071338	383607	2736791	0
	2015	267020	1472900	1906	14955	3933648	9121880	4107614	2425201	1809	19693721	686978	3550534	0
	2016	288433	1744903	1059	24664	5113335	7749102	4237633	2110930	1937	21502123	0	5137033	0
MLT	2016	0	0	0	0	0	0	2350	37501	0	0	0	0	0
FRA	2016	0	0	0	0	0	0	0	0	0	0	0	16295	0

6.6.1.3 SURVEY DATA

Abundance and biomass indexes calculated from the data reported to STECF EWG 17-09 through DCF. Atlantic horse mackerel time series of abundance and biomass indices from MEDITS surveys are shown and described in the following figures for the region belonging to GSAs 9, 10, 11.

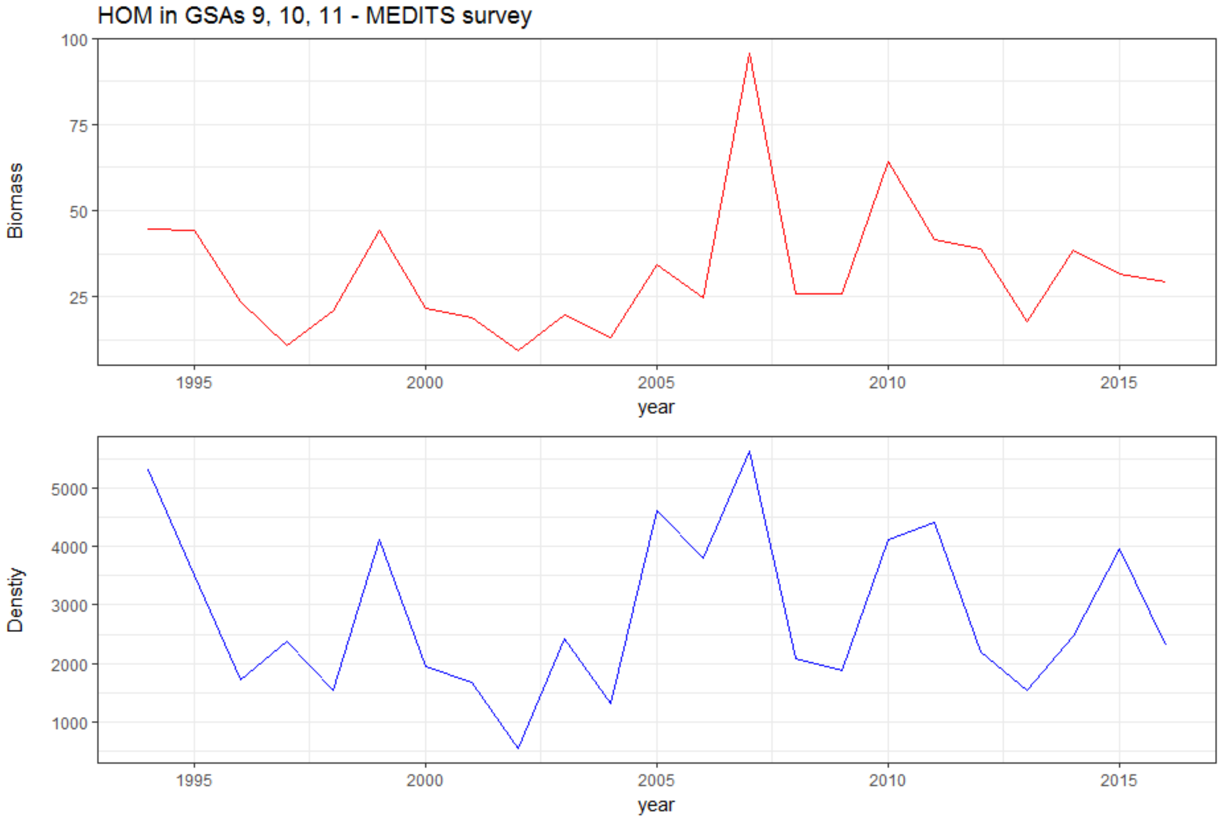
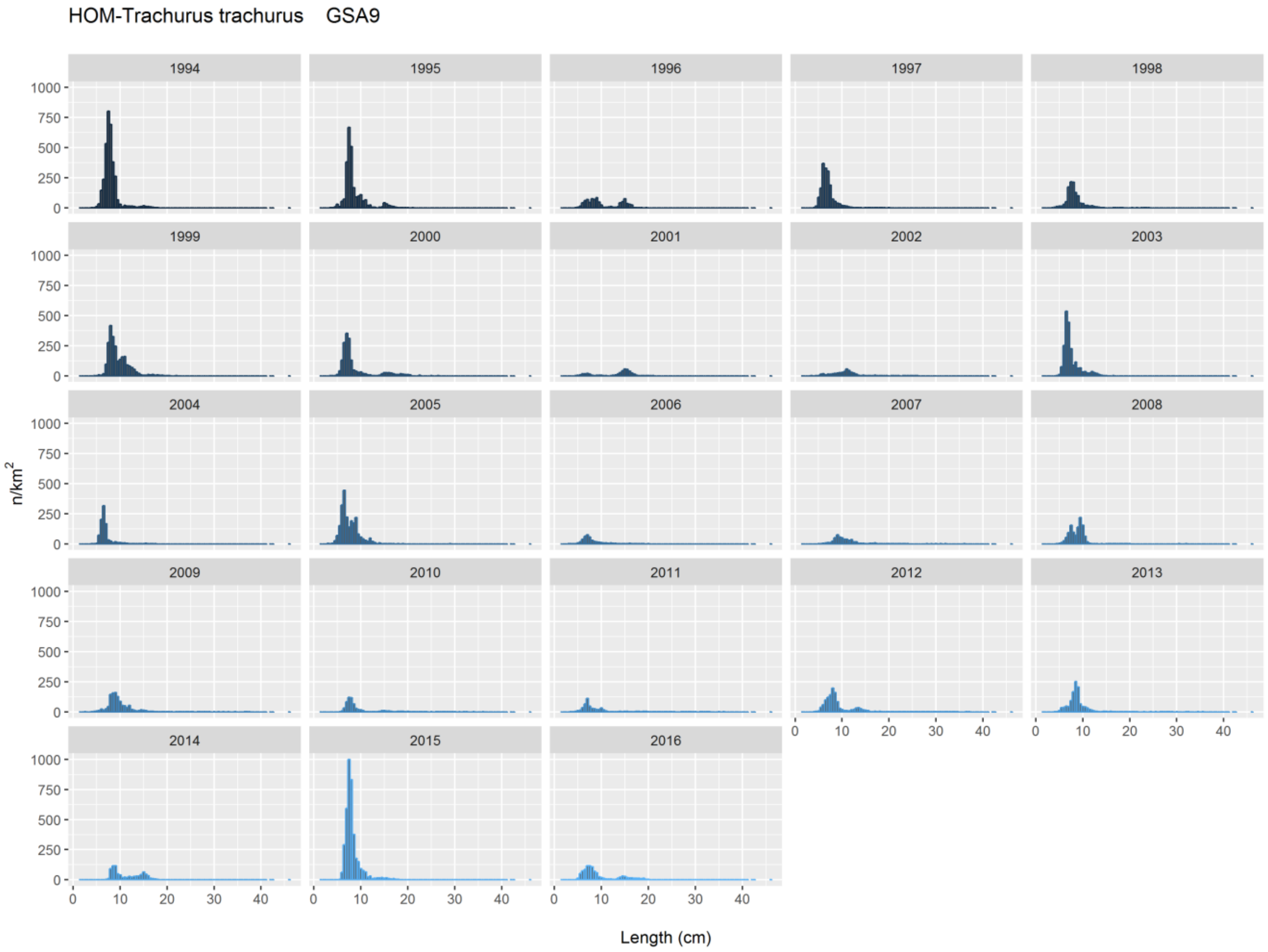


Figure 6.6.1.3.1 Atlantic horse mackerel in GSAs 9, 10 & 11. Historical trends of abundance (blue) and biomass index (red) estimated by MEDITS survey.



HOM-Trachurus trachurus GSA9
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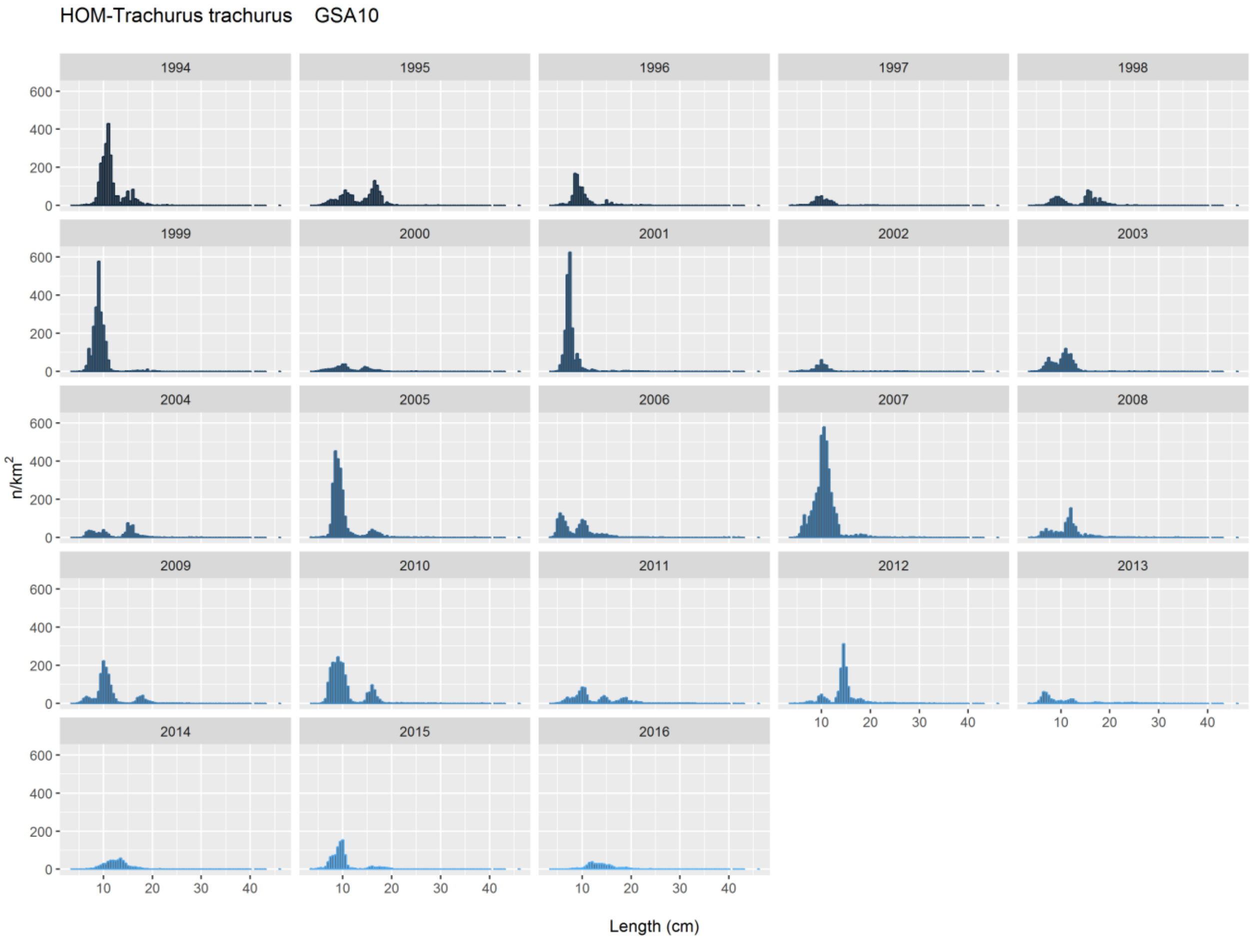
2014
2015
2016
1000
750
500
250
0
n/km2
0
10
20
30
40
Length (cm)

A



HOM-Trachurus trachurus GSA10
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
n/km²
Length (cm)
0
200
400
600
10
20
30
40

B

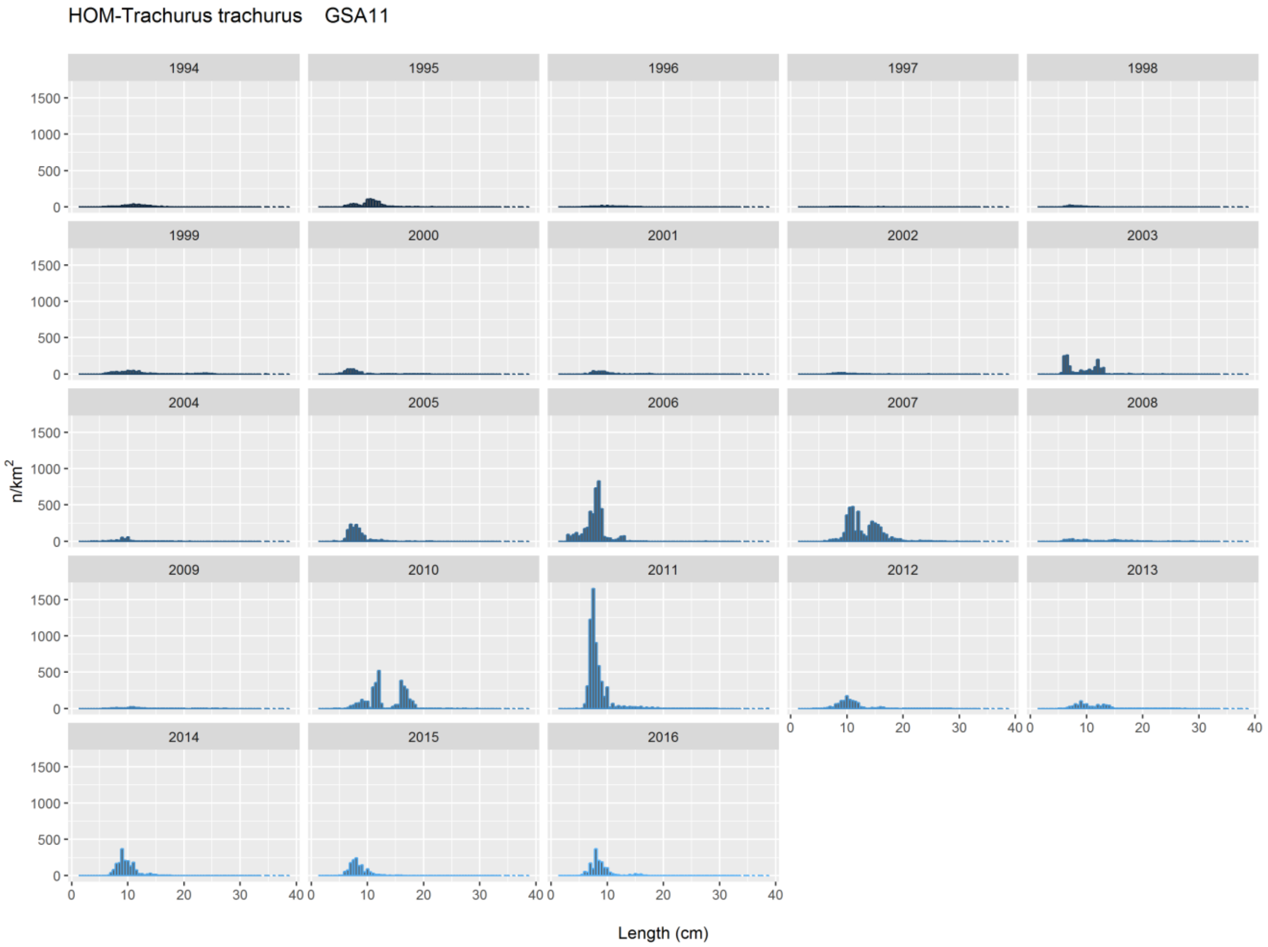


Figure 6.6.1.3.2 Atlantic horse mackerel in GSAs 9, 10 & 11. Size structure of the abundance index estimated by MEDITS survey (a=GSA9, b=GSA10, c=GSA11).

6.6.2 Stock assessment

Methods

The Atlantic horse mackerel was assessed before by the EWG 16_03, though the results were considered preliminary. The data provided to EWG 17-09 has been considered covering more than the mean life span of the species, allowing to makes an attempt of stock assessment with an XSA method.

By using the FLR libraries (Kell et al.2007) an Extended Survivors Analysis (XSA – Darby and Flatman, 1994) was carried out to assess trends in fishing mortality, stock biomass, spawning stock biomass, and recruitment in the region belonging to GSAs 9, 10, 11.

Input data

The XSA was applied using as input data the DCF official data on the age structure and the landing of commercial catches. As a tuning fleet the data of MEDITS survey were used. For the analysis the timeframe (2009-2016) was set since taking in to account the availability of landing at length or catch at age data. The analysis was carried out for sex combined using the following growth parameters to slice the DCF annual size distributions:

L_inf	k	t0
43.2	0.27	-0.9

To convert the length-based DCF data into age-based data, landings and discards at length were sliced for each GSA using the stochastic method implemented in the l2a r routine (Jardin et al., 2017) and then summed to obtain the catch and landing matrices used as input data for the XSA.

For big individuals a 7+ group has been used.

When information on landings and discards at length for some years and some GSAs were missing, the data were reconstructed. An average proportion of landings and/or discards over the total were estimated for age and GSA of neighborhood years and used to reconstruct the catch at age matrix by pooling all the GSA and source of information by year and age. Discard proportions were very variable, ranging from around 32% to around 86% of catch. Finally, a SOP correction was applied to catch numbers at age to fill in for unsampled fleets, applying the length /age distributions equally across the fishery.

Natural mortality and maturity vectors were taken from the EWG16-13 report.

All the input parameters (landings, catch number at age, weight at age, maturity at age, natural mortality at age and the tuning series at age) to the XSA were listed (Table 6.6.2.1) below.

Table 6.6.2.1 Atlantic horse mackerel in GSAs 9, 10 & 11. Input parameters and data for XSA assessment

TUNING

Medits

age	2009	2010	2011	2012	2013	2014	2015	2016
0	2450	5521	7054	3433	2298	3238	6177	2937
1	149.4	369.2	233.6	129.7	60.28	80.06	82.79	152.5
2	7.52	14.33	11.81	27.14	22.88	21.25	9.53	15.4
3	1.08	2.35	9.11	11.95	2.35	4.72	1.93	3.54
4	0.4	0.42	3.07	3.64	0.15	0.45	0.72	1.7
5	0.08	0.27	0.16	0.07	0.15	0.03	0.03	0.13
6	0.49	0.03	0.03	0.31	0.03	0.03	0.03	0.06
7	0.03	0.15	0.11	0.03	0.03	0.07	0.03	0.06

initial settings

min	max	plusgroup	minyear	maxyear	minfbar	maxfbar

0	7	7	2009	2016	2	6

Mortality and Maturity vectors@age

age	0	1	2	3	4	5	6	7
maturity	0.04	0.24	0.76	0.97	1	1	1	1
mortality	0.9	0.6	0.4	0.3	0.2	0.15	0.15	0.15

Mean Weight vector@age (kg) in stock, catch, landings

year/age	0	1	2	3	4	5	6	7
2009-2016	0.015	0.0316	0.0688	0.1062	0.153	0.2018	0.2755	0.3447

catch in weight (ton) by year

age	2009	2010	2011	2012	2013	2014	2015	2016
tot	5282	7765.2	4173	1902	955	820.6	6857.2	3769

Catch at age matrix (numbers in thousands)

age	2009	2010	2011	2012	2013	2014	2015	2016
0	202265	252962	92475	24439	21722	13683	422728	205551
1	49023	96952	34149	11869	6338	8131	9662	15357
2	7466	9494	9983	9756	3805	3771	2253	2091
3	798	1703	7165	3176	1119	722	394	341
4	158	135	527	517	104	67	48	86
5	109	113	439	172	49	30	18	29
6	108	65	266	97	58	21	10	4
7	72	35	49	32	18	0	1	1

Results

A sensitivity analysis was performed to select the most suitable best parameters to be used in the XSA. Several different runs (n=144) have been carried out, changing all the combination of rage (0 to 1, step of 1), qage (1 to 4, step of 1), shk.ages (1 to 3, step of 1) and fse (0.5 to 3, step of 0.5).

Among all setting runs, absolute means of residuals range from -10.08 to 5.72 (mean 1.783, 1st quartile 1.186). Only 36 runs are within the first quartile of absolute means of residuals (Table 6.6.2.2).

Table 6.6.2.2 Atlantic horse mackerel in GSAs 9, 10 & 11. Results of the sensitivity analysis in terms of min, max and absolute mean values of residuals

run_n	setsens	shkage	fse	rage	qage	minres	maxres	absmean	absmax
72	sh3se3r0q4	sh3	se3	r0	q4	-6.974	4.922	1.062	6.974
60	sh1se3r0q4	sh1	se3	r0	q4	-6.972	4.921	1.068	6.972

run_n	setsens	shkage	fse	rage	qage	minres	maxres	absmean	absmax
36	sh3se3r0q2	sh3	se3	r0	q2	-6.919	4.910	1.068	6.919
24	sh1se3r0q2	sh1	se3	r0	q2	-6.919	4.910	1.074	6.919
66	sh2se3r0q4	sh2	se3	r0	q4	-6.972	4.921	1.075	6.972
30	sh2se3r0q2	sh2	se3	r0	q2	-6.918	4.910	1.083	6.918
144	sh3se3r1q4	sh3	se3	r1	q4	-6.988	4.795	1.092	6.988
132	sh1se3r1q4	sh1	se3	r1	q4	-6.986	4.794	1.098	6.986
108	sh3se3r1q2	sh3	se3	r1	q2	-6.945	4.786	1.103	6.945
71	sh3se2.5r0q4	sh3	se2.5	r0	q4	-7.096	4.973	1.104	7.096
138	sh2se3r1q4	sh2	se3	r1	q4	-6.985	4.794	1.105	6.985
35	sh3se2.5r0q2	sh3	se2.5	r0	q2	-7.042	4.961	1.107	7.042
96	sh1se3r1q2	sh1	se3	r1	q2	-6.945	4.786	1.108	6.945
59	sh1se2.5r0q4	sh1	se2.5	r0	q4	-7.094	4.972	1.109	7.094
23	sh1se2.5r0q2	sh1	se2.5	r0	q2	-7.042	4.961	1.114	7.042
102	sh2se3r1q2	sh2	se3	r1	q2	-6.944	4.786	1.117	6.944
65	sh2se2.5r0q4	sh2	se2.5	r0	q4	-7.093	4.971	1.119	7.093
29	sh2se2.5r0q2	sh2	se2.5	r0	q2	-7.041	4.961	1.125	7.041
54	sh3se3r0q3	sh3	se3	r0	q3	-7.025	4.946	1.127	7.025
42	sh1se3r0q3	sh1	se3	r0	q3	-7.025	4.946	1.132	7.025
143	sh3se2.5r1q4	sh3	se2.5	r1	q4	-7.114	4.856	1.138	7.114
131	sh1se2.5r1q4	sh1	se2.5	r1	q4	-7.112	4.855	1.142	7.112
48	sh2se3r0q3	sh2	se3	r0	q3	-7.024	4.946	1.142	7.024
107	sh3se2.5r1q2	sh3	se2.5	r1	q2	-7.075	4.848	1.146	7.075
137	sh2se2.5r1q4	sh2	se2.5	r1	q4	-7.111	4.854	1.152	7.111
95	sh1se2.5r1q2	sh1	se2.5	r1	q2	-7.076	4.847	1.153	7.076
101	sh2se2.5r1q2	sh2	se2.5	r1	q2	-7.074	4.847	1.164	7.074
126	sh3se3r1q3	sh3	se3	r1	q3	-7.045	4.823	1.165	7.045
70	sh3se2r0q4	sh3	se2	r0	q4	-7.293	5.054	1.170	7.293
114	sh1se3r1q3	sh1	se3	r1	q3	-7.045	4.823	1.170	7.045
53	sh3se2.5r0q3	sh3	se2.5	r0	q3	-7.145	4.995	1.174	7.145
34	sh3se2r0q2	sh3	se2	r0	q2	-7.256	5.046	1.174	7.256
58	sh1se2r0q4	sh1	se2	r0	q4	-7.291	5.052	1.175	7.291
120	sh2se3r1q3	sh2	se3	r1	q3	-7.044	4.823	1.180	7.044
41	sh1se2.5r0q3	sh1	se2.5	r0	q3	-7.145	4.994	1.181	7.145
22	sh1se2r0q2	sh1	se2	r0	q2	-7.256	5.045	1.184	7.256

Sensitivity analyses were conducted to assess the effect of the main parameters in the top 36 runs in terms of minimizations of residuals (figure 6.6.2.1). The sensitivity analysis shows small changes in SSB and HR.

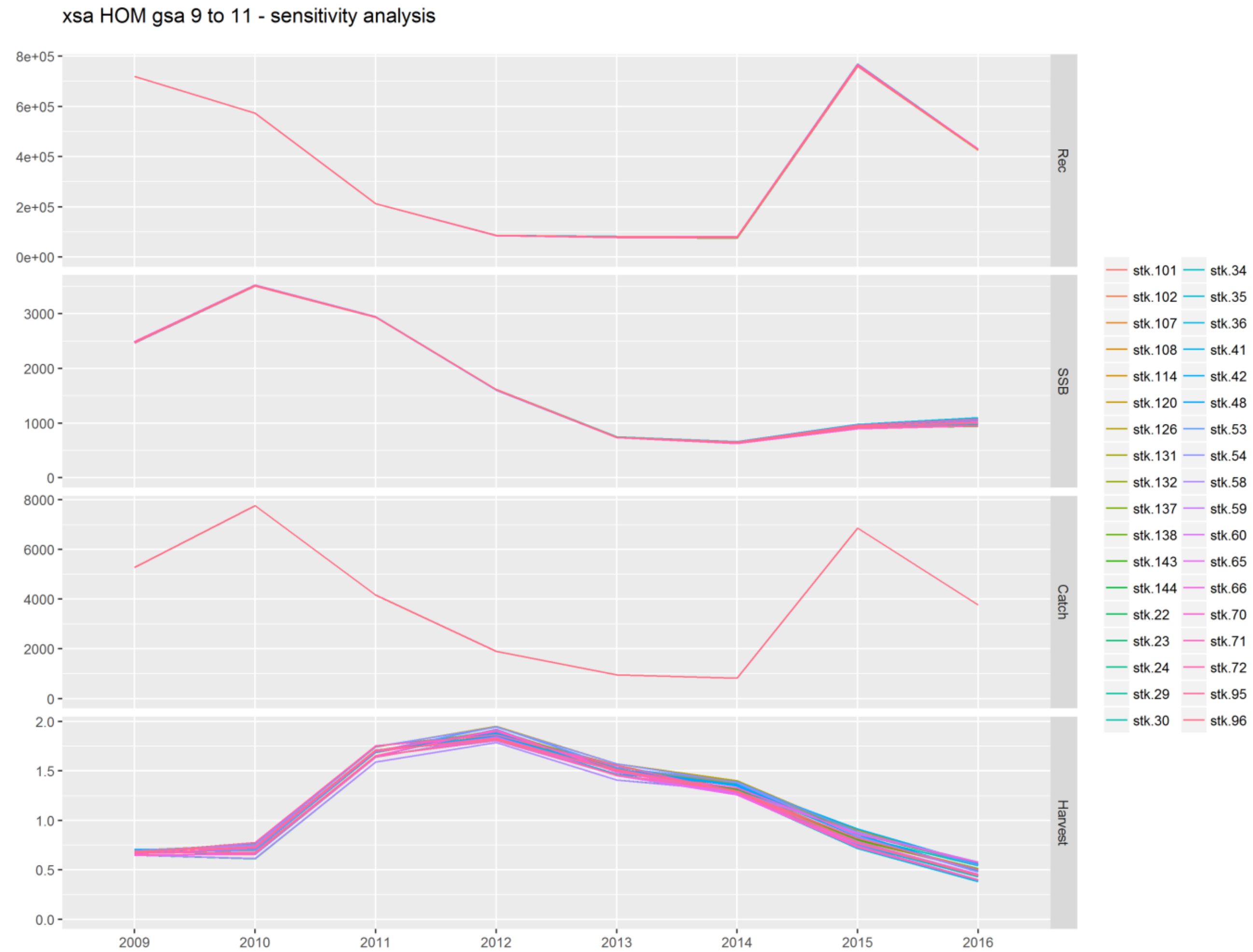


Figure 6.6.2.1 Atlantic horse mackerel in GSAs 9, 10 & 11. Sensitivity analyses of the 31 top XSA runs.

To select by the diagnostic analysis the best setting parameters to be used in the final assessment a retrospective analysis was carried out for all the 36 models. By analysing the retrospective patterns of recruitment, F and SSB, the most stable results the model number 22 was considered the best (Figure 6.6.2.2, control parameters: fse_2, rage_0, qage_2, shk.yrs_3, shk.ages_1).

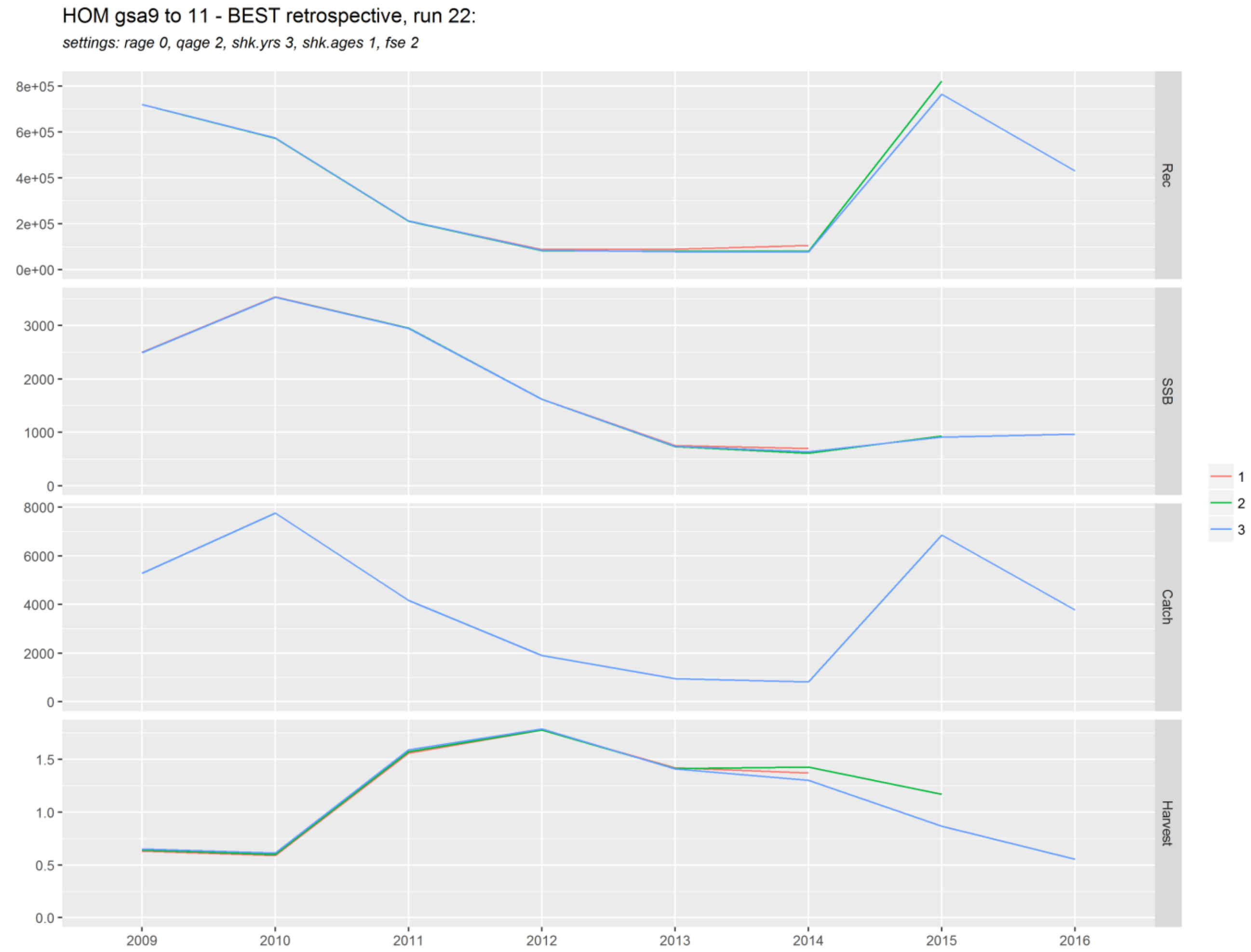


Figure 6.6.2.2 Atlantic horse mackerel in GSAs 9, 10 & 11. Some of the retrospective analyses of the best XSA run.

The XSA results show an peak of recruitment in 2015 and a decreasing trend of fishing mortality in the last years in with an estimated F_{cur} of about 0.56 (Figure 6.6.2.3, Table 6.6.2.3).

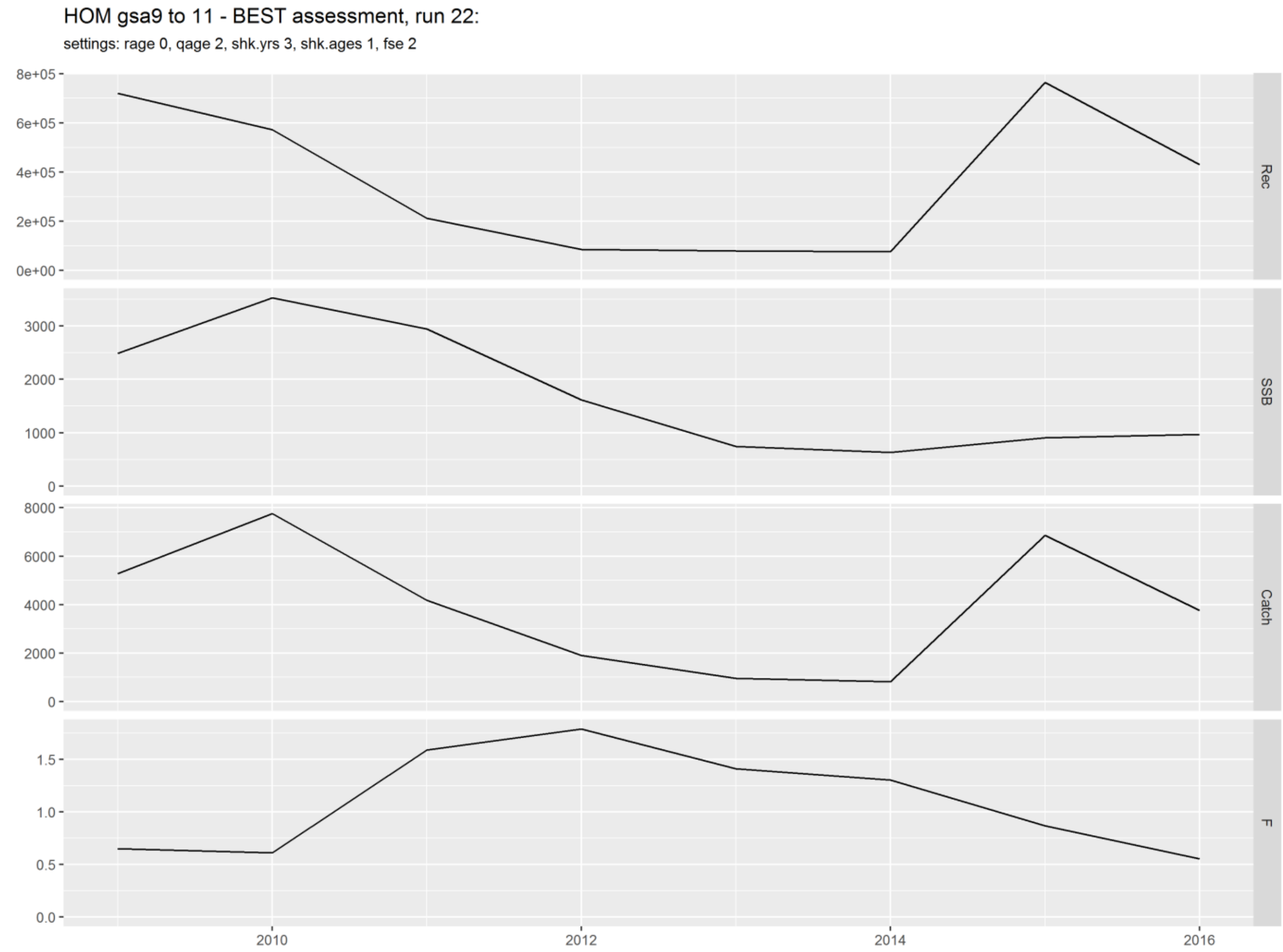


Figure 6.6.2.3. Atlantic horse mackerel in GSAs 9, 10 & 11. XSA summary results. SSB and catch are in tons, recruitment in 1000s individuals.

Table 6.6.2.3. Atlantic horse mackerel in GSAs 9, 10 & 11. XSA summary results. SSB and catch are in tons, recruitment in 1000s individuals.

	ssb	fbar	rec	catch	landings
2009	2489.1	0.65	720023	5282.3	5282.3
2010	3529.4	0.61	573254	7765.2	7765.2
2011	2948.4	1.59	212087	4173	4173
2012	1617.8	1.79	85719	1902	1902
2013	741.9	1.41	79147	955	955
2014	633.8	1.3	76654	820.6	820.6
2015	908.2	0.87	764932	6857.2	6857.2
2016	969.6	0.56	430635	3769	3769

6.6.3 Reference Points

The mainly exploited ages were from 2 to 6 and for this age range were estimated the corresponding mean F values. These values were used to computed a corresponding value of exploitation rate (E) to compare with exploitation rate reference point (E=0.4) proposed by Patterson (1992) (Figure 6.6.3.1). The F equivalent to E=0.4 is estimated to be 0.23 from XSA assessment M and fishery selection.

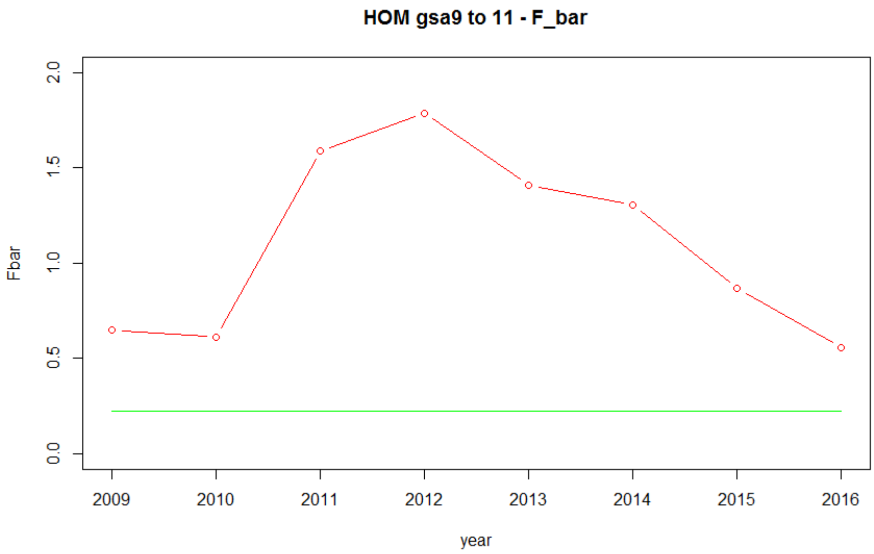


Figure 6.6.3.1 Atlantic horse mackerel in GSAs 9, 10 & 11. Trend in the exploitation rate compare to E=0.4.

6.6.4 Short term Forecast and Catch Options

Short-term forecast results are shown in the following table (Table 6.6.4.1). No specific calculation the FMSY level is provided due to the uncertainty in estimating an appropriate reference point (see section 4.3).
In the absence of MSY reference point advice is given based on precautionary considerations E=F/(F+M) = 0.4 (Patterson 1992), for this stock M varies by age (see above Table), for comparison with F mean M is taken as the weighted M over the selection in the fishery based on recent (last 3 years selection pattern, Table 6.6.2.3.3) and results in mean M = 0.34 giving F=0.23 for E=0.4 resulting in a catch of 3769.

Table 6.6.4.1. Atlantic horse mackerel in GSAs 9, 10 & 11. Short-term forecasts results showing catch options at different level of F.

Rationale	**F factor**	**F bar**	**Catch 2017**	**Catch 2018**	**Catch 2019**	**SSB 2019**	**Change_SSB 2018-2019(%)**	**Change_Catch 2016-2018(%)**
zero catch	0.0	0.00	3342	0.0	0.0	3354.3	135	-100
E = 0.4	0.3	0.23	3342	1183.0	1579.1	2632.6	85	-69
Status quo	1.0	0.86	3342	3306.13	3259.66	3306.13	-3	-12
Different scenarios	0.1	0.09	3342	483.0	701.0	3058.2	114	-87
	0.2	0.17	3342	922.8	1271.7	2790.3	96	-76

Rationale	F factor	F bar	Catch 2017	Catch 2018	Catch 2019	SSB 2019	Change_SSB 2018-2019(%)	Change_Catch 2016-2018(%)
	0.3	0.26	3342	1323.4	1735.6	2547.8	79	-65
	0.4	0.34	3342	1688.6	2112.2	2328.2	63	-55
	0.5	0.43	3342	2022.0	2417.5	2129.4	49	-46
	0.6	0.51	3342	2326.4	2664.6	1949.3	37	-38
	0.7	0.60	3342	2604.6	2864.3	1786.1	25	-31
	0.8	0.69	3342	2859.2	3025.4	1638.2	15	-24
	0.9	0.77	3342	3092.4	3155.2	1504.1	5	-18
	1.0	0.86	3342	3306.1	3259.7	1382.5	-3	-12
	1.1	0.94	3342	3502.2	3343.6	1272.2	-11	-7
	1.2	1.03	3342	3682.3	3411.0	1172.1	-18	-2
	1.3	1.11	3342	3847.9	3465.2	1081.3	-24	2
	1.4	1.20	3342	4000.4	3508.7	998.8	-30	6
	1.5	1.28	3342	4140.8	3543.7	923.9	-35	10
	1.6	1.37	3342	4270.3	3572.0	855.8	-40	13
	1.7	1.46	3342	4389.9	3594.9	793.9	-44	16
	1.8	1.54	3342	4500.5	3613.7	737.7	-48	19
	1.9	1.63	3342	4602.8	3629.2	686.6	-52	22
	2.0	1.71	3342	4697.6	3642.2	640.1	-55	25

6.6.5 Data Deficiencies

Data utilised for the analyses come from the last DCF official data call (2016). Some errors and deficiencies have been detected and the detailed list is reported in section 7.6 (Data quality). Total discards and discards at length are missing for 2009, 2014 and 2015 in GSA 10 and for 2010 and 2014 in GSA11, while reported for all other years in time frame (2009-2016). Total landings are reported from 2003 for GSA9, from 2006 for GSA10 and from 2009 for GSA11, while structures at length from 2007 for GSA9, 2009 for GSA10 and 2010 for GSA11 with differences on gears among years. In some years the difference among reported total catches and catches derived from the biological sampling of landing and discards can be explained taking in to account that this species is not an economically important and generally is poorly landed in the region.

A check and eventually an update on catch data and more appropriate sample procedures of landings would improve the assessment.

6.7 STOCK ASSESSMENT ON ANCHOVY IN GSAs 17 & 18

Stock Identity and biology

Many studies have been carried out regarding the presence of a unique stock or different sub-populations of anchovy in the Adriatic Sea (GSAs 17 and 18). This has several implications for the management, i.e. differences in the growth features between sub-populations imply the necessity of *ad hoc* strategies in the management. The hypothesis of two distinct populations claims the evidence of morphometric differences between northern and southern Adriatic anchovy, such as colour and length, and some variability in their genetic structure (Bembo et al., 1996). Nevertheless, many authors warn against the use of morphological data in studies on population structure (Tudela, 1999) and, a recent study from Magoulas et al. (2006), revealed the presence of two different clades in the Mediterranean, one of those is characterized by a high frequency in the Adriatic Sea (higher than 85%) with a low nucleotide diversity (around 1%). More recently Ruggeri et al. (2016) analysed genetic markers from anchovy samples from Adriatic Sea and Tyrrhenian Sea and didn't find clear evidence of two distinct anchovy populations in these areas, even if in the northern Adriatic Sea geographic gradients in sea temperature, salinity and dissolved oxygen appear to drive adaptive differences in spawning time and early larval development among populations. Moreover, recent outcomes of EU project STOCKMED and EWG 17-02 indicated existence of one single stock of anchovy in the Adriatic Sea also. Therefore, also according to the fact that a lot of vessels registered in GSA 18 fish in GSA 17, it was decided to merge the two GSAs and thus carry out an assessment for anchovy in GSA 17-18.

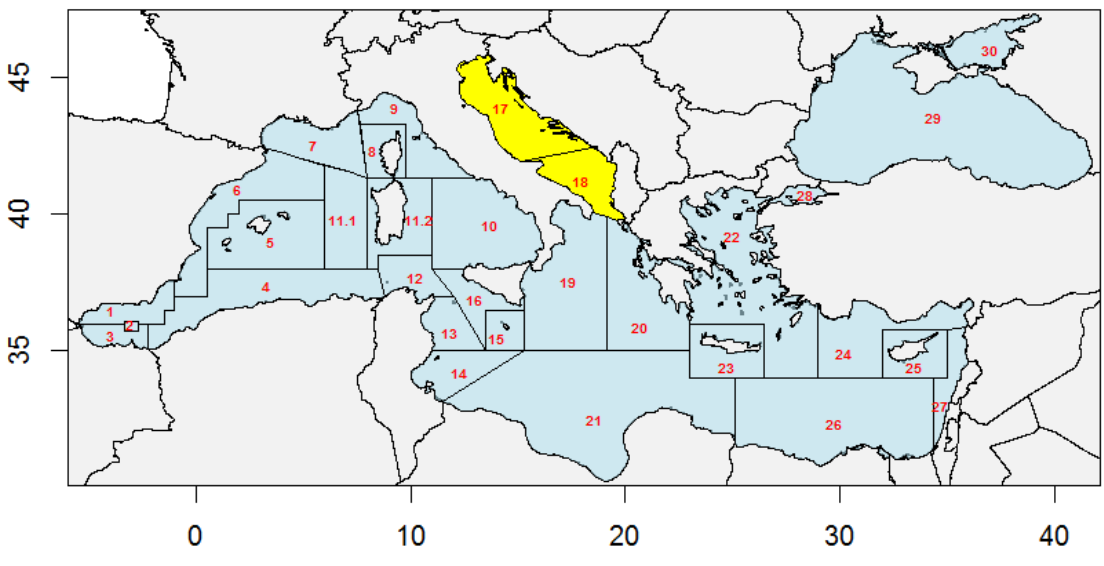


Figure 6.1 Geographical location of GSAs 17-18.

A revision of the historical dataset for anchovy in the Adriatic Sea has been carried out in 2015: the main changes concern the use of one age length key (ALK) to split the length frequency distribution of eastern side into numbers at age and the use of calendar year data, instead of using the split year assumption. The same data were used in this assessment also.

The growth parameters were not re-estimated during this meeting, but the same parameters as in previous GFCM 2016 stock assessment were used (Table 6.7.1). Proportion of mature and natural mortality are also shown (Tab 6.7.2 and Tab 6.7.3). The proportion mature is changed from 0.5 to 0.0 in previous years. The basis of this is that the assessment is set up on a calendar year (Jan to Dec) with annual catches from each calendar year. Spawning is extended over late string to earkly autumn, but with mean spaewing occring in summer. In such a model individuals increment age on the first of January, on average after 6 moths of life. So it is expected that anchovy spawned in one year will reach maturity only the next calendar year by which time they are all classed at age 1. The impact of this on spawing stock biomass is discussed in the assessment section below.

Table 6.7.1 European anchovy in GSAs 17-18. Von Bertalanffy growth and length-weight parameters used.

	Growth parameters			Length-weight	
	L_{inf}	k	t_0	a	b
Sex Combined	19.4	0.57	-0.5	0.003	3.233

Table 6.7.2 European anchovy in GSAs 17-18. Proportion of mature specimens at age.

Period	Age	0	1	2	3	4
1975-2016	**Prop. Matures**	0	1.00	1.00	1.00	1.00

Table 6.7.3 European anchovy in GSAs 17-18. Natural mortality vector by age from Gislason et al. (2010).

Period	Age	0	1	2	3	4
1975-2015	**M**	2.36	1.10	0.81	0.69	0.625

6.7.1 DATA

6.7.1.1 CATCH (LANDINGS AND DISCARDS)

General description of Fisheries

Anchovy is commercially very important in the Adriatic Sea: it is targeted by pelagic trawlers (Italy) and purse seiners (Italy, Croatia, Slovenia). The number of vessels targeting small pelagic fish (anchovy and sardine) is around 400. Several Italian boats registered in ports located in GSA 18 actually fish and land in GSA 17.

In Montenegro, most of the catches come from small-scale beach seine fisheries and from the fishery with small purse seiners in coastal waters (< 70 m depth); currently, the three existing large purse seiners as well as the pelagic trawler are currently not active due to market constrains and lack of skilled fishers (UNEP-MAP-RAC/SPA. 2014): the catches therefore are really low (FAO Official Fisheries Statistics 2016) but no information on the real magnitude of catches is available although the length structure of the Montenegrin catches are available for 2007 to 2016. Almost no information is available for Albania; nevertheless from the FAO Official Fisheries Statistics (2016) it appears that also Albanian catches are small.

Management regulations applicable in 2016

A multi–annual management plan for small pelagic fisheries in the Adriatic Sea has been established by the General Fisheries Commission for the Mediterranean (GFCM) in 2012. Besides this: Italy has been enforcing for years a general regulation concerning the fishing gears and since 1988 a suspension (about one month) of fishing activity of pelagic trawlers in summer; A closure period is observed from 10th December to 22nd December and from 16th to 31st January from the Croatian purse seiners. A temporal fishing closure period of around 40 days is observed by the Italian fleet between July and September; and in Montenegro the fishing closure period was observed from the 1st April to the 15th April.

Landings and catch at age data

Concerning GSA 17 and 18, landings and landings at age data from 2002 were available through the DCF database for Italy, whereas for Slovenia the DCF database includes landings from 2005 and catch at age data from 2006. Croatian data were available from 2013 through the DCF database. However, a longer time series of data was used in the assessment thanks to the possibility of using the updated data set from the last GFCM stock assessment (GFCM, 2017). The GFCM database includes also data for Montenegro and Albania.

The entire time series of landings is presented in Figure 6.7.1.1.1. Observing the landings trend, a collapse of anchovy catch was recorded in 1987. Also, it is clear that until the 2000 most of the anchovy landings were retained by the West side of the Adriatic Sea. From 1988 the landings trend increased reaching the maximum of the entire time series in 2007 with 65,317 tons. From 2007 the landings decreased to 2013. In the last years a positive trend is showed.

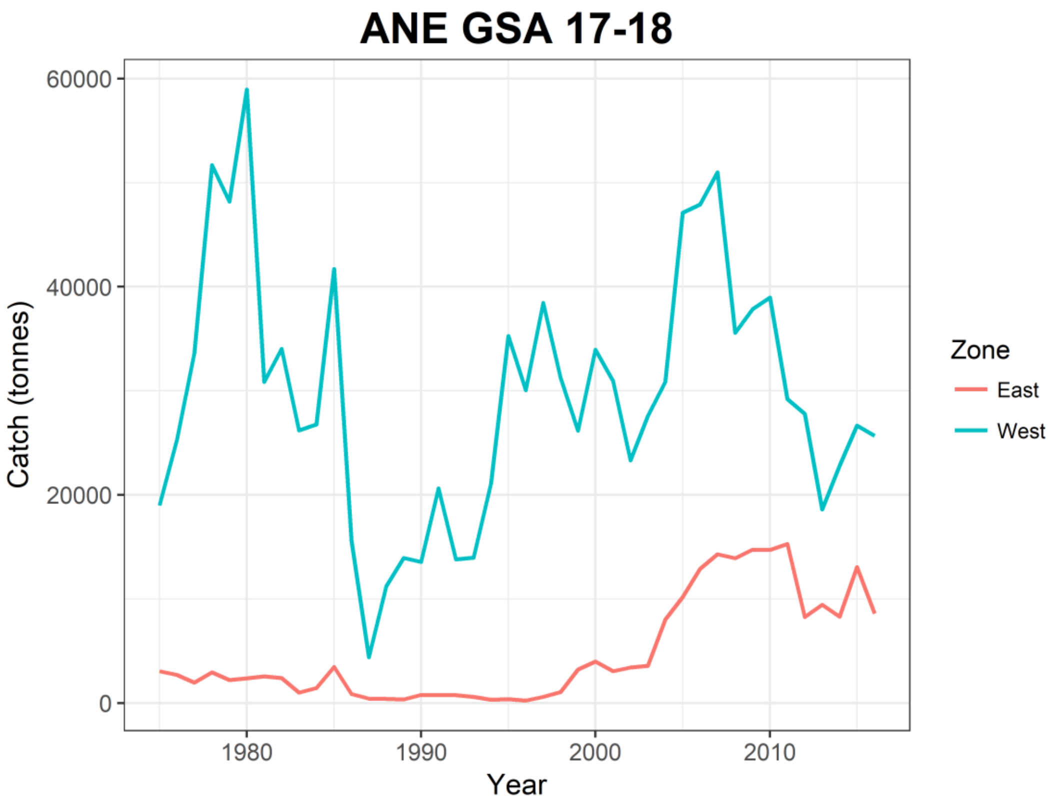


Figure 6.7.1.1.1 European anchovy in GSAs 17 & 18. Landings from 1975 to 2016 divided by West (Italy) and East (Croatia, Slovenia, Montenegro and Albania) side. (i.e. Slovenia landings are included in the East part, not West)

The Table 6.7.1.1.1 shows the annual landings (t) from 1975 to 2016.

Table 6.7.1.1.1 European anchovy in GSAs 17 & 18. Landings for GSA 17 and 18.

Year	Landing (t)	Year	Landing (t)
1975	22049	1996	30304
1976	28001	1997	39040
1977	35565	1998	32294
1978	54624	1999	29383
1979	50378	2000	37952
1980	61323	2001	33984
1981	33422	2002	26721
1982	36425	2003	31172
1983	27201	2004	38859

1984	28211	2005	57301
1985	45198	2006	60803
1986	16446	2007	65317
1987	4848	2008	49486
1988	11624	2009	52578
1989	14287	2010	53689
1990	14363	2011	44487
1991	21371	2012	36045
1992	14557	2013	28043
1993	14562	2014	31085
1994	21424	2015	39737
1995	35665	2016	34252

The mean weight at age (kg) of the catches is show in Figure 6.7.1.1.2

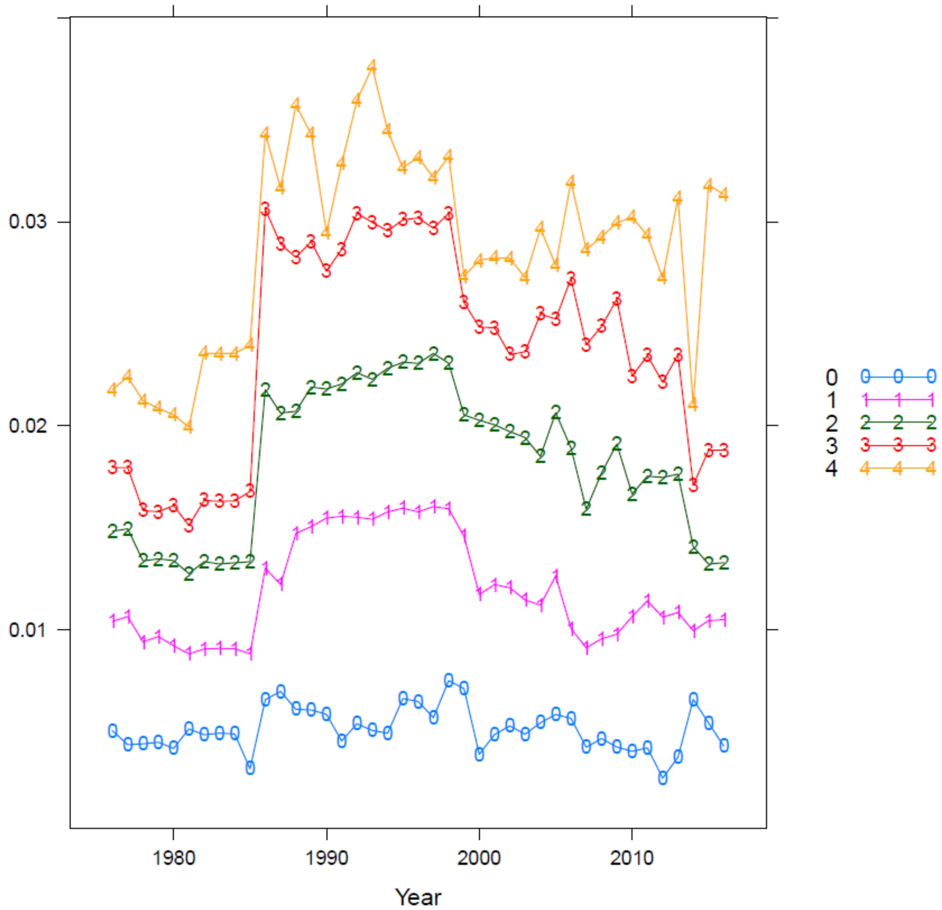


Figure 6.7.1.1.2 European anchovy in GSAs 17 & 18. Mean weight of single fish at age (kg) in the catches.

Discards

Discard data for anchovy are available for GSA17 only in DCF database. These data are available for Croatia (2014-2016) for PS gear only. From Italy, discard data are available for 2 gears (PTM and OTB) in the period 2011-2014 from GSA17, only. No discard data from Italy are available for GSA18. The most complete discard data of anchovy are available by Slovenia, in the period 2005-2016, including data from pelagic (SPF) and demersal fisheries (DEMSP – various gears). EWG 17-09 noticed that in case of Croatia, all available data have zero values (0), indicating that no anchovies were discarded by Croatian fishing fleet.

Despite this information, discard was not included in the assessment since the values are sparse, variable but very small, and the practice of discarding small pelagic species for these fisheries can be considered negligible. Landings data can be considered representative of catch.

6.7.1.2 EFFORT

The number of vessels from Italy, Croatia and Slovenia targeting small pelagic species (i.e. anchovy and sardine) is around 400. In Montenegro most of the catches comes from small-scale beach seine fisheries and from the fishery with small purse seiners in coastal waters (< 70 m depth); currently, the three existing large purse seiners as well as the pelagic trawler are currently not active due to market constrains and lack of skilled fishers (UNEP-MAP-RAC/SPA. 2014): the catches therefore are really low (FAO Official Fisheries Statistics 2016) but no information on the real magnitude of catches is available although the length structure of the Montenegrin catches are available for 2007 to 2016. Almost no information are available for Albania, nevertheless from the FAO database it appears that also Albanian catches are small.

Data on nominal effort for small pelagic fisheries (SPF), targeting small pelagic species (i.e. anchovy and sardine) are available for Italy (years from 2004 to 2016), for Slovenia (2005-2016) and for Croatia (2012-2016) (Table 6.7.1.2.1).

Table 6.7.1.2.1 European anchovy in GSAs 17 & 18. Data on nominal effort for small pelagic fisheries (SPF) in GSA17 and GSA18

YEAR / COUNTRY	CROATIA	ITALY	SLOVENIA
2004	-	10947573	-
2005	-	9957313	291862
2006	-	9544684	263692
2007	-	10415198	285762
2008	-	8237549	230328
2009	-	8660943	308307
2010	-	8349886	272630
2011	-	6724554	447979

2012	10969269	7719805	35372
2013	11675983	8239957	24695
2014	11995028	8972672	32264
2015	10748959	7478123	22081
2016	11090157	8877163	12093

6.7.1.3 SURVEY DATA

MEDIAS

In the western part of the Adriatic Sea, acoustic surveys have been carried out since 1976 in the Northern Adriatic (2/3 of the area: western GSA 17), and since 1987 also in the Mid Adriatic (1/3 of the area: western GSA 17) and South Adriatic (GSA 18). Since 2009, acoustic surveys are carried out under the MEDIAS framework. The eastern part has been surveyed by the Croatian national pelagic monitoring program PELMON (2003-2012) and later on through DCF-MEDIAS. During 2011-2012 acoustic survey covered approximately a half of eastern part of GSA17 only, and for those years fish biomass in a part of eastern survey area was estimated as corresponding to the average percentage of biomass during 2009-2015 in missing area. The survey methods for MEDIAS are given in the MEDIAS handbook (MEDIAS, March 2015). The acoustic surveys in eastern GSA 18 have been carried out as extension of the MEDIAS survey to the Albanian and Montenegrin waters with the intent to cover the entire GSA 18.

MEDIAS estimates were included in the assessment model considering three tuning indexes:

1) Acoustic survey West that includes the western side of GSA 17 and the entire GSA 18 in the form of numbers-at-age from 2004 to 2016, with data based on a preliminary agreement and the discussion inside AdriaMed Study Group on intercalibration of anchovy otolith reading and taking into account the ICES WKARA2 2016 Report;
2) Acoustic survey East, that includes the eastern side of GSA 17 in the form of numbers-at-age from 2013 to 2016, with data based on ICES WKARA2 age-reading protocol;
3) Acoustic survey East biomass that includes the eastern side of GSA 17 in the form of total biomass from 2003 to 2012.

Acoustic sampling transects and the total area covered in GSA 17 and GSA18 is shown in Figure 6.7.1.3.1.

Figure 6.7.1.3.1 European Anchovy in GSAs 17 & 18. Acoustic transects for the western acoustic survey (white tracks) and the eastern acoustic survey (pink tracks) for the GSA 17 and GSA 18.

Trends in abundance & biomass

Acoustic index for the western side of the Adriatic Sea and the GSA 18 show the highest abundance in 2008, 110,553,007 number of individuals. Then there has been a generally continuous decreasing trend up to 2016 (15,899,377 individuals.), with a peak in 2012 (104,912,841 individuals.). The index of abundance at age for the eastern Adriatic was available only for the years from 2013 to 2016. The contribution of this index is much lower compared to the western Adriatic acoustic survey.

Tables 6.7.1.3.1 and 6.7.1.3.2 show the abundance at age respectively for the West acoustic survey and East acoustic survey, whereas tables 6.7.1.3.3 show the biomass trend for the East acoustic survey.

Table 6.7.1.3.1 European anchovy in GSAs 17 & 18. Abundance at age from echo survey West in thousands

Year	age 0	age 1	age 2	age 3	age 4
2004	35560685	18764020	613692	5645	2540
2005	40787857	10033202	134557	4072	1832
2006	76696622	26700888	3988381	151803	61547
2007	73618538	28091728	2747682	70127	25026
2008	64356278	44561926	1557486	64161	13156
2009	73769477	21903651	429701	16421	17861

2010	45236308	26066281	566016	21460	23342
2011	49485704	23424898	305350	17105	13498
2012	86799211	18037774	62577	6364	6915
2013	43260113	18805485	480456	946	158
2014	28448153	18667773	273617	133	0
2015	18400911	14596893	621395	47936	22799
2016	11384028	4493347	21872	0	0

Table 6.7.1.3.2 European anchovy in GSAs 17 & 18. Abundance at age from echo survey East in thousands.

Year	age 0	age 1	age 2	age 3	age 4
2013	2477404	2384276	1846	0	0
2014	8202814	1417362	1531	0	0
2015	3024067	1585048	1875	0	0
2016	3410073	1220159	15772	0	0

Table 6.7.1.3.3 European anchovy in GSAs 17 & 18. Acoustic biomass for the echo survey East GSA 17 from 2003 to 2012, later years are provided as an age based index fitted separately see Table 6.7.1.3.2

Year	Biomass (t)
2003	56223
2004	81866
2005	132340
2006	142089
2007	56488
2008	110290
2009	122170
2010	166325
2011	46472
2012	11639

Data exploration of the tuning data is showed in the figures below (Figure 6.7.1.3.2 and 6.7.1.3.3).

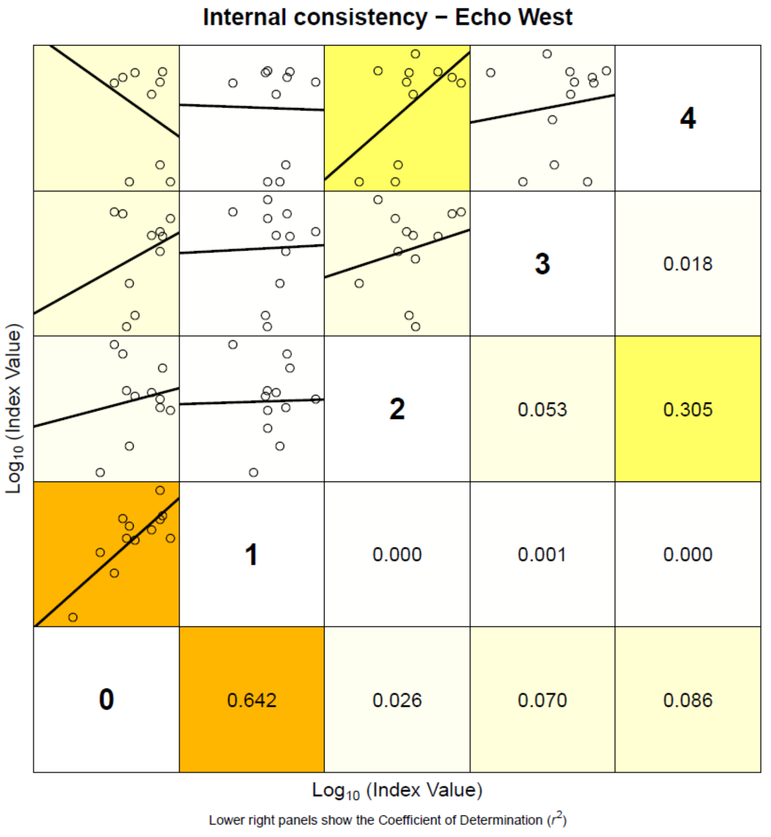


Figure 6.7.1.3.2 European anchovy in GSAs 17 & 18. Internal consistency between ages for the acoustic survey West.

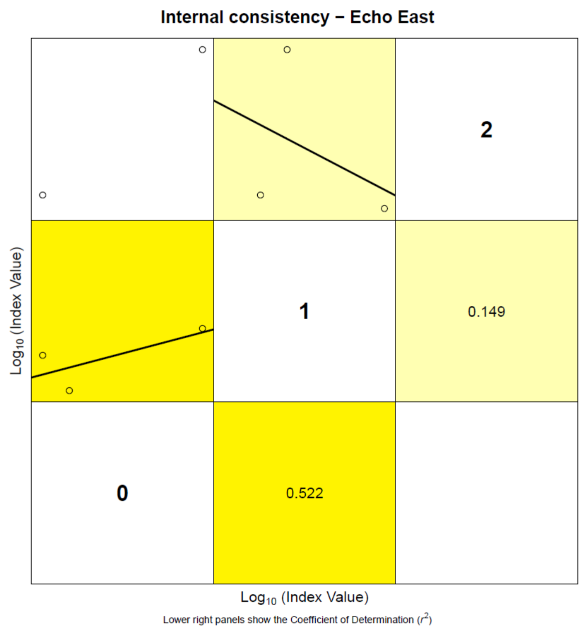


Figure 6.7.1.3.3 European anchovy in GSAs 17 & 18. Internal consistency between ages for the acoustic survey East.

The trends in numbers at age for the two surveys are shown in Figure 6.7.1.3.4 and Figure 6.7.1.3.5.

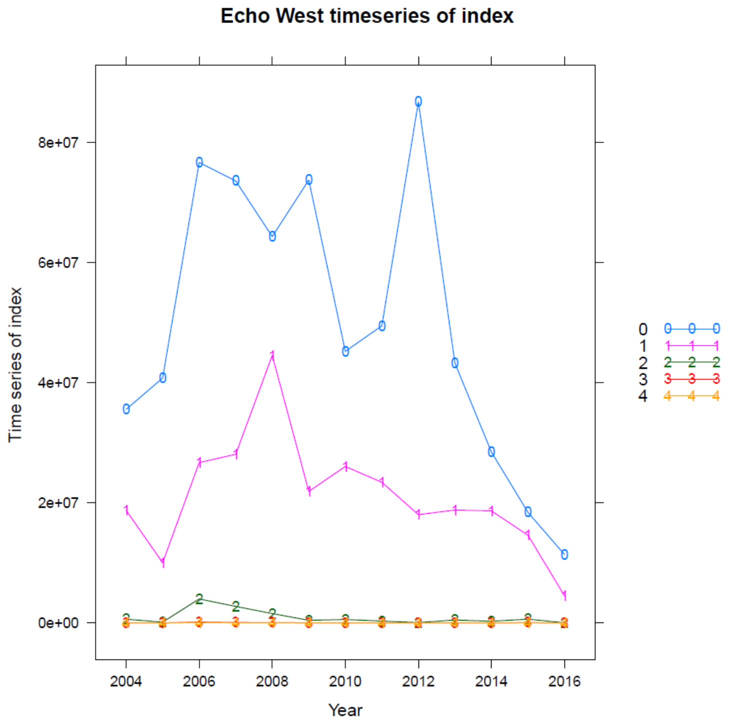


Figure 6.7.1.3.4 European anchovy in GSAs 17 & 18. Trend in numbers at age for the West acoustic survey.

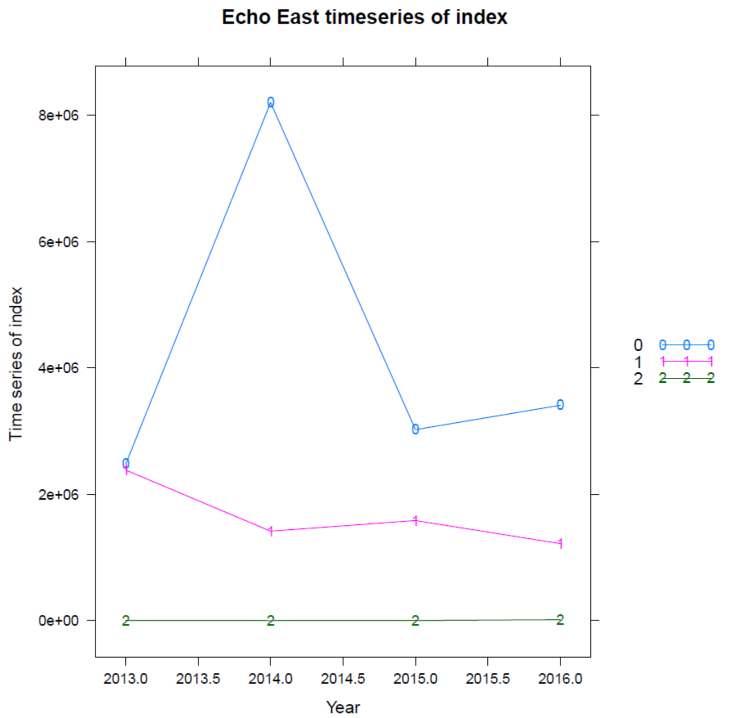


Figure 6.7.1.3.5 European anchovy in GSAs 17 & 18. Trend in numbers at age for the East acoustic survey.

6.7.2 STOCK ASSESSMENT

Methods: SAM (State-space Assessment Model)

The stock of anchovy in GSAs 17-18 was assessed using the State-space Assessment Model (SAM) (Nielsen et al., 2014) in FLR environment with data from 1975 to 2016. The SAM environment is encapsulated into the Fisheries Library in R (FLR) (Kell et al., 2007) in the form of the package "FLSAM". The state-space assessment model (SAM) is an assessment model used for several assessments of small pelagic stocks within ICES. The model allows selectivity to evolve gradually over time. It has fewer model parameters than full parametric statistical assessment models, with quantities such as recruitment and fishing mortality modelled as random effects.

Three tuning indexes were used in the assessment: 1) the abundance index at age for the Western side of GSA 17 and GSA 18 from 2004 to 2016, 2) the abundance index at age for the Eastern side of GSA 17 from 2013 to 2016, and 3) a biomass index for the Eastern side of GSA 17 from 2003 to 2012.

Since the spawning takes place mostly in spring-summer (Zorica et al., 2013), previous assessments (STECF EWG 15-11) were carried out taking into account a conventional birth date on the first of June (split-year), as in Santojanni et al. (2003). Consequently, all data were shifted by 6 months in order to have each year compounded by the time interval ranging from the first of June, up to May 31st of the following year; the tuning indices were shifted as well.

Following the suggestions by STECF EWG 14-09, the present assessment was based on the calendar-year data. This approach is expected to simplify calculations, limiting the errors, and allowing using the most recent survey indices available.

Assessment was performed with version 1.02 of FLSAM, together with version 2.6.5 of the FLR library (FLCore). Two runs were performed: one including all the time series 1975-2016 and the other one including years from 2000 to 2016.

Input data

This assessment was performed using the updated data set from the last GFCM stock assessment (GFCM, 2016). Discarding is considered negligible and landings are assumed to be catch. In order to maintain agreement with total catch small SoP corrections were included, in all cases less than 10%. However, some modifications were carried out:

1) Albania sent new catch data for years from 2008 to 2016, thus landings and catch at age data for these years were updated with the new estimates
2) Abundance indices at age for acoustic survey West and East were updated applying new age length keys. The 2016 ALK (Figure 6.7.2.1), derived from the new criteria of otolith reading on the base of a preliminary agreement and the discussion inside AdriaMed Study Group on intercalibration of anchovy otolith reading and taking into account the ICES WKARA2 2016 report, was used to estimate the abundance-at-age for the anchovy in GSAs 17 and 18 West data. In the case of the East acoustic survey, new ALK is produced each year (Figure 6.7.2.2) and abundance indices by age are calculated accordingly.

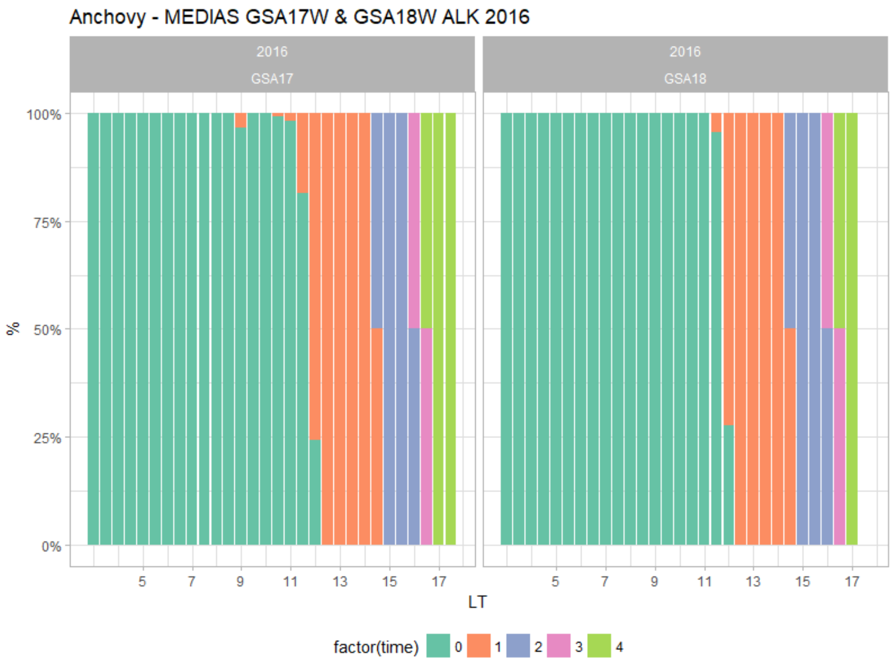


Figure 6.7.2.1 European Anchovy in GSAs 17 & 18. Age length-key from MEDIAS for GSAs 17-18 West

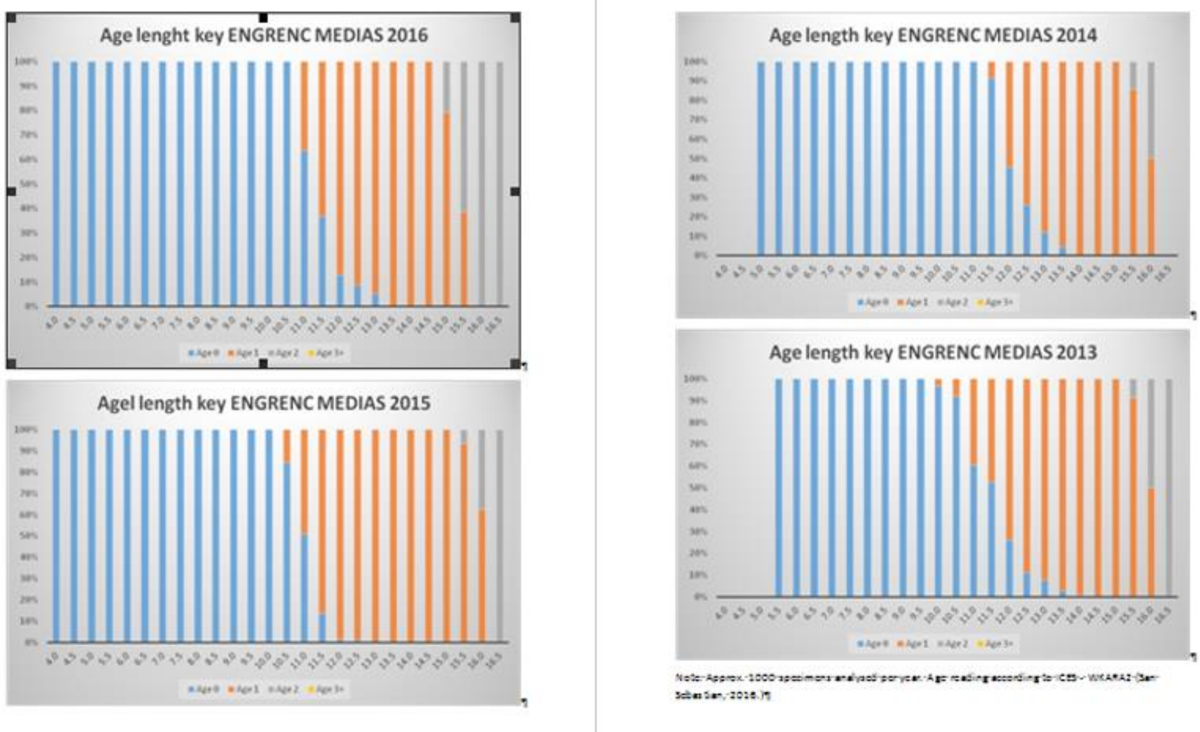


Figure 6.7.2.2 European anchovy in GSAs 17 & 18. Age-length keys (2013-2016) used to calculate abundance-at-age indices from MEDIAS covering eastern part of GSA17.

The growth parameters were not re-estimated during this meeting, since they were not used in the assessment for age slicing purposes. The natural mortality vector was estimated on the basis of the same growth parameters as used in previous GFCM 2016 stock assessment (Table 6.7.1 and Table 6.7.3).

Landings data included in the assessment are shown in Table 6.7.1.1.1, maturity-at-age information are included in Table 6.7.2 , natural mortality-at-age is shown in Table 6.7.3. Catch numbers-at-age and mean weight-at-age are shown in the following tables.

Two runs were performed: one including all the available data from 1975 to 2016 and the other run using a truncated data set including only years from 2000 to 2016. Input data are the same for the both models; results of the stock assessment are reported for both the runs.

Table 6.7.2.3 European anchovy in GSAs 17 & 18. Input data for the SAM assessment. Catch numbers-at-age matrix (thousands).

age	0	1	2	3	4
1975	482092	838593	526958	126873	67692
1976	546700	871860	620105	212748	143470
1977	855182	1151096	628420	276774	230727
1978	703778	1635116	1405033	721213	276345
1979	608478	1401892	1169253	701390	346055
1980	396695	1263525	1507232	1093211	496358
1981	363550	897099	909873	536268	195789
1982	311340	684511	813774	580203	354486
1983	226546	491870	585420	437479	285655
1984	235759	515742	612714	448569	293053
1985	469534	752725	739741	564111	739260
1986	199939	186764	144217	115497	175410
1987	91551	80929	62344	39121	25316
1988	360736	271133	129518	56632	31938
1989	529317	287824	185917	69425	18800
1990	399513	391977	187817	53015	13257
1991	664502	503464	281725	111255	33338
1992	239126	285232	229990	89614	25370
1993	321326	285794	227184	86514	23056

1994	743359	557188	272533	74472	15473
1995	779560	854068	488011	149939	32304
1996	637643	629839	436178	160960	39182
1997	1033852	921285	547882	150329	30795
1998	550646	675040	505319	152831	32790
1999	910877	802753	411223	88520	15399
2000	551555	1352876	658685	215994	42218
2001	303874	1223921	610490	176276	32814
2002	185243	980195	517524	128525	24269
2003	540595	1576735	468440	54943	1473
2004	889913	1310272	852746	126502	9896
2005	828627	2105130	1067552	147358	1814
2006	625804	1104045	1945985	305944	30817
2007	306937	1008445	2172848	698241	121239
2008	328454	708483	1584265	432828	67849
2009	588808	2220233	1255758	130538	19687
2010	470353	2048993	1606682	121756	15213
2011	578464	1678148	1183670	98578	19466
2012	648892	1369598	1079939	32647	4065
2013	306895	1029190	819622	51239	1570
2014	332484	1053303	1136174	186128	3169
2015	215147	1547601	1517949	116784	3219
2016	332131	1594711	1142627	45008	478

Table 6.7.2.4 European anchovy in GSAs 17 & 18. Mean weight-at-age of catches by year.

Year	**age 0**	**age 1**	**age 2**	**age 3**	**age 4**
1975	0.0039	0.0101	0.0148	0.0182	0.0231
1976	0.0051	0.0104	0.0148	0.0180	0.0218

1977	0.0044	0.0107	0.0150	0.0179	0.0224
1978	0.0044	0.0094	0.0134	0.0159	0.0212
1979	0.0045	0.0097	0.0135	0.0158	0.0209
1980	0.0042	0.0092	0.0134	0.0161	0.0205
1981	0.0052	0.0088	0.0128	0.0151	0.0199
1982	0.0049	0.0091	0.0134	0.0163	0.0236
1983	0.0050	0.0091	0.0132	0.0163	0.0235
1984	0.0049	0.0091	0.0133	0.0163	0.0235
1985	0.0032	0.0088	0.0133	0.0168	0.0240
1986	0.0066	0.0130	0.0218	0.0306	0.0343
1987	0.0070	0.0122	0.0206	0.0289	0.0316
1988	0.0061	0.0147	0.0207	0.0283	0.0357
1989	0.0061	0.0151	0.0219	0.0290	0.0343
1990	0.0059	0.0155	0.0218	0.0276	0.0295
1991	0.0046	0.0156	0.0220	0.0287	0.0329
1992	0.0054	0.0155	0.0226	0.0304	0.0359
1993	0.0051	0.0154	0.0223	0.0300	0.0376
1994	0.0049	0.0158	0.0228	0.0295	0.0345
1995	0.0066	0.0160	0.0231	0.0301	0.0326
1996	0.0065	0.0158	0.0231	0.0302	0.0332
1997	0.0057	0.0160	0.0235	0.0297	0.0322
1998	0.0075	0.0159	0.0231	0.0304	0.0332
1999	0.0071	0.0146	0.0205	0.0260	0.0273
2000	0.0039	0.0117	0.0203	0.0248	0.0281
2001	0.0049	0.0122	0.0201	0.0248	0.0282
2002	0.0053	0.0121	0.0197	0.0235	0.0282
2003	0.0049	0.0115	0.0194	0.0236	0.0273
2004	0.0055	0.0112	0.0185	0.0255	0.0297
2005	0.0059	0.0127	0.0206	0.0252	0.0279
2006	0.0057	0.0101	0.0189	0.0272	0.0320
2007	0.0043	0.0091	0.0159	0.0240	0.0286
2008	0.0047	0.0096	0.0177	0.0249	0.0292

2009	0.0043	0.0098	0.0191	0.0262	0.0299
2010	0.0041	0.0107	0.0167	0.0224	0.0302
2011	0.0042	0.0114	0.0175	0.0234	0.0293
2012	0.0027	0.0106	0.0175	0.0221	0.0272
2013	0.0038	0.0109	0.0176	0.0235	0.0312
2014	0.0066	0.0100	0.0141	0.0171	0.0210
2015	0.0055	0.0105	0.0132	0.0188	0.0318
2016	0.0043	0.0105	0.0133	0.0188	0.0313

Results

- Entire time series 1975 - 2016

SAM outputs are listed in Table 6.7.2.5 and Table 6.7.2.6; the fishing mortality-at-age by year and the stock numbers-at-age by year (in thousand) are respectively shown in Table 6.7.2.6 and Table 6.7.2.7.

Table 6.7.2.5 European anchovy in GSAs 17 & 18. Main results of the anchovy SAM assessment 1975-2016.

Year	Recruits Age 0 (Thousands) Mean	Recruits Age 0 (Thousands) Low	Recruits Age 0 (Thousands) High	Total biomass (tonnes) Mean	Total biomass (tonnes) Low	Total biomass (tonnes) High	Spawning biomass (tonnes) Mean	Spawning biomass (tonnes) Low	Spawning biomass (tonnes) High
1975	151031654	97751470	233352606	755398	514594	1108885	87204	54786	138803
1976	182817693	121966869	274027767	1138247	780141	1660734	114806	76459	172385
1977	203871408	137217800	302902037	1160081	804479	1672867	143774	95684	216034
1978	190468998	129843391	279401507	1137109	807031	1602191	157787	108794	228843
1979	155942826	107400006	226426104	995500	715530	1385014	156061	107466	226628
1980	120721887	83421982	174699445	768350	561574	1051262	137036	94852	197982
1981	94773463	65435769	137264517	674684	486940	934816	98420	68455	141502
1982	75075137	52058154	108268845	528607	385344	725132	84373	58151	122419
1983	57139145	39886002	81855332	412091	303091	560290	66703	45879	96978
1984	37693567	25698860	55286693	293902	214580	402544	55326	37623	81359
1985	24471017	16283342	36775661	172301	119830	247748	44667	24910	80094
1986	19855667	13381627	29461851	196614	139369	277373	32761	20180	53186
1987	22953936	15943121	33047682	197008	140816	275622	19103	12645	28860
1988	29680476	20989457	41970150	229349	167063	314857	24909	17075	36339

1989	35962957	25473213	50772326	279288	204327	381750	31445	21955	45037
1990	36143222	25663194	50902958	284646	209960	385898	37459	26486	52979
1991	34795548	24803328	48813213	238948	178484	319894	40741	28558	58123
1992	34414894	24593128	48159183	261974	195760	350583	38561	27287	54493
1993	44812604	32386350	62006663	301040	226009	400981	37309	26597	52336
1994	55118722	40081346	75797692	365492	276963	482318	46911	34068	64594
1995	56911045	41482956	78077056	498321	378093	656781	59635	43480	81792
1996	57828946	42179294	79285039	498820	379399	655829	60174	43999	82295
1997	58468576	42647499	80158846	461852	353243	603855	61883	45256	84619
1998	60611791	44466275	82619674	580126	441604	762099	59635	43781	81231
1999	66452635	48526277	91001268	587129	445247	774223	54285	40220	73268
2000	60430228	43995486	83004253	348015	267300	453103	51226	37383	70195
2001	57540523	42234636	78393283	384231	295383	499805	46444	33664	64075
2002	70915529	52536672	95723846	467428	359390	607943	41151	30291	55905
2003	93455879	69443276	125771736	557936	428559	726371	46630	34999	62126
2004	115872383	83201805	161371610	766814	571993	1027992	62818	47820	82520
2005	117506005	87119073	158491829	882929	676266	1152747	91491	67425	124148
2006	108254988	82152744	142650651	813418	646132	1024014	91035	70251	117968
2007	97757453	73386606	130221578	591845	470478	744521	77343	59735	100140
2008	106856781	81163224	140684056	652131	517112	822403	65644	50707	84980
2009	104636186	78911569	138746849	596002	471374	753581	64087	49821	82438
2010	88631688	67400864	116550079	509915	407029	638809	62630	47955	81795
2011	81981158	62278673	107916723	476870	379735	598853	53477	40996	69757
2012	89254286	68124890	116937107	355045	284939	442400	45615	35016	59423
2013	63974812	47607954	85968336	361132	289847	449950	51896	39954	67408
2014	67120495	52391556	85990209	530725	422794	666210	34926	26499	46034
2015	52064818	39575373	68495760	375120	295936	475490	35739	28096	45462
2016	46085089	29323694	72427281	271577	188907	390425	27667	20907	36612

Table 6.7.2.6 European anchovy in GSAs 17 & 18. Main results of the anchovy SAM assessment 1975-2016.

Year	Catch (tonnes)	Catch (tonnes)	Catch (tonnes)	Yield / SSB (ratio)	Yield / SSB (ratio) Low	Yield / SSB (ratio) High	Mean F ages 1-2	Mean F ages 1-2	Mean F ages 1-2	Mean F ages

	Mean	Low	High	Mean			Mean	Low	High	0-1
1975	21753	17050	27753	0.249	0.311	0.200	0.231	0.148	0.359	0.067
1976	30001	24632	36541	0.261	0.322	0.212	0.225	0.150	0.338	0.066
1977	38025	30880	46824	0.264	0.323	0.217	0.221	0.150	0.323	0.067
1978	47667	39016	58237	0.302	0.359	0.254	0.241	0.168	0.345	0.071
1979	51021	41882	62155	0.327	0.390	0.274	0.247	0.174	0.350	0.073
1980	52733	42243	65829	0.385	0.445	0.332	0.264	0.187	0.373	0.075
1981	36171	29551	44272	0.368	0.432	0.313	0.260	0.185	0.366	0.076
1982	35596	28676	44186	0.422	0.493	0.361	0.265	0.189	0.370	0.077
1983	28854	23214	35864	0.433	0.506	0.370	0.270	0.194	0.375	0.081
1984	27038	21515	33980	0.489	0.572	0.418	0.298	0.215	0.413	0.093
1985	30761	20986	45089	0.689	0.842	0.563	0.342	0.238	0.492	0.110
1986	18354	14206	23712	0.560	0.704	0.446	0.298	0.207	0.430	0.099
1987	7832	5977	10264	0.410	0.473	0.356	0.266	0.181	0.392	0.089
1988	10124	8389	12219	0.406	0.491	0.336	0.301	0.210	0.431	0.102
1989	12965	10706	15700	0.412	0.488	0.349	0.331	0.234	0.469	0.109
1990	14802	12133	18057	0.395	0.458	0.341	0.344	0.244	0.484	0.116
1991	17518	14414	21291	0.430	0.505	0.366	0.370	0.264	0.519	0.121
1992	16806	13862	20376	0.436	0.508	0.374	0.372	0.266	0.519	0.115
1993	16732	13759	20349	0.448	0.517	0.389	0.383	0.277	0.529	0.116
1994	20925	17169	25502	0.446	0.504	0.395	0.407	0.299	0.553	0.128
1995	30485	24937	37268	0.511	0.574	0.456	0.452	0.335	0.611	0.140
1996	32145	26563	38899	0.534	0.604	0.473	0.474	0.353	0.638	0.144
1997	34510	28365	41985	0.558	0.627	0.496	0.515	0.384	0.692	0.154
1998	34752	28599	42230	0.583	0.653	0.520	0.536	0.401	0.717	0.156
1999	31351	25278	38884	0.578	0.628	0.531	0.543	0.409	0.720	0.166
2000	33190	26895	40958	0.648	0.719	0.583	0.620	0.466	0.823	0.185
2001	32209	26114	39726	0.694	0.776	0.620	0.687	0.510	0.925	0.193
2002	27834	22528	34389	0.676	0.744	0.615	0.716	0.533	0.962	0.186
2003	28254	22369	35688	0.606	0.639	0.574	0.690	0.526	0.904	0.177

2004	37309	30383	45815	0.594	0.635	0.555	0.666	0.515	0.861	0.157
2005	51124	41441	63068	0.559	0.615	0.508	0.636	0.490	0.824	0.144
2006	61084	48681	76646	0.671	0.693	0.650	0.643	0.494	0.838	0.123
2007	58689	45414	75843	0.759	0.760	0.757	0.729	0.566	0.938	0.119
2008	51380	41612	63440	0.783	0.821	0.747	0.854	0.667	1.092	0.124
2009	48923	39314	60880	0.763	0.789	0.738	0.974	0.772	1.229	0.156
2010	51124	41078	63626	0.816	0.857	0.778	1.146	0.911	1.441	0.178
2011	44400	35400	55689	0.830	0.864	0.798	1.317	1.023	1.695	0.186
2012	36827	29272	46333	0.807	0.836	0.780	1.254	1.005	1.563	0.183
2013	36425	27949	47470	0.702	0.700	0.704	1.081	0.856	1.364	0.174
2014	33157	26760	41083	0.949	1.010	0.892	1.186	0.956	1.471	0.194
2015	33996	26043	44378	0.951	0.927	0.976	1.419	1.115	1.806	0.217
2016	28681	22242	36984	1.037	1.064	1.010	1.428	0.992	2.055	0.241

Table 6.7.2.7 European anchovy in GSAs 17 & 18. F-at-age estimated from 1975 to 2016.

age	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	0.009	0.009	0.010	0.010	0.010	0.010	0.011	0.012	0.014
1	0.125	0.122	0.125	0.133	0.136	0.140	0.140	0.143	0.149
2	0.337	0.328	0.316	0.349	0.358	0.388	0.380	0.387	0.391
3	0.537	0.551	0.587	0.648	0.679	0.721	0.709	0.723	0.729
4	1.665	1.671	1.665	1.653	1.633	1.610	1.563	1.542	1.516
	year								
age	1984	1985	1986	1987	1988	1989	1990	1991	1992
0	0.018	0.022	0.023	0.022	0.026	0.028	0.029	0.030	0.027
1	0.169	0.198	0.176	0.157	0.179	0.190	0.203	0.213	0.202
2	0.427	0.487	0.421	0.375	0.423	0.473	0.485	0.527	0.542
3	0.743	0.766	0.728	0.715	0.764	0.796	0.804	0.859	0.886

4	1.496	1.497	1.444	1.361	1.322	1.277	1.230	1.205	1.166
	year								
age	1993	1994	1995	1996	1997	1998	1999	2000	2001
0	0.027	0.029	0.030	0.030	0.030	0.027	0.025	0.021	0.017
1	0.205	0.227	0.251	0.257	0.279	0.285	0.306	0.350	0.369
2	0.561	0.587	0.654	0.692	0.752	0.788	0.779	0.889	1.005
3	0.924	0.954	1.026	1.084	1.135	1.193	1.224	1.366	1.492
4	1.129	1.095	1.079	1.057	1.025	0.998	0.959	0.946	0.918
	year								
age	2002	2003	2004	2005	2006	2007	2008	2009	2010
0	0.014	0.015	0.015	0.015	0.014	0.012	0.012	0.013	0.014
1	0.358	0.339	0.298	0.272	0.233	0.226	0.236	0.299	0.341
2	1.074	1.040	1.035	0.999	1.054	1.231	1.471	1.649	1.951
3	1.620	1.576	1.654	1.542	1.529	1.661	1.747	1.782	1.886
4	0.883	0.805	0.787	0.743	0.747	0.768	0.755	0.723	0.716
	year								
age	2011	2012	2013	2014	2015	2016			
0	0.015	0.015	0.014	0.014	0.014	0.015			
1	0.356	0.351	0.333	0.373	0.420	0.468			
2	2.278	2.156	1.829	1.998	2.418	2.387			
3	2.105	2.341	2.672	3.171	3.481	3.845			
4	0.735	0.732	0.749	0.773	0.763	0.746			

Table 6.7.2.8 European anchovy in GSAs 17 & 18. Stock numbers-at-age (thousands) from 1975 to 2016.

	Year						
age	1975	1976	1977	1978	1979	1980	age

0	1.51E+08	1.83E+08	2.04E+08	1.90E+08	1.56E+08	1.21E+08	0
1	1.11E+07	1.40E+07	1.72E+07	1.92E+07	1.79E+07	1.46E+07	1
2	2.56E+06	3.14E+06	3.85E+06	6.10E+06	5.80E+06	5.92E+06	2
3	4.43E+05	7.82E+05	9.66E+05	1.47E+06	1.94E+06	2.02E+06	3
4	1.04E+05	2.03E+05	3.32E+05	4.00E+05	5.15E+05	7.15E+05	4
	year						
age	1981	1982	1983	1984	1985	1986	age
0	9.48E+07	7.51E+07	5.71E+07	3.77E+07	2.45E+07	1.99E+07	0
1	1.13E+07	8.87E+06	7.03E+06	5.38E+06	3.50E+06	2.21E+06	1
2	4.24E+06	3.53E+06	2.74E+06	2.49E+06	1.97E+06	6.63E+05	2
3	1.67E+06	1.36E+06	1.11E+06	9.80E+05	8.89E+05	4.23E+05	3
4	3.47E+05	5.43E+05	4.50E+05	4.57E+05	9.06E+05	2.80E+05	4
	year						
age	1987	1988	1989	1990	1991	1992	age
0	2.30E+07	2.97E+07	3.60E+07	3.61E+07	3.48E+07	3.44E+07	0
1	1.80E+06	2.14E+06	2.73E+06	3.31E+06	3.32E+06	3.15E+06	1
2	3.90E+05	5.25E+05	6.35E+05	7.32E+05	9.16E+05	8.02E+05	2
3	1.59E+05	1.25E+05	1.53E+05	1.62E+05	2.15E+05	2.24E+05	3
4	5.35E+04	5.29E+04	3.33E+04	2.63E+04	5.58E+04	4.79E+04	4
	year						
age	1993	1994	1995	1996	1997	1998	age
0	4.48E+07	5.51E+07	5.69E+07	5.78E+07	5.85E+07	6.06E+07	0
1	3.15E+06	4.16E+06	5.08E+06	5.20E+06	5.30E+06	5.31E+06	1
2	7.72E+05	8.99E+05	1.30E+06	1.26E+06	1.38E+06	1.25E+06	2
3	1.97E+05	1.87E+05	2.50E+05	3.05E+05	2.85E+05	2.82E+05	3
4	4.47E+04	3.25E+04	5.85E+04	7.20E+04	6.23E+04	6.36E+04	4
	year						
age	1999	2000	2001	2002	2003	2004	age
0	6.65E+07	6.04E+07	5.75E+07	7.09E+07	9.35E+07	1.16E+08	0
1	5.57E+06	6.13E+06	5.57E+06	5.30E+06	6.68E+06	8.71E+06	1

2	1.22E+06	1.48E+06	1.31E+06	1.07E+06	1.07E+06	1.72E+06	2
3	2.28E+05	2.86E+05	2.77E+05	1.93E+05	1.36E+05	1.63E+05	3
4	3.62E+04	7.77E+04	6.66E+04	4.62E+04	5.16E+03	2.05E+04	4
	year						
age	2005	2006	2007	2008	2009	2010	age
0	1.18E+08	1.08E+08	9.78E+07	1.07E+08	1.05E+08	8.86E+07	0
1	1.09E+07	1.10E+07	1.00E+07	9.06E+06	1.01E+07	9.74E+06	1
2	2.37E+06	3.86E+06	3.76E+06	2.66E+06	2.20E+06	2.45E+06	2
3	2.69E+05	4.62E+05	7.35E+05	5.38E+05	2.48E+05	1.93E+05	3
4	6.22E+03	7.35E+04	2.24E+05	1.50E+05	5.77E+04	4.22E+04	4

The assessment indicates that the anchovy stock size fluctuated over the time period examined. Maximum values of SSB were obtained in 1978 (158000 t). After that, the stock started to decline reaching a minimum level in 1987 (around 19000 t). In the following years, the stock started recovering until 2006, when the biomass reached another maximum (SSB at 91000 tons). From 2005, the stock started to decline again, reaching in 2016 a SSB level of 28000 tons. SSB is currently at a low level, above and not far above the biomass of 1987 from which a slow stock recovery has been observed, the recovery occurred with F at about 50% of $F_{MSY.}$

The assessment shows fluctuations in the number of recruits since the beginning of the time series, similar to those observed for the SSB. The recruitment (age 0) reached a maximum in 1977 (204 million individuals) and a minimum value of 20 million individuals in 1986. A second peak was registered in 2005, with a value of 117 million individuals. Since then, recruitment decreased until 2016 (46 million individuals).

F has increased from the 1980s and is estimated to have peaked at around 1.3 in 2011. After a slight decrease, F increased again in the last years, being estimated at 1.42 in 2016. F has been above F_{MSY} since 2000 and now about 2.3* F_{MSY}, the stock is classed as overfished.

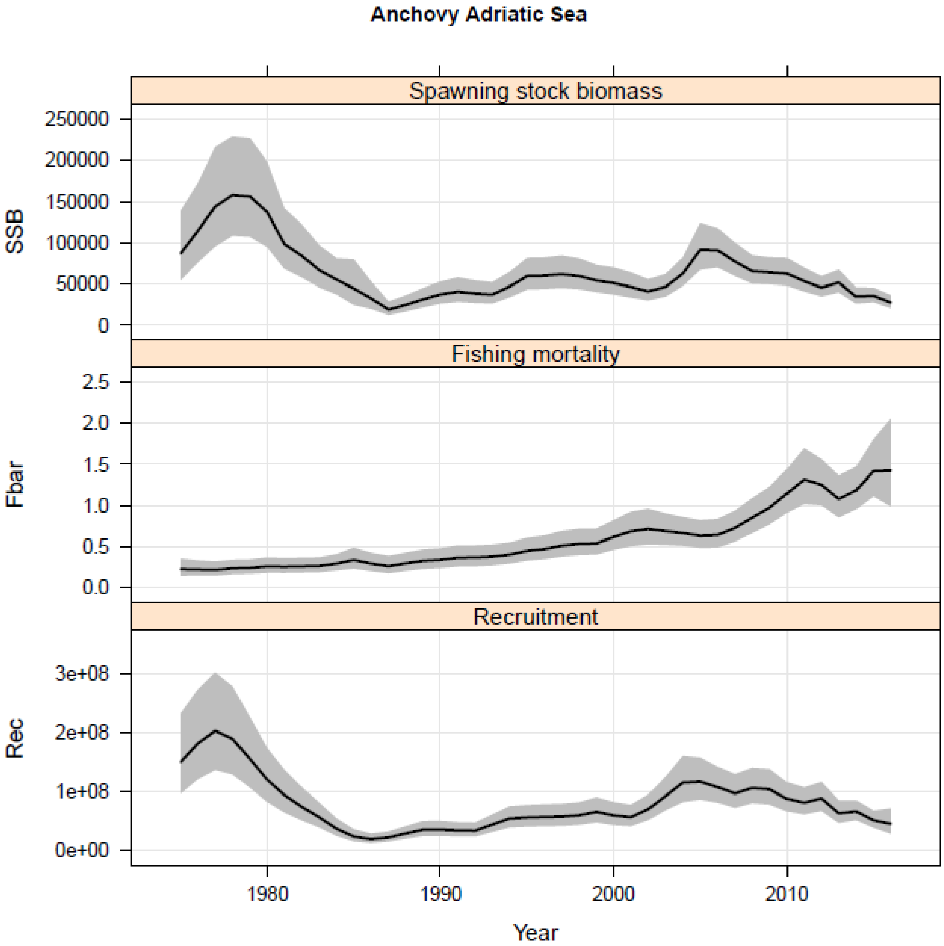


Figure 6.7.2.3 European anchovy in GSAs 17 & 18. Stock Biomass (SSB) in tons (on top). F (age 1 to 2) (middle); recruitment (as thousands individuals) (bottom); 95% confidence intervals are shown.

Due to the short time series of the tuning index acoustic East (2013 – 2016), the retrospective analysis was run on 1 year only. The outputs are shown in Figure, and describe a rather consistent behaviour of the assessment model.

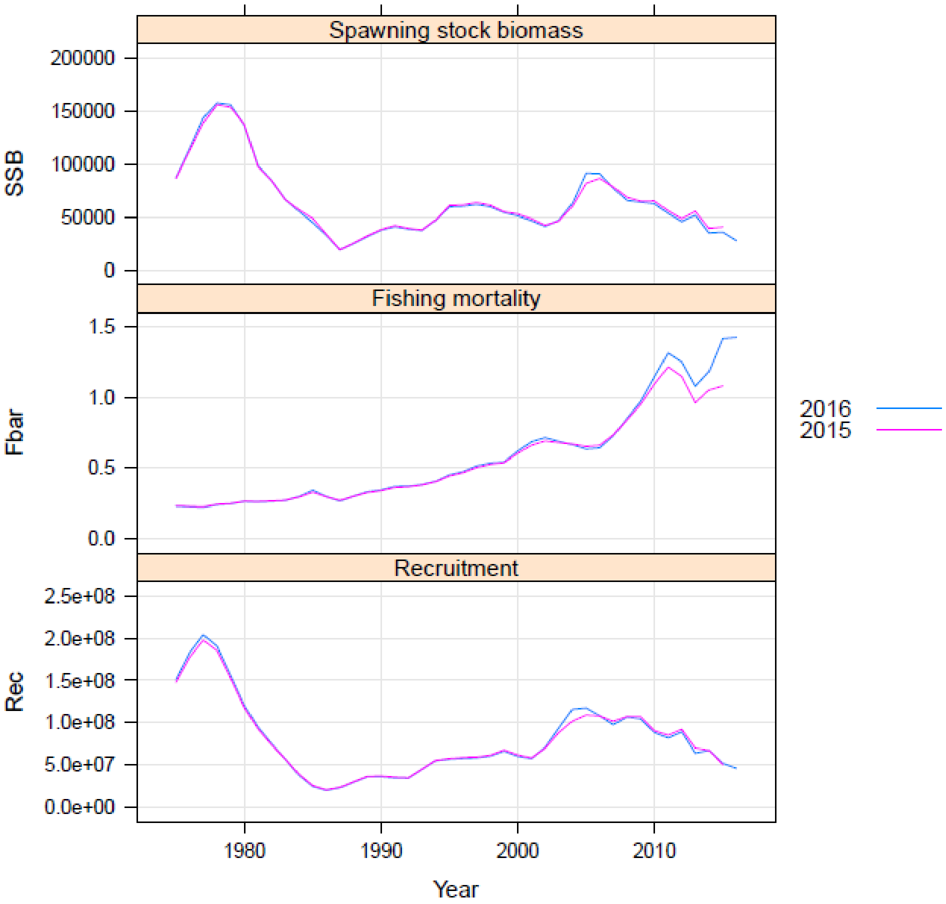


Figure 6.7.2.4 European anchovy in GSAs 17 & 18. Retrospective analysis. Stock Biomass (SSB) in tons (on top). F (age 1 to 2) (middle); recruitment (as thousands individuals) (bottom).

Selection pattern (F/F_{bar}) by age class is plotted in Figure 6.7.2.5. The plots show basically two behaviours: one for the less recent years from 1975 to 1990's, and the other from 1995's to 2016 in which the ratio between F and F_{bar} decreases for age 3 and 4.

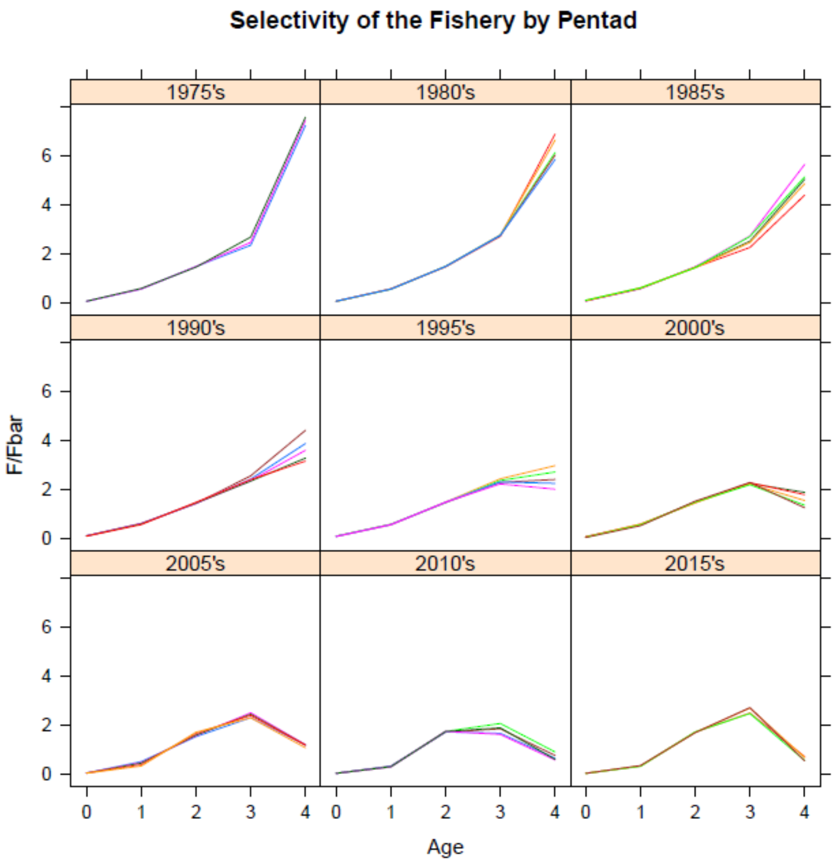


Figure 6.7.2.5 European anchovy in GSAs 17 & 18. Selectivity at age by pentads as estimated by the SAM model.

In general, catch residuals did not show any trend (figures are not included in the report). As concerns survey data, mostly age 3 and 4 of the West acoustic survey and age 1 for the East acoustic survey showed some patterns in the residuals.

Observation variances by input data (Figure 6.7.2.6) showed that model is fitting most closely to the acoustic East age 1 and the catch data, and among the survey data, age 4 is practically not used as the variability is very high.

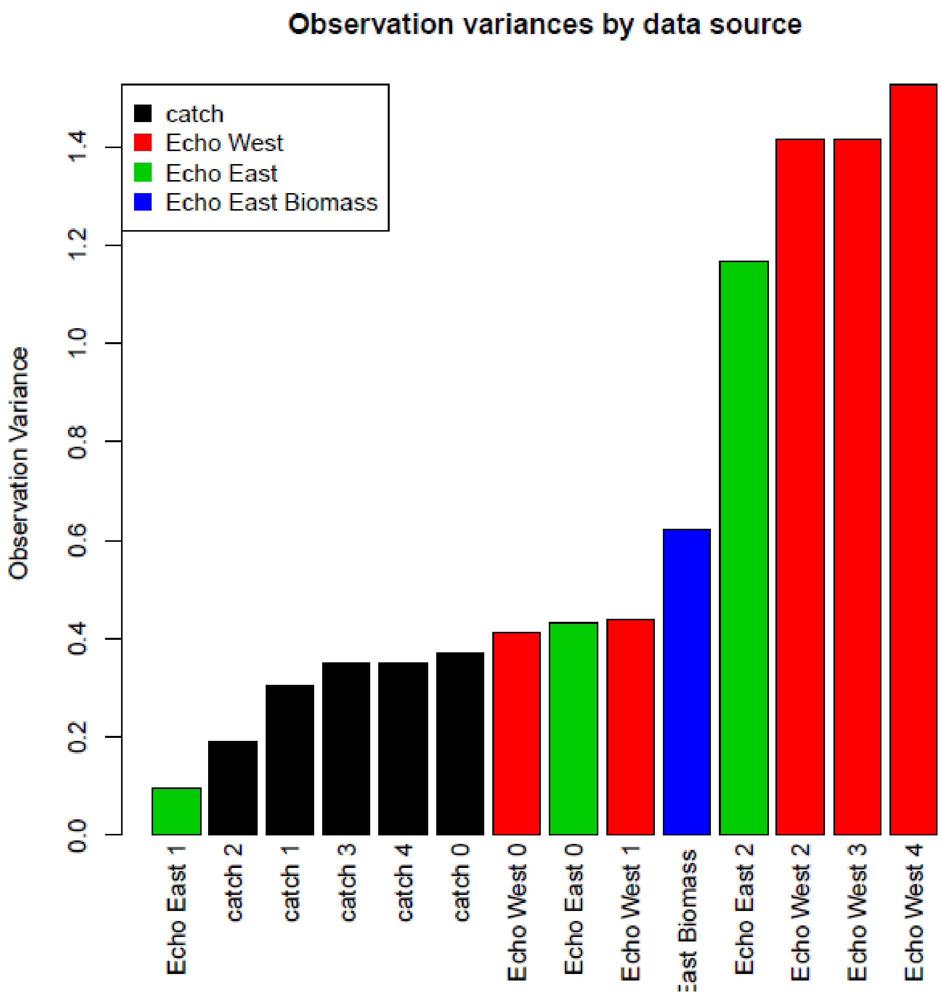


Figure 6.7.2.6 European anchovy in GSAs 17 & 18. Plot of the observation variances by input data.

- **Short time series 2000 - 2016**

Some concerns were raise regarding the accuracy of the historical part of data series, it has been decided to perform also a stock assessment including only years from 2000 to 2016.

SAM outputs in particular the fishing mortality-at-age by year and the stock numbers-at-age by year (in thousand) are respectively shown in Table 6.7.2.9 and Table 6.7.2.10.

Table 6.7.2.9 European anchovy in GSAs 17 & 18. F-at-age estimated from truncated data set 2000 to 2016.

	year								
age	2000	2001	2002	2003	2004	2005	2006	2007	2008
0	0.016	0.014	0.012	0.014	0.016	0.015	0.014	0.012	0.012
1	0.415	0.403	0.375	0.354	0.321	0.284	0.226	0.214	0.225

2	1.022	1.059	1.070	1.029	1.091	1.054	1.125	1.294	1.489
3	1.765	1.785	1.798	1.719	1.749	1.649	1.629	1.721	1.790
4	0.627	0.632	0.635	0.612	0.617	0.598	0.605	0.625	0.624
	year								
age	2009	2010	2011	2012	2013	2014	2015	2016	
0	0.013	0.014	0.015	0.015	0.014	0.014	0.013	0.014	
1	0.306	0.350	0.356	0.351	0.320	0.364	0.425	0.510	
2	1.611	1.859	2.084	2.072	1.829	2.027	2.463	2.442	
3	1.841	1.948	2.139	2.386	2.725	3.151	3.339	3.719	
4	0.608	0.607	0.622	0.628	0.646	0.665	0.657	0.653	

Table 6.7.2.10 European anchovy in GSAs 17 & 18. Stock numbers-at-age (thousands) from 2000 to 2016.

	year								
age	2000	2001	2002	2003	2004	2005	2006	2007	2008
0	66386000	65660000	79797000	98149000	116690000	117980000	112000000	102770000	110440000
1	6280800	6131800	6022400	7534500	9147600	10963000	11040000	10397000	9492400
2	1448400	1326400	1132600	1041300	2145800	2251300	3980800	4176600	3011700
3	350110	243290	194660	150990	170420	302250	418740	688310	561860
4	126750	90129	55492	6585	26582	7498	91766	252960	178970
	year								
age	2009	2010	2011	2012	2013	2014	2015	2016	
0	106110000	91697000	83470000	87051000	70421000	69930000	56741000	52641000	
1	10428000	9899600	8503600	7640700	8137600	6498000	6583000	5298800	
2	2167300	2528200	1676100	1649500	1329100	1845000	2033000	1718600	
3	277340	197010	165380	78511	85306	113660	121540	66970	
4	69773	51021	46397	14043	4585	6790	8420	1632	

The average fishing mortality for ages 1-2 (Figure 6.7.2.7) started at quite high value, 0.72, and increased to 2012 reaching the maximum value in 2016 (F_{bar1-2} = 1.48). The spawning stock biomass shows an increasing trend to 2006, 91084 tonnes, followed by a continuous decrease reaching the minimum value in 2016, 29567 tonnes. Recruitment (Age 0) appears rather stable during the years, describing a decreasing trend in the last ten years. The maximum value is report in 2005 is 118 billion recruits, whereas the minimum value is in 2016, 53 billion recruits.

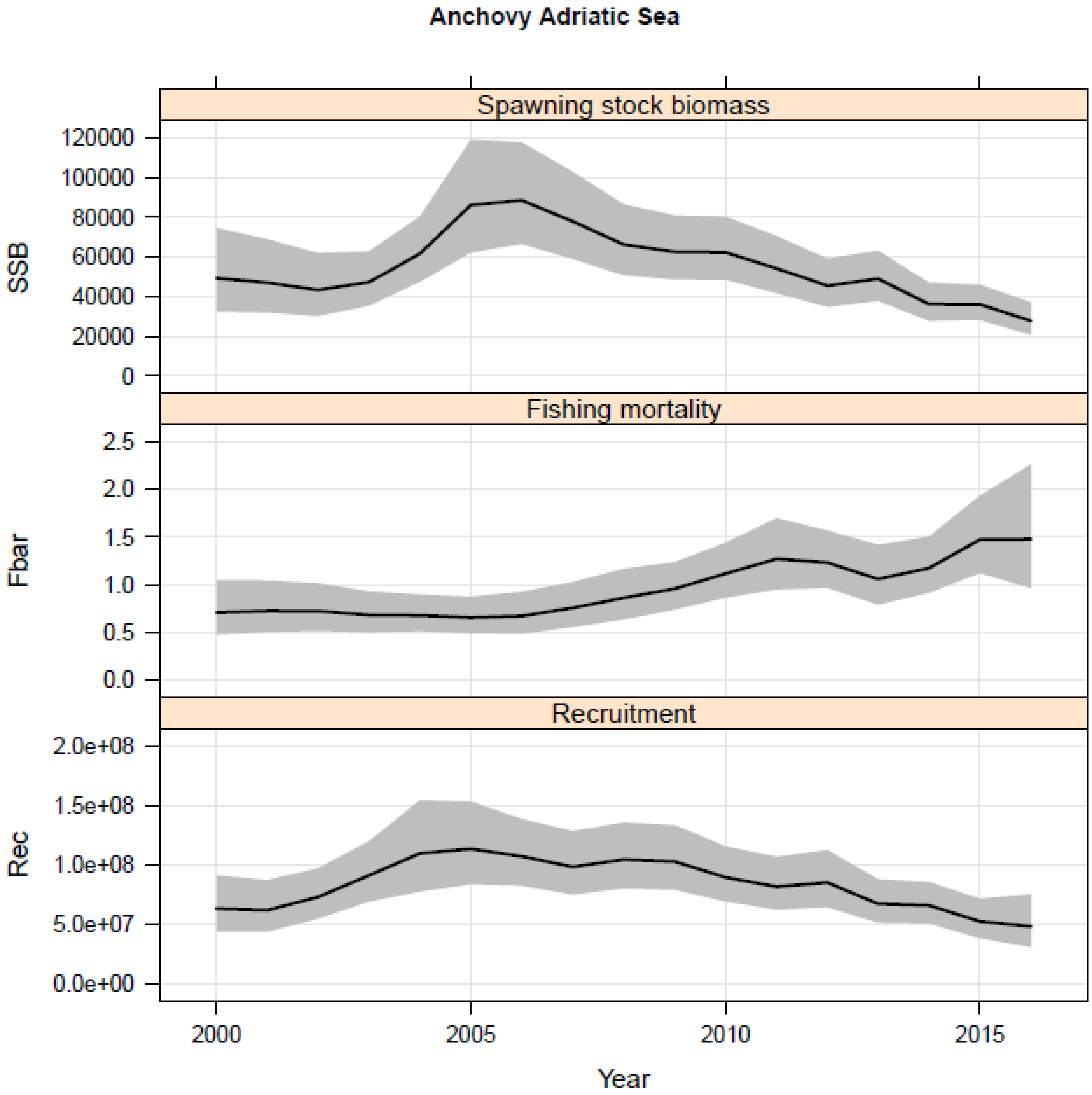


Figure 6.7.2.7 European anchovy in GSAs 17 & 18. Stock Biomass (SSB) in tons (on top). F (age 1 to 2) (middle); recruitment (as thousands individuals) (bottom); 95% confidence intervals are shown.

Due to the short time series of the tuning index acoustic East (2013 – 2016), the retrospective analysis was run on 1 year only. The outputs are shown in Figure 6.7.2.8; the model appears to be less stable than the longer time series.

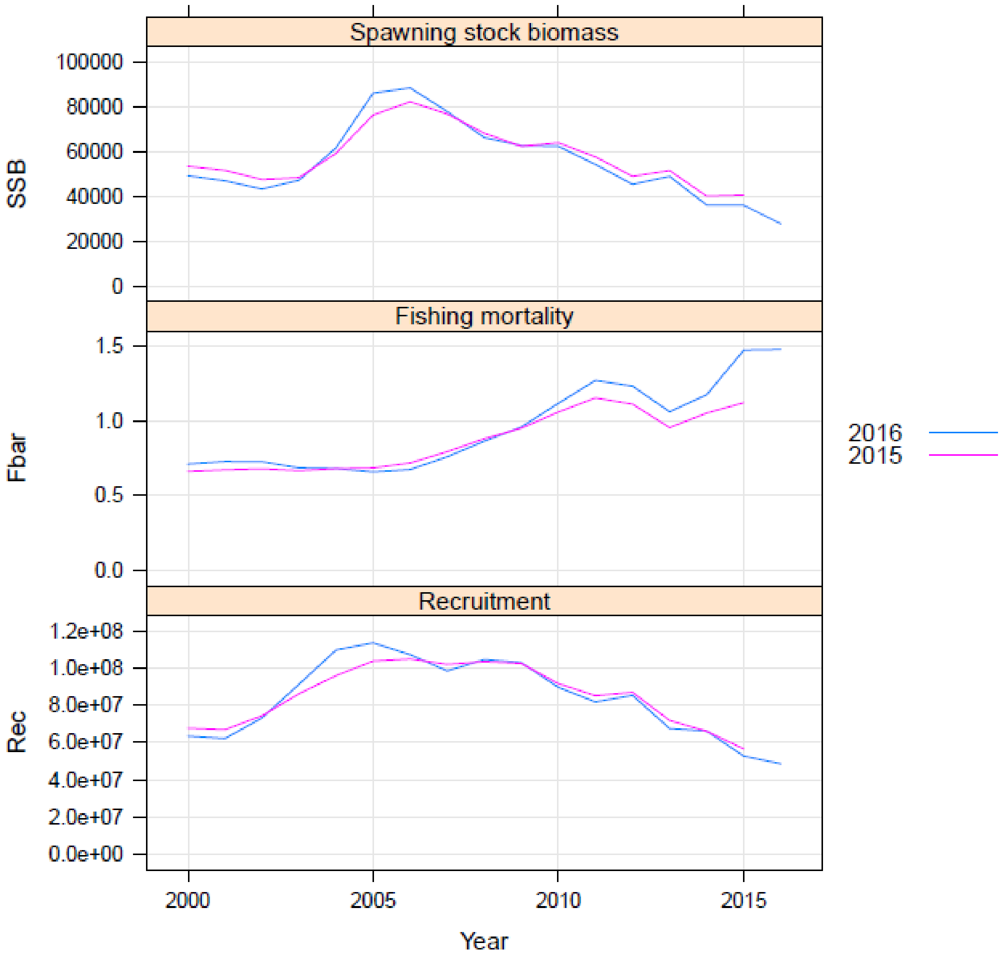


Figure 6.7.2.8 European anchovy in GSAs 17 & 18. Retrospective analysis. Stock Biomass (SSB) in tons (on top). F (age 1 to 2) (middle); recruitment (as thousands individuals) (bottom).

Selection pattern (F/F_{bar}) by age class is plotted in Figure 6.7.2.9. The plots show a rather constant pattern in selectivity in all the pentads in the time series of data.

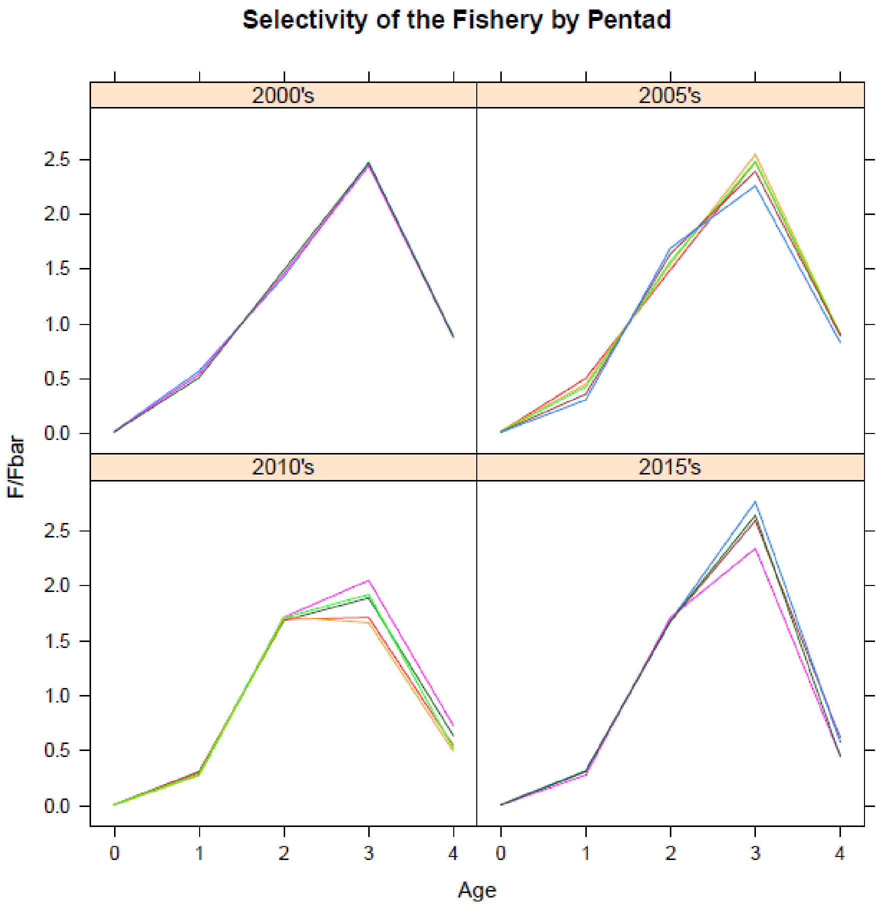


Figure 6.7.2.9 European anchovy in GSAs 17 & 18. Selectivity at age by pentads as estimated by the SAM model.

In general, catch residuals did not show any trend (figures are not included in the report). As concerns survey data, mostly age 3 and 4 of the West survey and age 1 for the East acoustic survey showed some patterns in the residuals.

Observation variances by input data (Figure 6.7.2.10) showed that model is fitting most closely to the catch data and East echo survey age 1. The highest variability is accounted for the West echo survey age 2 to 4.

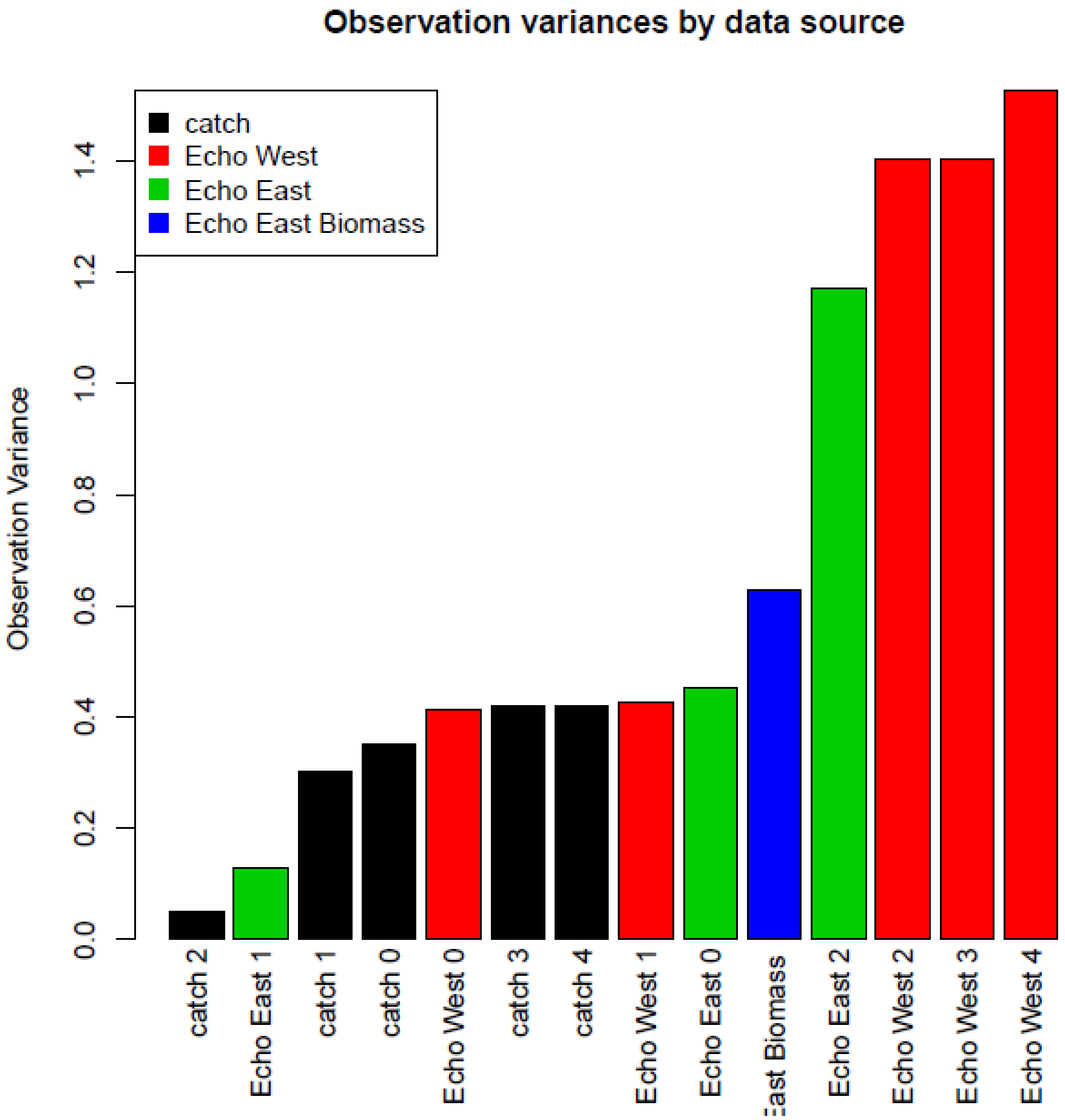


Figure 6.7.2.10 European anchovy in GSAs 17 & 18. Plot of the observation variances by input data.

6.7.3 Reference Points

STECF EWG 17-09 was not able to estimate and provide a reliable reference point in terms of FMSY. Thus it was estimated the F value corresponding to the reference point of Patterson (1992), E = 0.4. The reference point is shown in Table 6.7.3.1.

Table 6.7.3.1 European anchovy in GSA 17 & 18. Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
F_{MSY}	F = 0.57		E = 0.4	This WG

			MSY proxy	

Figure 6.7.3.1 shows the exploitation rate (E) for all the time series considered; it exceeds the point of Patterson since 2000. Figure 6.7.3.2 represent the $F_{bar(1-2)}$ for all the time series, the straight line corresponds to the F at the reference point. The fishing mortality exceeds the reference point since 2000, reaching the maximum value of 1.48 in 2016. Thus, the stock results overexploited.

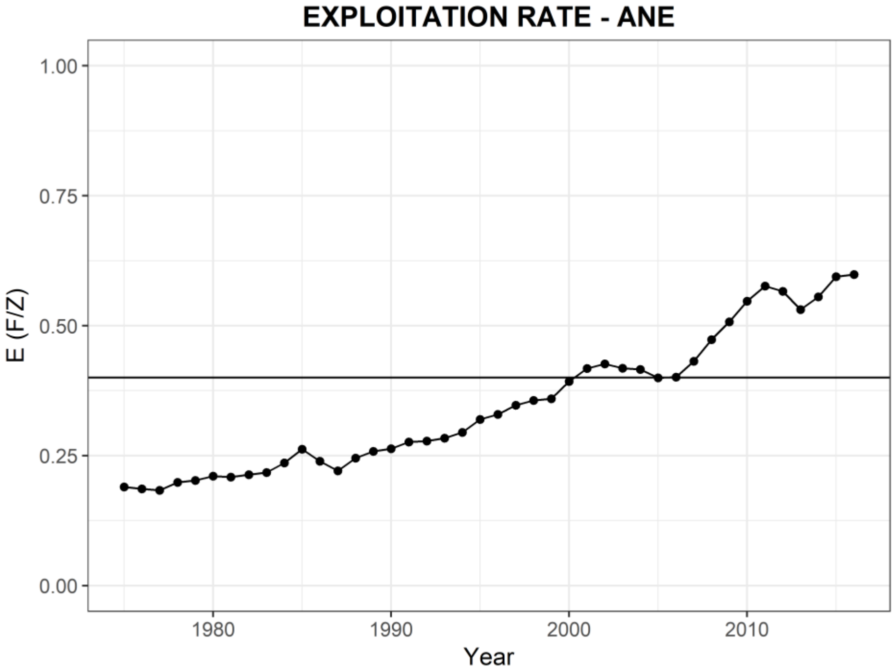


Figure 6.7.3.1 European anchovy in GSAs 17 & 18. Estimations of the exploitation rate by year. The line represents the reference point E=0.4.

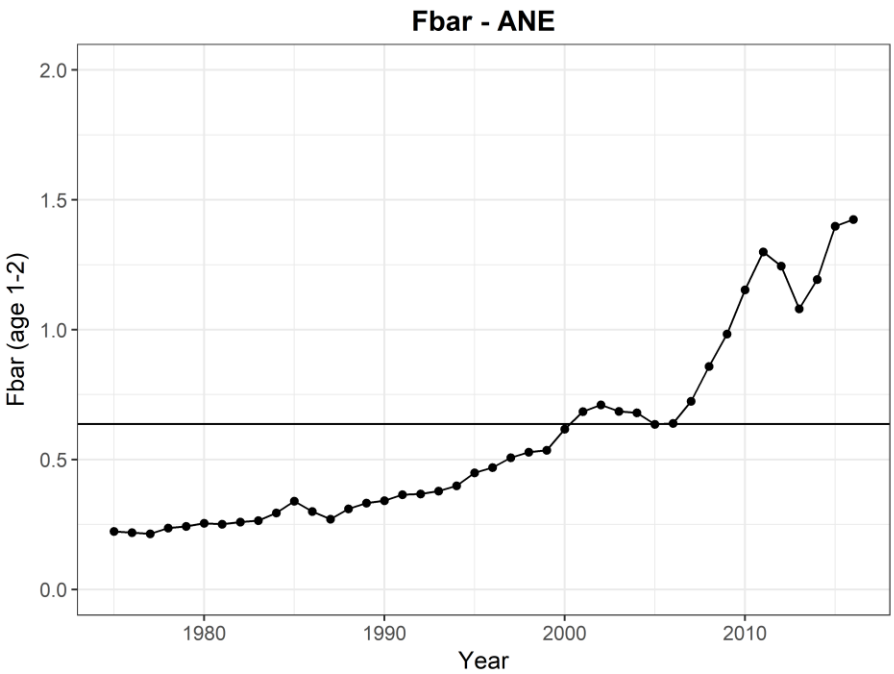


Figure 6.7.3.2 European anchovy in GSAs 17 & 18. $F_{bar(age\ 1\text{-}2)}$ for the entire time series. The line represents the value of F corresponding to E=0.4

Biomass reference points are not estimated for this stock, the biomass for the timeseries is lower than in the last assessment, due just to the change in maturity ate age 0 from 0.5 to 0.0. Although the biomass is changed, this change acts as a scaling to the assessment, implying very little change to the underlying population dynamics. Biomass reference points under the two different assumptions of maturity at age 0 are different but the differences are scalled directly with the assessment implying only minor differences in the detail. The MSY reference point E0.4 is independent if this difference in biomass.

6.7.4 Short term Forecast and Catch Options

The short term forecast and catch options were run considering the entire time series 1975-2016. Results are shown in the following table (Table 6.7.4.1). No indication about the F_{MSY} level is provided due to the uncertainty in estimating an appropriate reference point.

In the absence of MSY reference point advice is given based on precautionary considerations E=F/(F+M) = 0.4 (Patterson, 1992). For this stock M varies by age (see Table 6.7.3), for comparison with F the mean M is taken over the selection in the fishery based on recent (last 3 years selection pattern, Table 6.7.2.9 and results in mean M = 0.995 giving F=0.57 for E=0.4 resulting in a catch of 17938 tonnes in 2019.

Table 6.7.4.1 European anchovy in GSAs 17 & 18. Short-term forecasts showing catch options at different level of F. F_{2017} = $S_{tatus\ Quo}$ is the geometric mean of the last 3 years of the assessment (2014-2016). Recruitment 2017 and 2018 is 58332 million (computed as the geometric mean of recruitment in the last 3 years of the assessment 2014-2016), resulting $Catch_{2017}$ is 23355 t.

Rationale	Ffactor	Fbar	Catch 2018	Catch 2019	SSB 2018	SSB 2019	Change SSB 2018-2019 (%)	Change Catch 2016-2018 (%)
Zero catch	0.00	0.00	0.0	0.0	39241.9	51676.7	31.7	-100.0
E = 0.4	0.43	0.57	12194.6	16382.2	33113.0	36744.8	11.0	-64.4
Status quo	1.00	1.33	22500.3	24060.6	27298.4	27784.2	1.8	-34.3
Different Scenarios	0.10	0.13	3442.6	5906.2	37613.2	46880.2	24.6	-89.9
	0.20	0.27	6478.5	10169.4	36109.9	43049.1	19.2	-81.1
	0.30	0.40	9181.8	13360.5	34718.8	39928.3	15.0	-73.2
	0.40	0.53	11611.1	15835.0	33428.3	37338.5	11.7	-66.1
	0.50	0.67	13813.2	17817.8	32228.2	35152.0	9.1	-59.7
	0.60	0.80	15825.7	19454.8	31109.4	33276.9	7.0	-53.8
	0.70	0.93	17678.6	20841.9	30063.8	31646.2	5.3	-48.4
	0.80	1.07	19396.1	22044.3	29084.2	30210.5	3.9	-43.4
	0.90	1.20	20998.0	23106.6	28164.3	28932.6	2.7	-38.7
	1.10	1.47	23915.9	24928.8	26481.5	26743.3	1.0	-30.2
	1.20	1.60	25255.8	25728.0	25709.1	25792.8	0.3	-26.3
	1.30	1.73	26528.7	26470.6	24977.3	24919.0	-0.2	-22.5
	1.40	1.87	27742.1	27166.2	24282.4	24110.7	-0.7	-19.0
	1.50	2.00	28902.1	27821.9	23621.2	23359.1	-1.1	-15.6
	1.60	2.14	30013.9	28443.6	22991.0	22656.7	-1.5	-12.4
	1.70	2.27	31081.9	29035.7	22389.2	21997.3	-1.8	-9.3
	1.80	2.40	32109.8	29601.8	21813.5	21375.8	-2.0	-6.3
	1.90	2.54	33100.9	30145.1	21261.8	20787.7	-2.2	-3.4
	2.00	2.67	34058.0	30667.8	20732.4	20229.5	-2.4	-0.6

6.7.5 DATA DEFICIENCIES

See section 7.7 for details

6.8 STOCK ASSESSMENT ON SARDINE IN GSAs 17 & 18

Stock Identity and biology

Although there is some evidence of differences on a series of morphometric, meristic, serological and ecological characteristics, the lack of genetic heterogeneity in the Adriatic stock has been demonstrated through allozymic and mitochondrial DNA (mtDNA) surveys (Carvalho et al., 1994) and through sequence variation analysis of a 307-bp cytochrome b gene (Tinti et al., 2002). Also, Ruggeri et al. (2013) supports the hypothesis of one stock on the basis of microsatellites DNA, even if suggests that some of the genetic homogeneity observed could be apparent and the identification of a subtle structuring in sardine population could be limited by technical difficulties and by the incomplete knowledge of molecular mechanisms. Recent outcomes of EU project STOCKMED and EWG 17-02 indicated existence of one single stock of anchovy in the Adriatic Sea (Fiorentino et al., 2014, STECF 17-07). Therefore, also according to the fact that a lot of vessels registered in GSA 18 fish sardines in GSA 17, it was decided to merge the two GSAs.

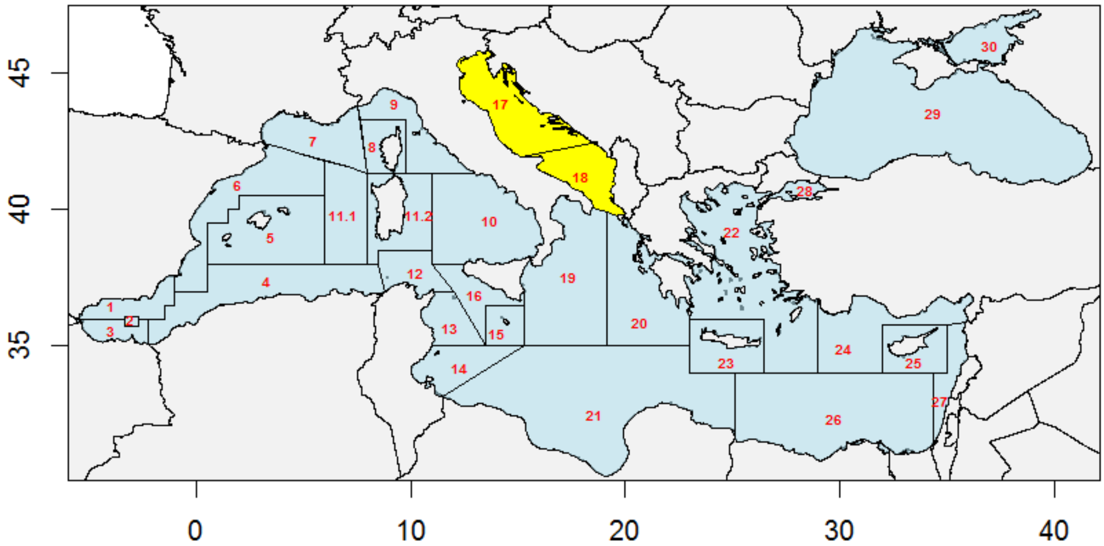


Figure 6.8.1. Geographical location of GSAs 17 & 18

The growth parameters were not re-estimated during this meeting, but the same parameters as in previous GFCM 2016 stock assessment (GFCM, 2017).were used (Table 6.8.1.1). Proportion of mature and natural mortality are also shown (Tab 6.8.1.2 and Tab 6.8.1.3). The maturity at age 0 was altered from 0.5 in previous assessments to 0.0 in this years assessment. As the spawning is considdred to occur at the beginning of each age year, those fish at age zero the result of spawing at the beginning of the year are considered to mature and inceare age and then spawn immediately at age one in their second year. This choice is consistent with annual dynamics, where age zero are not considered to contribute to their own spawning, the previous assignment at50% mature at age zero is not conceptually compatible with a spawing date at the start of the year, as age 0 fish do not exist at that time.

Table 6.8.1.1 Sardine in GSAs 17-18. Von Bertalanffy growth and length-weight parameters used.

	Growth parameters			Length-weight	
	L_{inf}	k	t_0	a	b
Sex Combined	19.8	0.38	-1.785	0.0058	3.119

Table 6.8.1.2 Sardine in GSAs 17-18. Proportion of mature specimens at age.

Period	Age	0	1	2	3	4
1975-2016	**Prop. Matures**	0.0	1.0	1.0	1.0	1.0

Table 6.8.1.3 Sardine in GSAs 17-18. Natural mortality vector by age from Gislason et al. (2010).

Period	Age	0	1	2	3	4
1975-2015	**M**	1.06	0.83	0.69	0.61	0.48

6.9.1 DATA

6.8.1.1 CATCH (LANDINGS AND DISCARDS)

Sardine is a commercially very important species in the Adriatic Sea: it is targeted mainly by pelagic trawlers (Italy) and purse seiners (Croatia, Slovenia, Italy). The number of vessels targeting small pelagic fish (sardine and anchovy) is around 400. Most of the Italian boats whose port of registry is located in GSA 18 actually fish and land in GSA 17. In Montenegro most of the catches are originated from small-scale beach seine fisheries from the fishery with small purse seiners in coastal waters (< 70 m depth); currently, the three existing large purse seiners as well as the pelagic trawler are currently not active due to market constrains and lack of skilled fishers (UNEP-MAP-RAC/SPA. 2014): the catches therefore are likely to be rather low (FAO-Statistic Database) but no information on the real magnitude of catches are available although the Montenegrin length structure is available for 2007 to 2016. Almost no information are available for Albania, nevertheless from the FAO database it appears that also Albanian catches are small.

Management regulations applicable in 2016

A multi–annual management plan for small pelagic fisheries in the Adriatic Sea has been established by the General Fisheries Commission for the Mediterranean

(GFCM) in 2012. Besides, Italy has been enforcing for years a general regulation concerning the fishing gears and since 1988 a suspension (about one month) of fishing activity of pelagic trawlers in summer. A closure period is observed from 10th December to 22nd December and from 16th to 31st January from the Croatian purse seiners. A temporal fishing closure period of around 40 days is observed by the Italian fleet between July and September, whereas in Montenegro the fishing closure period was observed from the 1st April to the 15th April.

Landings and catch at age data

Concerning GSA 17, landings and catch at age data from 2002 were available through the DCF database for Italy and Slovenia. For Croatia, data from 2013 were available through DCF data base, since Croatia is participating to the Data Collection Program starting in 2013. Data sets from last GFCM assessment (GFCM, 2017) were updated and used as a basis in this assessment.

Concerning GSA 18, the data were available through the DCF program starting in 2005; before that, the data were reconstructed as follows:

✓ Western side- 1975-1994: total landings for maritime compartment from the Italian National Institute of Statistic. The data were available until 1999, but in the last 5 years of data, the landings showed an unreliable pattern, with high peaks. A similar behaviour was evident also for the landings of another small pelagic, i.e. anchovy, and it was therefore ascribed to some sampling issues (e.g. changing in the sampling methodology). For this reason, the data from 1995 to 1999 were not included. 1995-2004: an average proportion of landings in GSA 18 over the landings in GSA 17 was estimated from the total landings available from the sampling program from 2006 to 2013 (i.e. GSA 18/GSA 17 = 12.3%). This ratio was used to derive an estimate of GSA 18 landings from GSA 17 for the period 1995-2004. In 2010 data were also not available for sardine, therefore the same procedure applied for the years from 1995 to 2004 was used.

✓ Eastern side-landings were reconstructed as portion in the GSA 17 eastern catches for the years before 2008 as from 2008 onwards, countries have provided total landings of the species.

The reconstructed landings are presented in Table 6.8.1.1.1. To account for the landings of Albania and Montenegro, the FAO Official Fisheries Statistics (version 2016) were used.

Table 6.8.1.1.1. Sardine in GSAs 17 & 18. Reconstructed landings of sardine in the GSA 17-18

Year	Total landings (t)	Year	Total landings (t)	Year	Total landings (t)	Year	Total landings (t)
1975	33887.17	1987	73428.22	1999	27949.15	2011	56300.59
1976	46985.35	1988	68191.02	2000	26107.1	2012	58638.4

1977	54576.48	1989	71097.7	2001	24138.39	2013	71923.35
1978	44820.34	1990	61881.52	2002	24100.79	2014	83139.14
1979	41362.21	1991	54138.19	2003	21620.5	2015	78012.43
1980	48593.04	1992	40049.74	2004	26929.9	2016	79405.18
1981	93559.14	1993	45885.19	2005	20906.72		
1982	84687.76	1994	39142.88	2006	20475.45		
1983	83926.93	1995	41128.89	2007	21984.36		
1984	92723.71	1996	44309.77	2008	27816.45		
1985	75520.8	1997	38522.34	2009	34382.5		
1986	79547.11	1998	36138.84	2010	35439.92		

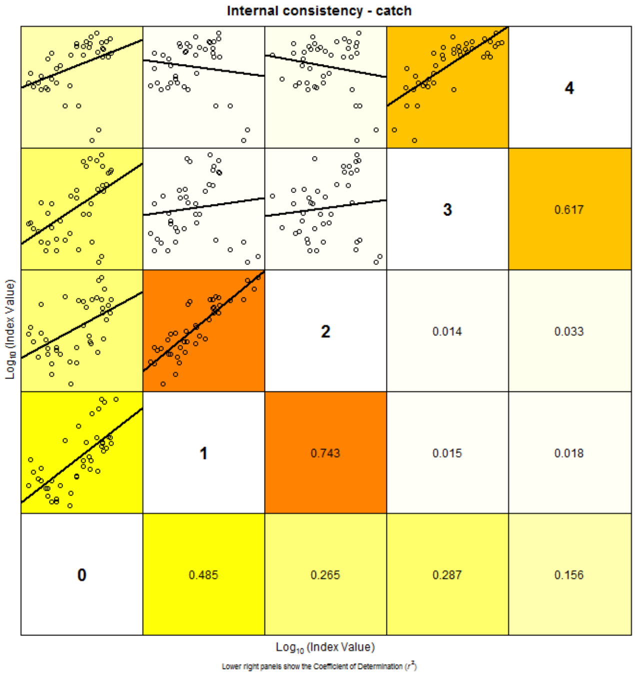


Figure 6.8.1.1.2 Sardine in GSAs 17 & 18. Internal consistency of the catch

Discards

Discard data for sardine in GSA17&18 are available for Slovenia (2005-2016), Croatia (2014-2016) and Italy (2011in GSA17&18; 2013 in GSA17 only). EWG 17-09 noticed that in case of Croatia, all available data have zero values (0), indicating that no sardines were discarded by Croatian fishing fleet.

Despite this information, discard was not included in the assessment since the values are sparse, variable but very small and the practice of discarding small pelagic species for these fisheries can be considered negligible. Landings data can be considered representative of catch.

6.8.1.2 EFFORT

The number of vessels from Italy, Croatia and Slovenia targeting this species is around 400. In Montenegro most of the catches are originated from small-scale beach seine fisheries and from the fishery with small purse seiners in coastal waters (< 70 m depth); currently, the three existing large purse seiners as well as the pelagic trawler are currently not active due to market constrains and lack of skilled fishers (UNEP-MAP-RAC/SPA. 2014): the catches therefore are really low (FAO-Statistic Database) but no information on the real magnitude of the catches is available, though Montenegrin length distribution data is available for 2017-2016. Almost no information is available for Albania.

Data on nominal effort for small pelagic fisheries (SPF), targeting small pelagic species (i.e. anchovy and sardine) are available from Italy (2004-2016), from Slovenia (2005-2016) and from Croatia (2012-2016) – see table below.

Table 6.8.1.2.1 Sardine in GSAs 17 & 18. Data on nominal effort for small pelagic fisheries (SPF) in GSA17 and GSA18

YEAR / COUNTRY	CROATIA	ITALY	SLOVENIA
2004	-	10947573	-
2005	-	9957313	291862
2006	-	9544684	263692
2007	-	10415198	285762
2008	-	8237549	230328
2009	-	8660943	308307
2010	-	8349886	272630
2011	-	6724554	447979
2012	10969269	7719805	35372
2013	11675983	8239957	24695
2014	11995028	8972672	32264
2015	10748959	7478123	22081
2016	11090157	8877163	12093

6.8.1.3 SURVEY DATA

MEDIAS and other acoustic surveys

In the western part of the Adriatic Sea, acoustic surveys have been carried out since 1976 in the Northern Adriatic (2/3 of the area: western GSA 17), and since 1987 also in the Mid Adriatic (1/3 of the area: western GSA 17) and South Adriatic (GSA 18). Since 2009, acoustic surveys are carried out under the MEDIAS framework.

The eastern part has been surveyed by the Croatian national pelagic monitoring program PELMON (2003-2012) and later on through DCF-MEDIAS. During 2011-2012 acoustic survey covered approximately a half of eastern part of GSA17 only, and for those years fish biomass in a part of eastern survey area was estimated as corresponding to the average percentage of biomass during 2009-2015 in missing area. The survey methods for MEDIAS are given in the MEDIAS handbook (MEDIAS, March 2015).

The acoustic surveys in eastern GSA 18 have been carried out as extension of the MEDIAS survey to the Albanian and Montenegrin waters with the intent to cover the entire GSA 18.

Estimates from acoustic surveys were included in the assessment model considering three tuning indexes:

1) The data from the surveys in GSA 17 West and GSA 18 in the form of numbers-at-age from 2004 to 2016 (Table 6.8.1.3.1). A revised 2014 ALK, following the guidelines of AdriaMed workshop (Split, April 2015) have been used to split the number at length into numbers at age for the 2004 to 2014 in the western part of GSA 17 and GSA 18. For the 2015 and 2016 new ALK is produced each year;
2) Acoustic survey East, that includes the eastern side of GSA 17 in the form of numbers-at-age from 2013 to 2016 (Table 6.8.1.3.2). ALKs from survey on the eastern part of GSA 17 were obtained on the basis of age readings following the same guidelines of before mentioned AdriaMed workshop;
3) Acoustic survey East biomass that includes the eastern side of GSA 17 in the form of total biomass from 2003 to 2012 (Table 6.8.1.3.3).

Acoustic sampling transects and the total area covered in GSA 17 and GSA18 are shown in Figure 6.8.1.3.1.

Figure 6.8.1.3.1 Sardine in GSAs 17 & 18. Acoustic transects for the western acoustic survey (white tracks) and the eastern acoustic survey (pink tracks) for the GSA 17 and GSA 18.

Table 6.8.1.3.1 Sardine in GSAs 17 & 18. European Sardine in GSAs 17 West and GSA 18. Abundance at age from acoustic survey West in thousands (ALK of 2016).

Year	age 0	age 1	age 2	age 3	age 4
2004	642614	1725618	1431214	1003905	51410
2005	438061	1264847	553052	602318	30814
2006	575220	1546199	1508479	1322416	124118
2007	917720	3037743	2110423	1366099	115372
2008	3804458	9049691	3399879	1684309	69607
2009	2366576	8322660	1581468	472427	71727
2010	2098915	6683795	2567964	758027	45771
2011	9879725	22828960	5757835	928614	13170
2012	9918526	11204898	1550743	282387	78442
2013	8229421	22055507	3897769	198738	4112
2014	2533931	17129516	4427857	167082	0
2015	3628719	10139650	5675860	324310	0
2016	5470972	4659918	1008994	67985	15760

Table 6.8.1.3.2 Sardine in GSAs 17 & 18. European Sardine in GSAs 17 East. Abundance at age from acoustic survey East in thousands.

Year	age 0	age 1	age 2
2013	4717910	3853280	3031
2014	1180050	4323384	64747
2015	12993118	2446710	3505
2016	13332270	709729	1515.5

Table 6.8.1.3.3 Sardine in GSAs17 & 18. Acoustic biomass for the acoustic survey East GSA 17 from 2003 to 2012 as used for tuning

2003	213410
2004	213477
2005	107902
2006	246593
2007	136907
2008	131542
2009	231809
2010	125031
2011	79372
2012	89329

Data exploration of the tuning data are shown in the figures below (Figure 6.8.1.3.2). Even though the data presented a general lack of internal consistencies, they were used to tune the assessment.

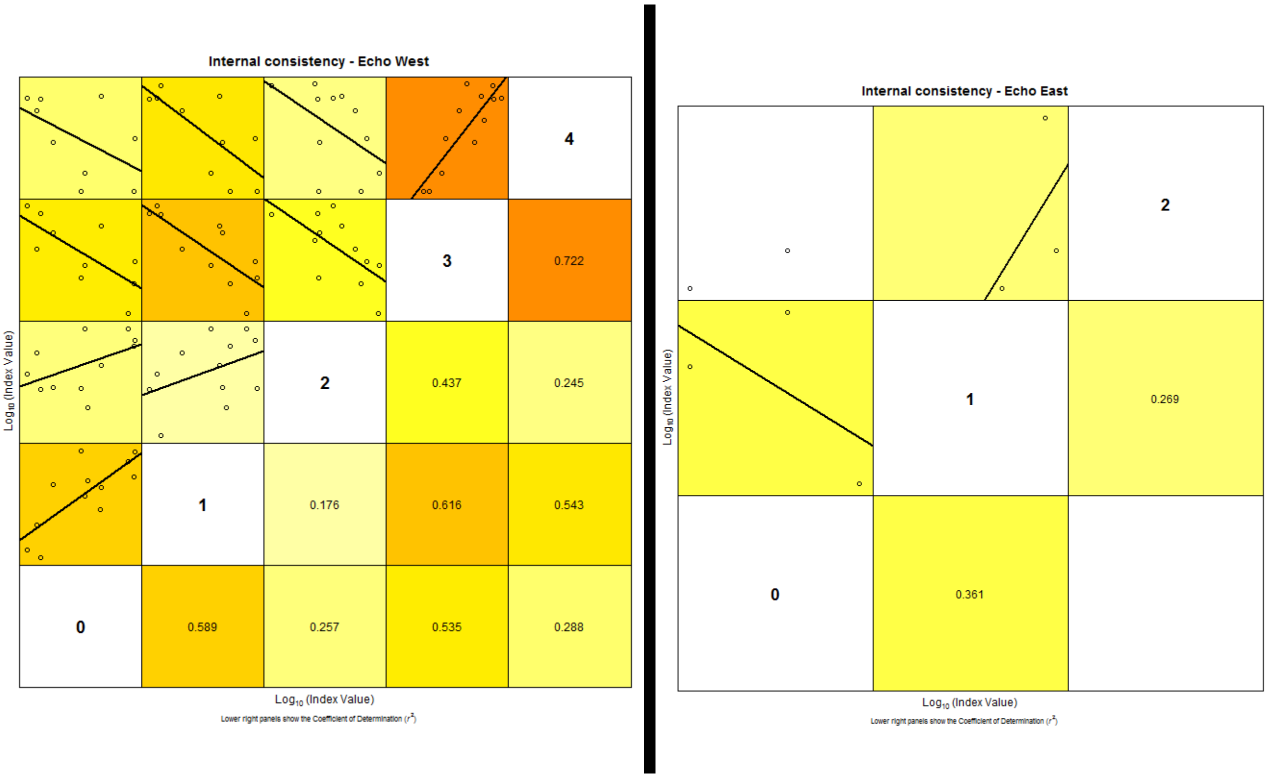


Figure 6.8.1.3.2 Sardine in GSAs 17 & 18. Internal consistency between ages for the acoustic surveys West and East.

6.8.2 Stock assessment

Methods: SAM (State-space Assessment Model)

The stock of sardine was assessed using the State-space Assessment Model (SAM) (Nielsen *et al*., 2014) in FLR environment with data from 1975 to 2016 as well as with short time series from 2000 to 2016. The SAM environment is encapsulated into the Fisheries Library in R (FLR) (Kell et al., 2007) in the form of the package "FLSAM". The state-space assessment model (SAM) is an assessment model which is used for several assessments within ICES. The model allows selectivity to evolve gradually over time. It has fewer model parameters than full parametric statistical assessment models, with quantities such as recruitment and fishing mortality modelled as random effects.

Three tuning index were used in the assessment: 1) the abundance index at age for the Western side of GSA 17 and GSA 18 from 2004 to 2016, 2) the abundance index at age for the Eastern side of GSA 17 from 2013 to 2016, and 3) a biomass index for the Eastern side of GSA 17 from 2003 to 2012.

All the analyses were performed with version 0.99-3 of FLSAM, together with version 2.5 of the FLR library (FLCore).

Input data

This assessment was performed using the updated data set from the last GFCM stock assessment (GFCM, 2017). These data include available DCF data for recent years, and historical data for periods before DCF took place. Landings are assumed to be catch, discards are considered negligible. In order to maintain catch data in line with reported data small SoP corrections, in all cases less than 10% were included and, some additional modifications were carried out:

1) Albania sent new catch data for years from 2008 to 2016, thus landings and catch at age data for these years were updated with the new estimates
2) Abundance indices at age for echo survey West and East were updated. In the case of East Echo survey, new ALK is produced each year (Figure 6.8.2.1) and abundance indices by age are calculated accordingly.

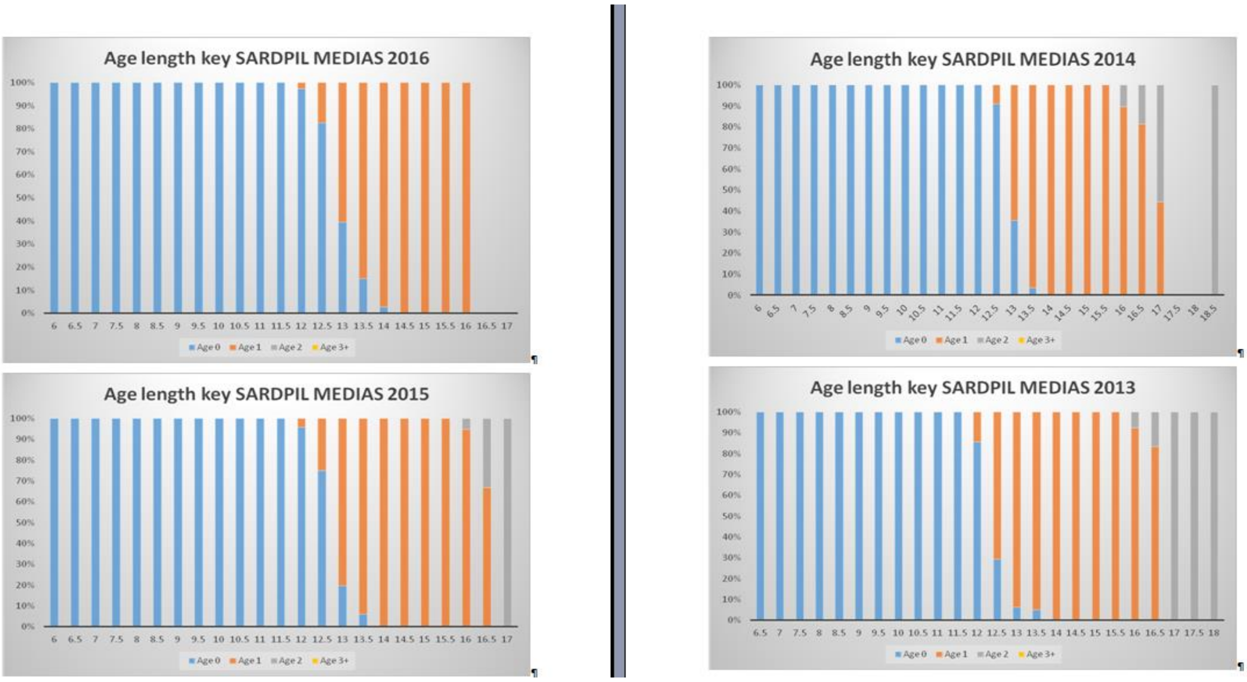


Figure 6.8.2.1 Sardine in GSAs 17 & 18. Age-length keys as used to obtain abundance at age indices from Echo East.

Table 6.8.2.5 Sardine in GSAs 17-18. Input data for the SAM assessment. Catch numbers-at-age matrix (thousands).

age		1975	1976	1977	1978	1979	1980	1981	1982	1983
	0	231022.9	267995.8	282511.3	280357.4	229090.2	245252.7	381863.4	341979.4	521857.9
	1	283396.9	364272.7	397544.8	361673.6	287281	311915.8	590103.1	557087.2	716120.1
	2	309248.4	402305.8	452105.2	371067.5	319110.3	327207.9	746419.3	686194.7	820504.2
	3	261505.3	363465.6	397068.5	301658.2	305273.8	358515.6	758172.9	752245.9	710606.1
	4	199913.7	296803.1	352147.8	333945.2	282414.7	383437.5	616913.4	481193.2	416684.2
year										
age		1984	1985	1986	1987	1988	1989	1990	1991	1992
	0	449281.6	378927.9	435926.7	502774.1	386307.9	416516.4	362614.6	188902.5	188196.4
	1	678101.6	494820.3	540285.9	687007.9	570319.2	597292.5	495757.6	277885.6	241577.4

	2	809503.2	571134.1	482560.3	640284.8	679412.9	786328.1	628339.3	358623.6	265605
	3	812475.3	712743.7	570811.9	486214.1	481061.8	603348.5	674664.2	701200.1	453118.2
	4	500248.7	453202.5	680315.3	558572.5	483827.5	378259.4	259922.8	312931.2	254541.4
year										
age		1993	1994	1995	1996	1997	1998	1999	2000	2001
	0	158560.9	88310.9	77377.2	111004.4	92446.9	152648.3	81158.4	81512.7	56292.9
	1	234442.1	147916.1	115543.1	167095.3	190835.3	209162.4	109389.5	150802.4	186400.4
	2	297275.5	215913.9	135497.7	205702.9	265853.4	254400.4	174552	238859	316794.8
	3	462078.2	402172.6	443962	401591	376411.5	305339.4	279739.9	259156.3	237756.1
	4	354022.2	321444.3	392925.3	450721.4	281167	302554	241390.9	185158.5	102042.6
year										
age		2002	2003	2004	2005	2006	2007	2008	2009	2010
	0	70298.2	67021.4	110638.3	132093.9	43670.4	50620.7	72541.6	150162.4	169687.7
	1	289735.4	237182.7	241222	162145.1	114109.7	198980	416636.7	337891.6	553657.8
	2	376286.9	379031.1	431203.5	309528.6	272860.1	318630	433896.9	503045.3	613610
	3	200252.5	185226.9	259503.6	244969.2	219861.2	213443.9	180955.2	293697.8	225009.4
	4	75504.7	64796.4	69602.5	84154.8	101188.3	83242.6	84931.3	170478.8	67682.7
year										
age		2011	2012	2013	2014	2015	2016			
	0	288048.8	405130.8	504501.3	466091.8	663116.7	1178435			
	1	952090.1	1531999	1994905	2237694	2024641	2185912			
	2	836096.7	868708	1015291	1284031	1382302	1070667			
	3	361420.7	218559.8	211498.8	205666	145520	160412.9			
	4	120453.9	63672.5	34976.9	29425.7	6174.3	9727.1			

As tuning index acoustic survey data were used (Table 6.8.1.3.1.- 6.8.1.3.3.).

Results

1. Entire time series 1975 - 2016

SAM outputs are listed in table. Tables. 6.8.2.6 and 6.8.2.7 show the fishing mortality-at-age by year and the stock numbers-at-age by year (in thousand), respectively.

The SAM analyses indicate that the sardine stock size fluctuated over the time period examined. Maximum value of SSB was estimated to be in 1982 (823000 t). After that, the stock declined reaching a minimum level in 2001 (around 116000 t). In the following years the stock started increasing, reaching in 2016 a SSB biomass level of 157314 tons.

SAM model estimates show fluctuations in the number of recruits since the beginning of the time series, similar to those observed for the SSB. The recruitment (age 0 – Figure, bottom) reached a maximum in 1981 (59.9 million individuals) and a minimum value of 9.5 million individuals in 1999. Since then, recruitment is constantly increasing until 2016 (24.3 million individuals).

Based on the assessment results F is estimated to have remained below 0.5 until 2010, the current F (Fbar ages 1-3) is estimated to be 1.30.

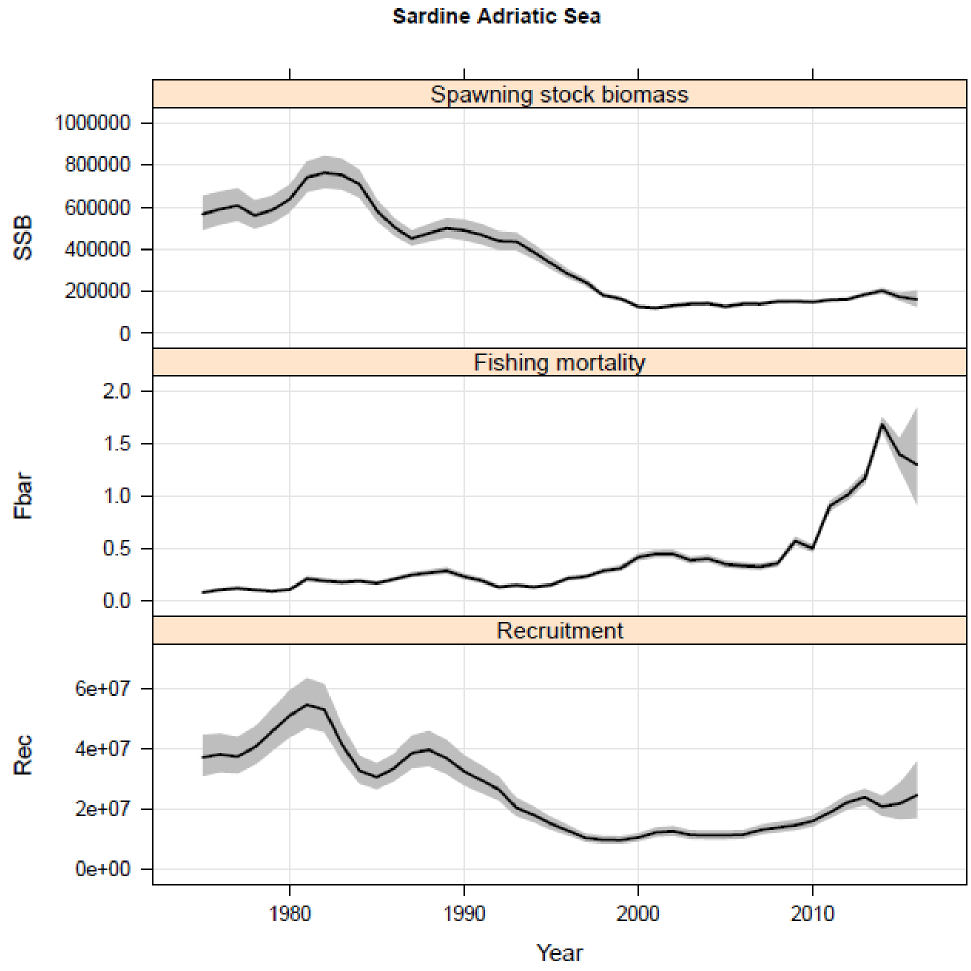


Figure 6.8.2.2 Sardine in GSAs 17 & 18. Main results of the sardine SAM assessment (long time series).

2. Short time series 2000 – 2016

The EWG raised concerns about the accuracy of historical part of data series without any age related data available, as well as doubtful accuracy of official catch statistics in the period before 2000., it has been decided to take into account recent part of data series only (2000-20016). The evaluate the impact of this period a second stock assessment, based on the same settings but shorter data series than previous one, was performed.

According to the model outputs sardine stock size fluctuated over the time period examined but in general it has demonstrated positive trend. Maximum value of SSB was estimated to be 195438 t in 2014 After that, the stock declined reaching in 2016 level of 156843 t. Fluctuations in the number of recruits were observed since the beginning of the short time series, similar to those observed for the SSB. The recruitment (age 0 – Figure, bottom) is constantly increasing until 2016 (22.7 million individuals).
Based on the assessment results F is estimated to have remained below 0.5 until 2008, the current F (Fbar ages 1-3) is estimated to be 1.27.

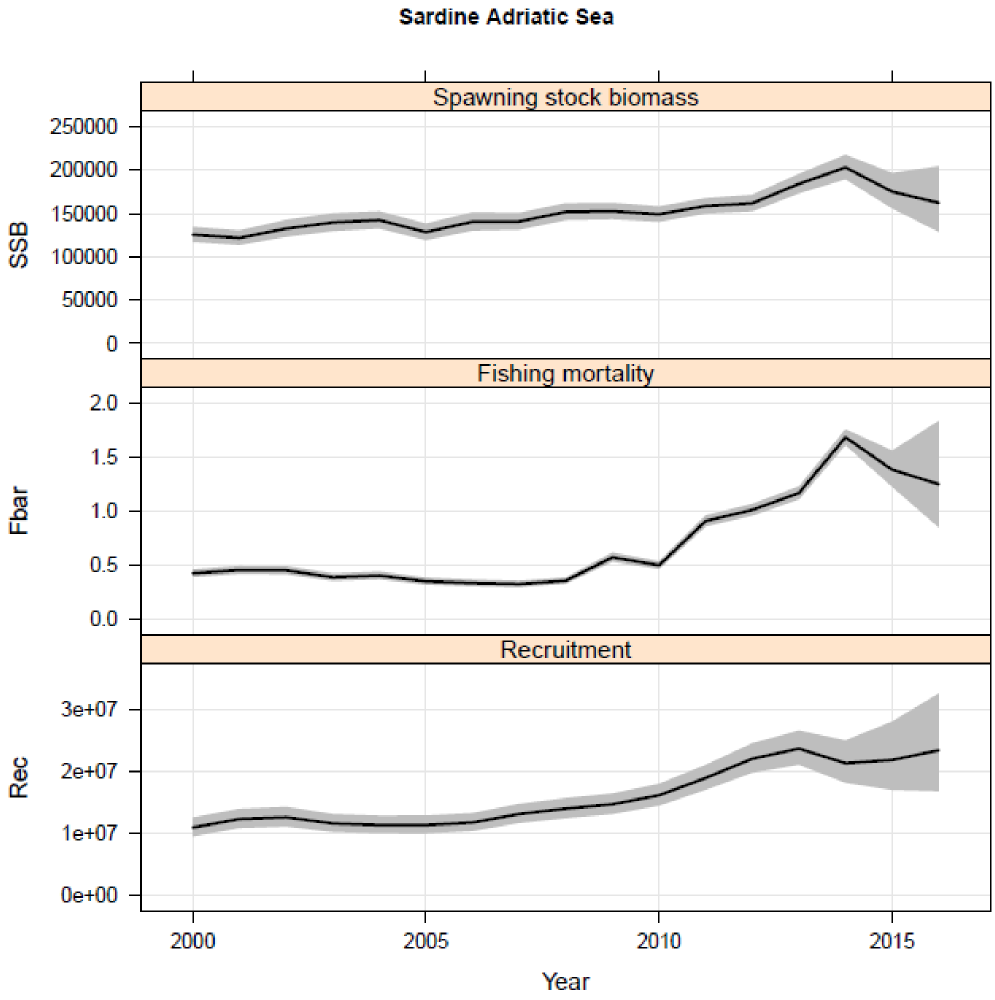


Figure 6.8.2.3 Sardine in GSAs 17 & 18. Main results of the sardine SAM assessment (short time series).

Table 6.8.2.6. Sardine in GSAs 17 & 18. F-at-age estimated from

a) 1975 to 2015.

age	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
0	0.010277	0.011274	0.01186	0.010849	0.008516	0.008314	0.010824	0.01152	0.018843	0.021481	0.020507
1	0.030559	0.042282	0.045067	0.042417	0.031248	0.029638	0.048933	0.044592	0.057052	0.072825	0.069135
2	0.076888	0.09753	0.122788	0.097832	0.088567	0.082208	0.156766	0.137752	0.15083	0.147947	0.151768
3	0.153677	0.194738	0.212354	0.192012	0.17538	0.230478	0.437631	0.403173	0.340957	0.360956	0.299393
4	0.153677	0.194738	0.212354	0.192012	0.17538	0.230478	0.437631	0.403173	0.340957	0.360956	0.299393
	year										
age	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
0	0.020929	0.020384	0.016756	0.017837	0.016791	0.011333	0.011479	0.011646	0.008548	0.008927	0.013198
1	0.080154	0.091364	0.065651	0.065109	0.058619	0.038128	0.035067	0.037471	0.032001	0.02759	0.04717
2	0.165862	0.240124	0.234782	0.21552	0.161637	0.101186	0.083492	0.096049	0.078544	0.068997	0.106896
3	0.38688	0.427548	0.51965	0.600976	0.49	0.455951	0.294788	0.332339	0.303674	0.377755	0.505883
4	0.38688	0.427548	0.51965	0.600976	0.49	0.455951	0.294788	0.332339	0.303674	0.377755	0.505883
	year										

age	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
0	0.015098	0.021348	0.014224	0.01193	0.008207	0.008975	0.010041	0.014727	0.015615	0.007188	0.006737
1	0.065415	0.088257	0.051617	0.068201	0.079103	0.100389	0.081561	0.092117	0.063615	0.045826	0.075005
2	0.178851	0.213675	0.195167	0.276595	0.381372	0.434582	0.350779	0.378477	0.317493	0.270983	0.316732
3	0.465194	0.574222	0.703998	0.916209	0.900604	0.826058	0.740529	0.749552	0.683663	0.699913	0.600454
4	0.465194	0.574222	0.703998	0.916209	0.900604	0.826058	0.740529	0.749552	0.683663	0.699913	0.600454
	year										
age	2008	2009	2010	2011	2012	2013	2014	2015	2016		
0	0.008913	0.015234	0.017819	0.024145	0.029381	0.034037	0.03822	0.051037	0.072919		
1	0.136846	0.109394	0.177302	0.28924	0.415917	0.471154	0.487015	0.538138	0.569174		
2	0.430861	0.488581	0.554122	0.94559	1.035685	1.275592	1.607998	1.552148	1.541306		
3	0.519427	1.125402	0.783966	1.491198	1.586896	1.763252	2.952641	2.108971	1.790581		
4	0.519427	1.125402	0.783966	1.491198	1.586896	1.763252	2.952641	2.108971	1.790581		

b) 2000 to 2016

age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
0	0.0121	0.0077	0.0092	0.0091	0.0152	0.0151	0.0066	0.0060	0.0076	0.0149	0.0217
1	0.0710	0.0786	0.1033	0.0807	0.0906	0.0528	0.0489	0.0734	0.1252	0.0956	0.2099
2	0.2857	0.3874	0.4451	0.3458	0.3878	0.2634	0.2891	0.3131	0.4109	0.4236	0.6246
3	0.9382	0.9128	0.8533	0.7322	0.7676	0.5799	0.7436	0.5978	0.4927	1.0048	0.8691
4	0.9382	0.9128	0.8533	0.7322	0.7676	0.5799	0.7436	0.5978	0.4927	1.0048	0.8691
age	2011	2012	2013	2014	2015	2016					
0	0.0288	0.0309	0.0304	0.0361	0.0507	0.0840					
1	0.3290	0.4430	0.4192	0.4833	0.5329	0.5780					
2	1.0393	1.1011	1.1682	1.6026	1.5388	1.4991					
3	1.6053	1.6695	1.6348	2.9523	2.0953	1.7436					
4	1.6053	1.6695	1.6348	2.9523	2.0953	1.7436					

Table 6.8.2.7. Sardine in GSAs 17-18. Stock numbers-at-age (thousands) from a) 1975 to 2015.

year										
age	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
0	37393221	38339835	37655892	40669948	45993011	51238410	54843816	53169740	41741233	32999402
1	13950139	12826193	13190402	12698571	13811332	15918619	17822994	18906191	18887294	14034091
2	5797863	5956538	5320086	5498578	5199120	5826925	6899779	7370529	8008388	8048530
3	2443642	2708756	2730513	2317501	2510519	2343134	2738717	2954973	3226795	3488561
4	1762070	2088591	2289857	2359594	2222182	2310559	2145751	1804872	1806677	2047234
	year									
age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
0	30768439	33733434	38763902	39864629	37095269	32736460	29769651	26695351	20645336	18201235
1	10929761	10272695	11375813	13256519	13825151	12647878	11017550	10334517	9295119	6906683
2	5587262	4373176	4069375	4443709	5504079	5734436	5168019	4611206	4421546	3945160
3	3591211	2376169	1845019	1570650	1735837	2242272	2468201	2347825	2141463	2026863
4	2208889	2551010	1970898	1457160	1031991	846613.9	1060234	1255444	1544175	1528810

	year									
age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
0	15263883	12942150	10501199	9889657	9820671	10659904	12385042	12800567	11570855	11398588
1	6350220	5288261	4412712	3544827	3265750	3341733	3598401	4373176	4465983	3957013
2	2850486	2788460	2204475	1797667	1370930	1347821	1350520	1435466	1744537	1832149
3	1848713	1326428	1298863	918962	721436.8	556821.5	510936.2	458630.4	460008.4	625308.2
4	1538010	1370930	946002	834009.4	578966.6	372130.5	210870.6	164555	152359.8	162754.8
	year									
age	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
0	11432835	11617231	13203599	14048132	14768395	16110793	19077115	22342472	24058526	20999307
1	3859314	3824736	4040989	4638957	4852478	4965378	5454765	6414041	7549561	8219336
2	1551915	1580102	1599178	1659455	1756792	1935740	1794075	1769133	1830318	2045187
3	636029.4	565802.3	609869.3	588893.1	543616.9	539824.8	569776.8	343863.5	315211.8	255250.3
4	208147	243044.5	227294.1	259626.7	294489.9	153891	180773.5	95035	49961.1	34961.4
	year									
age	2015	2016								
0	21943905	24791217								
1	6927434	7152697								
2	2222182	1748030								
3	203007.9	235625.7								
4	8289.1	13927.2								

b)2000-2016

age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
0	10617350	11698837	12091339	11307763	11387195	11547737	11923240	13660240	14916820	15325061
1	3162900	3523622	4130876	4226987	3863175	3851603	3878659	4089773	4799393	5235642
2	1288514	1287226	1387480	1647880	1732368	1512085	1603982	1602379	1661116	1850562
3	531256.4	488453.7	437573.5	435826.7	593623.2	593623.2	585370.3	606221.1	588304.5	550179.6
4	361493.7	200385.8	156529.5	142343.7	154817.1	193687.2	252205.6	225257.6	258590.2	298343.3
year										
age	2010	2011	2012	2013	2014	2015	2016			
0	15791778	17557645	20419482	22521929	20728083	21167975	22725541			
1	5193924	5261886	5803664	6892883	7865526	6837960	6906683			
2	2150046	1817550	1626596	1599178	1976820	2156506	1730637			
3	613539.5	590662.5	318379.7	269952.1	248202.4	197600	232350			
4	176486.6	188527.7	88168.1	42574	33996.1	8072.4	13748.7			

Table 6.8.2.8 Sardine in GSAs 17 & 18. Main results of the anchovy SAM assessment 1975-2016.

Year	Recruits Age 0 (Thousand	Recruits Age 0 (Thousands	Recruits Age 0 (Thousands)	Total biomass (tonnes)	Total biomass (tonnes)	Total biomass (tonnes)	Spawning biomass (tonnes)	Spawning biomass (tonnes)	Spawning biomass (tonnes)

	s) Mean	) Low	High	Mean	Low	High	Mean	Low	High
1975	37393221	31145094	44894808	829020	726351	946202	566935	490784	654902
1976	38339835	32431461	45324600	869784	767564	985616	589482	516217	673146
1977	37655892	32065202	44221340	882046	783463	993035	606828	534160	689381
1978	40669948	34836002	47480898	861991	771193	963479	561294	497190	633663
1979	45993011	39523413	53521618	908000	818326	1007501	585956	524306	654855
1980	51238410	44035889	59618977	1011556	915352	1117871	637303	575116	706213
1981	54843816	47163690	63774573	1141667	1035816	1258335	741181	671068	818619
1982	53169740	45782604	61748809	1156606	1049698	1274401	762990	689944	843769
1983	41741233	36164792	48177535	1053891	961570	1155076	753135	682562	831006
1984	32999402	28618022	38051566	949794	872025	1034498	709276	646904	777662
1985	30768439	26783503	35346266	799706	737317	867375	584201	535394	637457
1986	33733434	29434387	38660379	795718	734423	862129	505347	465789	548264
1987	38763902	33671035	44627083	738222	679373	802169	451351	416485	489136
1988	39864629	34418267	46172826	759184	694195	830258	476394	436607	519806
1989	37095269	31851977	43201683	759184	690537	834657	499319	454606	548429
1990	32736460	28071116	38177171	718557	651243	792829	489921	442990	541824
1991	29769651	25575993	34650937	677388	613784	747584	468832	422857	519806
1992	26695351	22999277	30985399	625308	568143	688225	438888	396341	486002
1993	20645336	17822366	23915451	580706	530997	635068	435827	395971	479695
1994	18201235	15775382	21000123	514525	473188	559474	386930	353774	423194
1995	15263883	13308633	17506390	439327	406790	474467	332369	306013	360994
1996	12942150	11333958	14778532	373622	348237	400858	281813	261386	303837
1997	10501199	9202522	11983148	320296	299765	342233	242316	225912	259913
1998	9889657	8673780	11275973	250446	235070	266828	181317	169997	193390
1999	9820671	8637637	11165736	250446	233966	268088	163898	153187	175358
2000	10659904	9388848	12103035	196614	183932	210172	127389	119388	135926
2001	12385042	10899074	14073605	226387	210117	243916	121176	113305	129594
2002	12800567	11256026	14557048	256273	236853	277286	132191	122871	142217

2003	11570855	10165505	13170491	226613	210496	243965	139804	129793	150588
2004	11398587	9996471	12997366	231886	215517	249497	141775	132135	152119
2005	11432835	10016881	13048943	197798	183718	212956	128027	118830	137936
2006	11617231	10236800	13183813	264078	244520	285201	139804	129645	150760
2007	13203599	11691518	14911240	292728	271322	315824	139665	130375	149617
2008	14048132	12445334	15857350	350810	324504	379249	151297	141712	161530
2009	14768395	13138309	16600728	279288	261156	298679	152207	142867	162159
2010	16110793	14388550	18039182	314582	293608	337054	148747	140050	157984
2011	19077115	17094703	21289420	371759	346685	398645	158103	149419	167291
2012	22342472	20031022	24920649	405145	377005	435385	161781	152449	171684
2013	24058526	21474207	26953855	441971	410570	475774	184610	173700	196205
2014	20999307	17918704	24609531	438888	398819	482983	203414	190279	217456
2015	21943905	16717583	28804103	480220	394895	583981	173165	154970	193496
2016	24791217	17083766	35975935	495836	364099	675236	161297	126490	205680

Table 6.8.2.9 European anchovy in GSAs 17 & 18. Main results of the anchovy SAM assessment 1975-2016.

Year	Catch (tonnes) Mean	Catch (tonnes) Low	Catch (tonnes) High	Yield / SSB (ratio) Mean	Yield / SSB (ratio) Low	Yield / SSB (ratio) High	Mean F ages 1-2 Mean	Mean F ages 1-2 Low	Mean F ages 1-2 High	Mean F ages 0-1
1975	34098	32466	35813	0.060	0.066	0.055	0.087	0.074	0.103	0.020
1976	46817	44595	49150	0.079	0.086	0.073	0.112	0.096	0.130	0.027
1977	54231	51636	56956	0.089	0.097	0.083	0.127	0.109	0.147	0.028
1978	44712	42553	46980	0.080	0.086	0.074	0.111	0.096	0.128	0.027
1979	41689	39646	43838	0.071	0.076	0.067	0.098	0.086	0.113	0.020
1980	49119	46652	51716	0.077	0.081	0.073	0.114	0.101	0.130	0.019
1981	92134	87667	96829	0.124	0.131	0.118	0.214	0.190	0.242	0.030
1982	85136	81034	89445	0.112	0.117	0.106	0.195	0.172	0.221	0.028
1983	83617	79677	87751	0.111	0.117	0.106	0.183	0.162	0.207	0.038

1984	92134	87748	96739	0.130	0.136	0.124	0.194	0.172	0.218	0.047
1985	75735	72041	79619	0.130	0.135	0.125	0.173	0.155	0.194	0.045
1986	79063	75080	83257	0.156	0.161	0.152	0.211	0.190	0.234	0.051
1987	72984	69506	76637	0.162	0.167	0.157	0.253	0.229	0.280	0.056
1988	68460	65227	71853	0.144	0.149	0.138	0.273	0.246	0.303	0.041
1989	70898	67583	74376	0.142	0.149	0.136	0.294	0.263	0.329	0.041
1990	61513	58548	64628	0.126	0.132	0.119	0.237	0.210	0.267	0.038
1991	54122	51338	57057	0.115	0.121	0.110	0.198	0.174	0.226	0.025
1992	40336	38305	42475	0.092	0.097	0.087	0.138	0.121	0.157	0.023
1993	45524	43212	47960	0.104	0.109	0.100	0.155	0.137	0.176	0.025
1994	39262	37189	41450	0.101	0.105	0.098	0.138	0.123	0.155	0.020
1995	41151	38806	43637	0.124	0.127	0.121	0.158	0.141	0.177	0.018
1996	43871	41463	46418	0.156	0.159	0.153	0.220	0.198	0.244	0.030
1997	38446	36528	40464	0.159	0.162	0.156	0.236	0.215	0.260	0.040
1998	35668	33861	37571	0.197	0.199	0.194	0.292	0.268	0.319	0.055
1999	28113	26698	29604	0.172	0.174	0.169	0.317	0.291	0.346	0.033
2000	26082	24801	27429	0.205	0.208	0.202	0.420	0.387	0.456	0.040
2001	24222	23051	25452	0.200	0.203	0.196	0.454	0.418	0.493	0.044
2002	24029	22867	25250	0.182	0.186	0.178	0.454	0.417	0.493	0.055
2003	21781	20691	22928	0.156	0.159	0.152	0.391	0.358	0.427	0.046
2004	26609	25259	28031	0.188	0.191	0.184	0.407	0.373	0.444	0.053
2005	20769	19729	21863	0.162	0.166	0.159	0.355	0.324	0.389	0.040
2006	20640	19614	21720	0.148	0.151	0.144	0.339	0.308	0.373	0.027
2007	22026	20954	23153	0.158	0.161	0.155	0.331	0.302	0.362	0.041
2008	27474	26139	28877	0.182	0.184	0.179	0.362	0.335	0.392	0.073
2009	33894	32284	35584	0.223	0.226	0.219	0.574	0.534	0.618	0.062
2010	34406	32653	36254	0.231	0.233	0.229	0.505	0.471	0.542	0.098

2011	54339	51628	57192	0.344	0.346	0.342	0.909	0.859	0.961	0.157
2012	58689	55461	62104	0.363	0.364	0.362	1.013	0.960	1.068	0.223
2013	71682	67578	76036	0.388	0.389	0.388	1.170	1.113	1.230	0.253
2014	82619	77814	87722	0.406	0.409	0.403	1.683	1.614	1.754	0.263
2015	78198	73434	83271	0.452	0.474	0.430	1.400	1.262	1.553	0.295
2016	78355	72678	84474	0.486	0.575	0.411	1.300	0.917	1.843	0.321

Due to the very short time series of the tuning index (2009-2016), the retrospective analysis was run on 1 year only. The outputs are shown in Figure 6.8.2.4. and describe a rather consistent behaviour of the assessment model, with the only exception of the slight variability and uncertainty in F estimate in the last year.

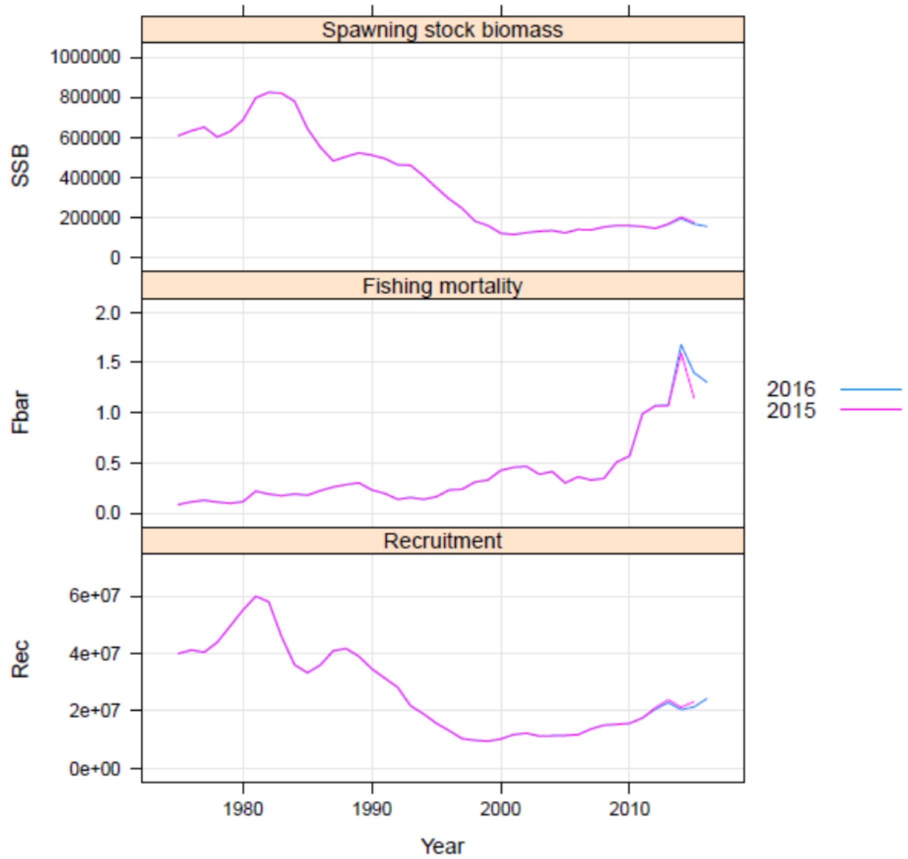


Figure 6.8.2.4 Sardine in GSA 17 & 18. Retrospective analysis. Stock Biomass (SSB) in tons (on top). F (age 1 to 2) (middle); recruitment (as thousands individuals)(bottom).

The selection pattern (F/Fbar) by age class is shown in Figure 6.8.2.5. The plots show a rather constant pattern in all the pentads in the time series of data.

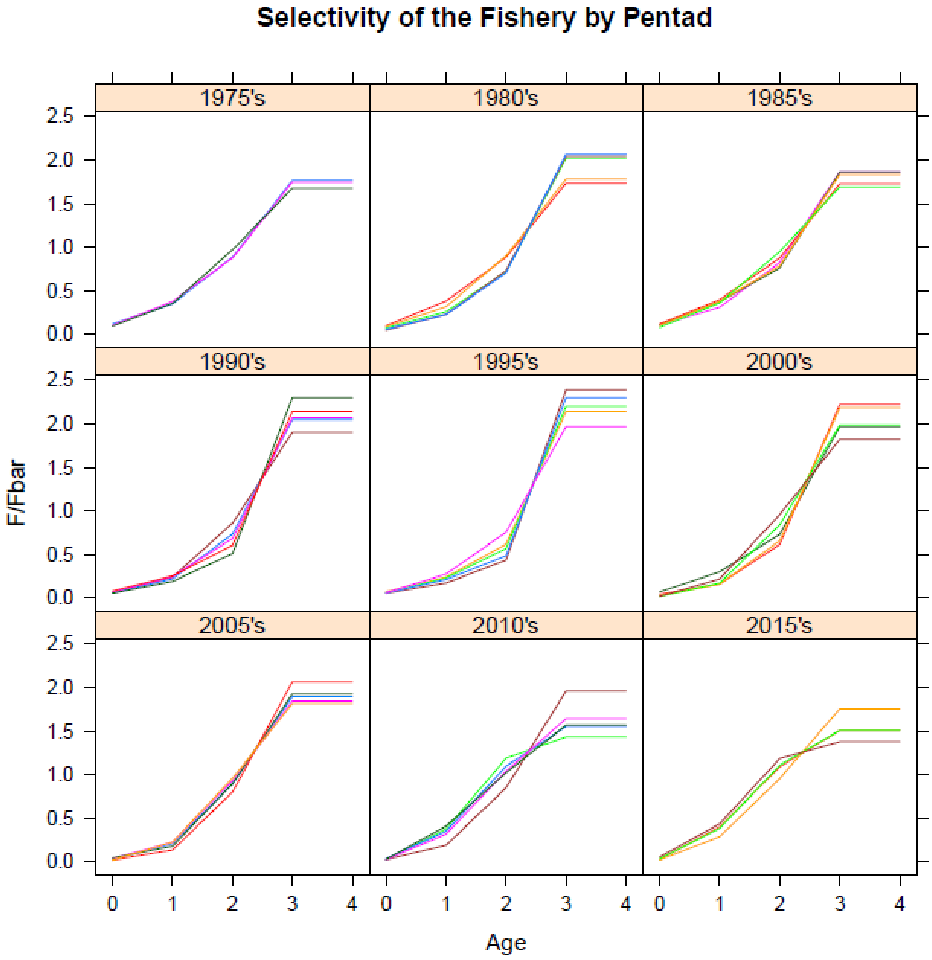


Figure 6.8.2.5 Sardine in GSAs 17 & 18. Selection pattern by age class, sardine GSA 17-18

Observation variances by input data (Figure 6.8.2.6) showed that model is fitting most closely to the catch data, and among the survey data, east age 2 is practically not used as the variability is very high.

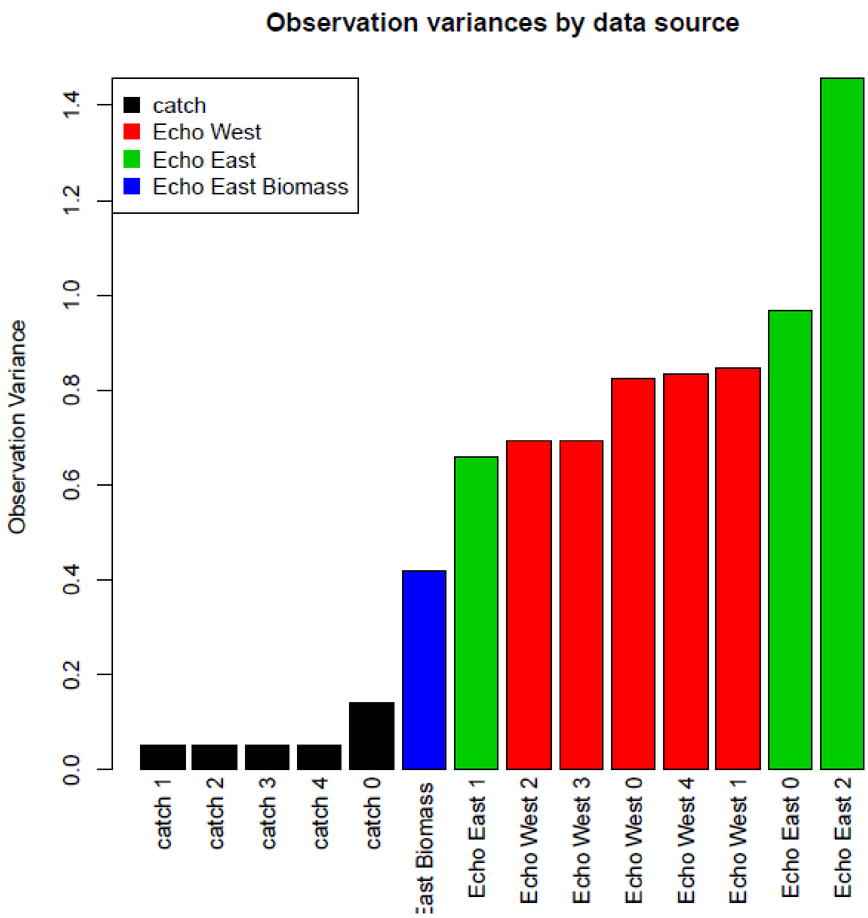


Figure 6.8.2.6 Sardine in GSA 17 & 18. Plot of the observation variances by input data.

During the evaluation of the model and data fit, it was noted that fits to survey at age data was poorer than for the catch at age, inspection of the age length keys noted that age transitions occurred at different fish length for catch and survey data. The shift observed is of some concern, further exportation of age data was evaluated during the meeting, all assessments tested resulted in the same conclusions regarding SSB and F and overall stock status. The issues are discussed in more detail in Section 3.1

Based on the improved retrospect patterns and the very similar estimates of stock it was decided to use the assessment based on the long time series.

6.8.3 Reference Points

Exploitation rate (E=0.4) was agreed to be used as reference point.

Table 6.8.3.1 Sardine in GSAs 17 & 18. Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
F_{MSY}	F = 0.44		E = 0.4	This WG

			MSY proxy	

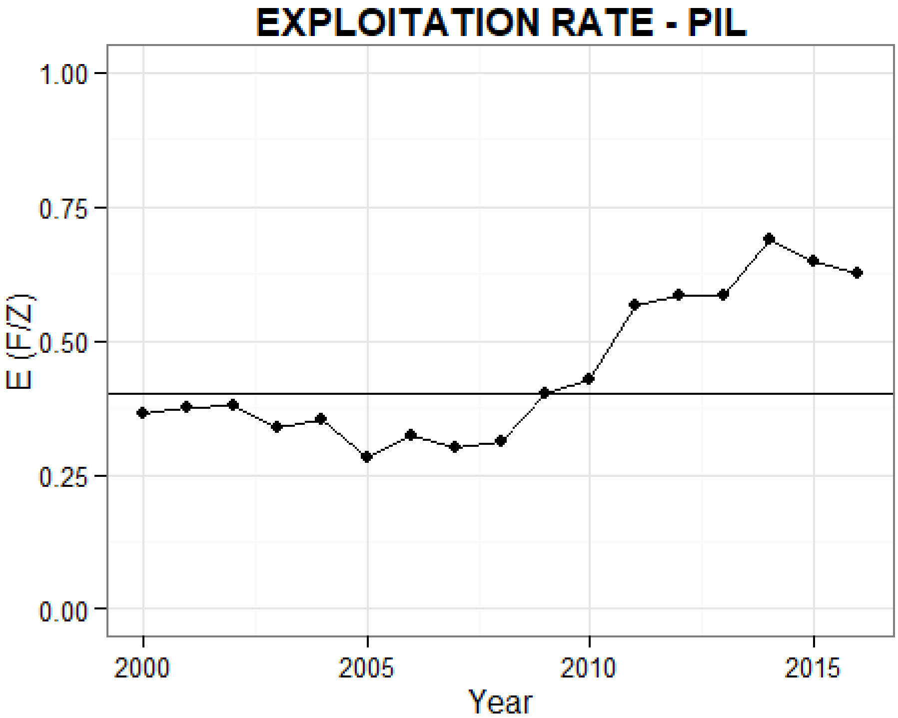


Figure 6.8.3.1 Sardine in GSAs 17 & 18. Exploitation rate sardine GSA 17-18

6.8.4 Short term Forecast and Catch Options

STECF EWG advises, based on precautionary considerations that exploitation rate E should be no more than 0.4, equivalent to a F of 0.44 equivalent to a total catch of 29966 t in 2018.

Catches should be reduced either through catch or effort control for the relevant fleets. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries considerations.

Short term forecast was carried out by STECF EWG. Short-term prediction results are shown in the following table.

Table 6.8.4.1. Sardine in GSAs 17 & 18. Short-term forecasts showing catch options at different level of F. F2017 is $F_{Status\ quo}$ which is the geometric mean of the last 3 years of the assessment (2014-2016). Recruitment 2017 & 2018 is kept constant at 21988 thousand (computed as the geometric mean of recruitment in the last 3 years of the assessment 2014-2016). $Catch_{2017}$ is 75916 t. SSB_{2018} is 173703 t.

Rationale	F factor	F bar	Catch 2018	Catch 2019	SSB 2018	SSB 2019	Change SSB 2018-2019 (%)	Change Catch 2016-2018 (%)
Zero catch	0.00	0.00	0.0	0.0	177927.0	238121.1	33.8	-100.0

E = 0.4	0.30	0.44	30679.0	41029.7	177927.0	212515.2	19.4	-61.4
Status quo	1.00	1.45	78493.7	77013.3	177927.0	175376.0	-1.4	-1.1
Different Scenarios	0.10	0.15	11071.6	17080.4	177927.0	228739.8	28.6	-86.1
	0.20	0.29	21168.8	30320.9	177927.0	220319.8	23.8	-73.3
	0.30	0.44	30414.7	40753.0	177927.0	212730.4	19.6	-61.7
	0.40	0.58	38914.6	49110.7	177927.0	205861.2	15.7	-51.0
	0.50	0.73	46758.5	55920.6	177927.0	199618.1	12.2	-41.1
	0.60	0.87	54023.6	61562.9	177927.0	193921.5	9.0	-32.0
	0.70	1.02	60776.3	66314.7	177927.0	188703.0	6.1	-23.5
	0.80	1.16	67073.7	70379.5	177927.0	183904.7	3.4	-15.5
	0.90	1.31	72965.2	73908.1	177927.0	179476.6	0.9	-8.1
	1.10	1.60	83696.2	79780.0	177927.0	171566.0	-3.6	5.4
	1.20	1.74	88605.2	82273.0	177927.0	168014.9	-5.6	11.6
	1.30	1.89	93248.9	84542.0	177927.0	164695.1	-7.4	17.4
	1.40	2.03	97652.0	86625.5	177927.0	161582.8	-9.2	23.0
	1.50	2.18	101836.3	88553.7	177927.0	158657.2	-10.8	28.2
	1.60	2.32	105820.9	90350.3	177927.0	155900.3	-12.4	33.3
	1.70	2.47	109622.7	92034.3	177927.0	153296.1	-13.8	38.1
	1.80	2.61	113256.7	93620.9	177927.0	150830.8	-15.2	42.6
	1.90	2.76	116736.2	95122.6	177927.0	148492.1	-16.5	47.0
	2.00	2.90	120073.0	96549.3	177927.0	146269.2	-17.8	51.2

6.8.5 DATA DEFICIENCIES

Data of the sardine from GSA 17&18 have shown some deficiencies.

- Catch and length data from the eastern side of GSA 18 are not available before 2007 and are reconstructed based on the GSA 17 eastern data.
- Eastern length data GSA 17&18 before 2000 are reconstructed as average of the 1998 to 2014 eastern GSA 17 data.
- Accuracy of catch data (eastern side GSA 17&18) for the period 1975 to 1998 is very doubtful, and should be revised if possible. These data do not contain any age indices of the catches.
- Eastern acoustic survey GSA 17 data were used as tuning index in the period from 2003 to 2012 and as length@age matrix from 2013 to 2016, but model is not fitting them very well.

6.9 STOCK ASSESSMENT ON ATLANTIC HORSE MACKEREL IN GSAs 17, 18, 19 & 20

Stock Identity and Biology

The area, gathered here belongs to 5 countries (ITA, SVN, HRC, ALB, MTN). It covers a surface of about 154439 km^2 in the depth range between 10-800 m (Figure 6.9.1.1). Atlantic horse mackerel (*Trachurus trachurus*) is a semi-pelagic fish species with a wide geographical distribution. It is common in the eastern part of the Atlantic and in the Mediterranean Sea including its adjacent seas. This oceanodromous, migratory species forms schools and usually lives between 100 and 200 m deep. As a batch spawner its spawning season is protracted and varies according to geography but mainly appears in colder part of the year (winter – early spring).

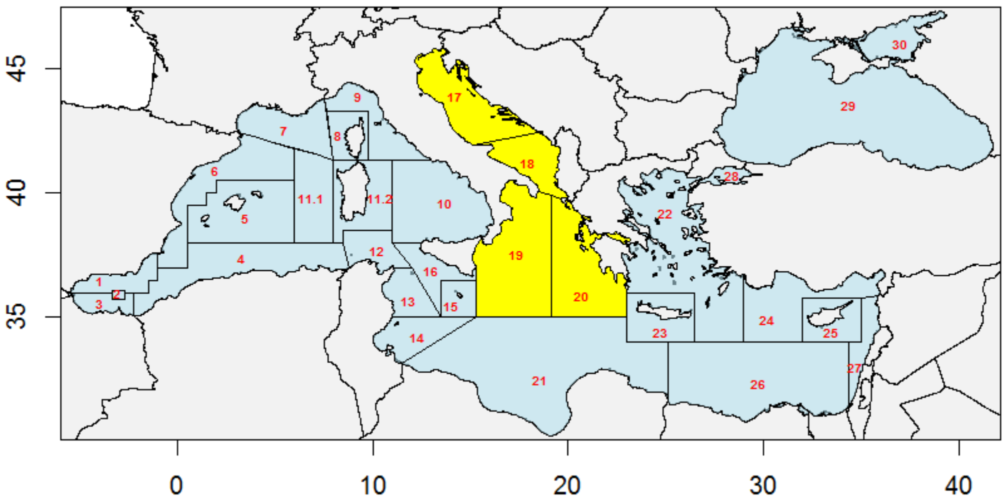


Figure 6.9.1 Geographical location of GSAs 17-18-19-20

Growth

Growth parameters obtained by otolith reading have been derived from the dataset of biological parameter (gp.csv) as reported in the last data call (Table 6.9.1) for the GSA18 and GSA19.

Table 6.9.1 Atlantic horse mackerel in GSAs 17,18,19 & 20. Growth parameters.

Stock Identification	L_inf	k	t_0	L-W: a	L-W: b	Source
GSA18	48.1193	0.1517	-1.3374	0.0102	2.9488	ITA GSA18
GSA19	48.1193	0.1517	-1.3374	0.0079	3.0225	ITA GSA19

Maturity

Maturity ogives were taken from the last DCF data call for each sex separately in the GSA 20.

Table 6.9.2 Atlantic horse mackerel in GSAs 17,18,19 & 20. Proportion of mature fish by age.

Age	0	1	2	3	4	5	6	7	8
Maturity (males)	0	0.069	0.385	0.667	1	1	-	1	1
Maturity (females)	0	0.13	0.333	0.706	0.5	0.5	0.833	1	-

6.9.1 DATA

6.9.1.1 CATCH (LANDINGS AND DISCARDS)

Landings

As reported on the DCF data call total landings (tonnes) are available since 2006 for GSAs 17-19, although for GSA17 two years (2008, 2009) landing data are missing (Figure 6.9.1.1.1). In order to fill in the missing years the landings were also explored within economic data for GSA17 (Figure 6.9.1.1.2). Economic data reported landing values were almost double the biological reported values in some years and values for years 2014 and 2016 were too low. The close to double values coming from the economic data are due to reported landings from midwater trawl fisheries which is not reported in the DCF landings. Generally, issues with the landing data are most probably link to the fact that the landings of this species in all observed GSAs referees not only to *Trachurus trachurus* but also to *Trachurus spp*. and/or *Trachurus mediterraneus*. Landings in GSA18 and GSA19 showed the opposite trend over the investigated years. Landings of the GSA20 are given separately as the range of the landings along with the time series were much shorter (Figure 6.9.1.1.3).

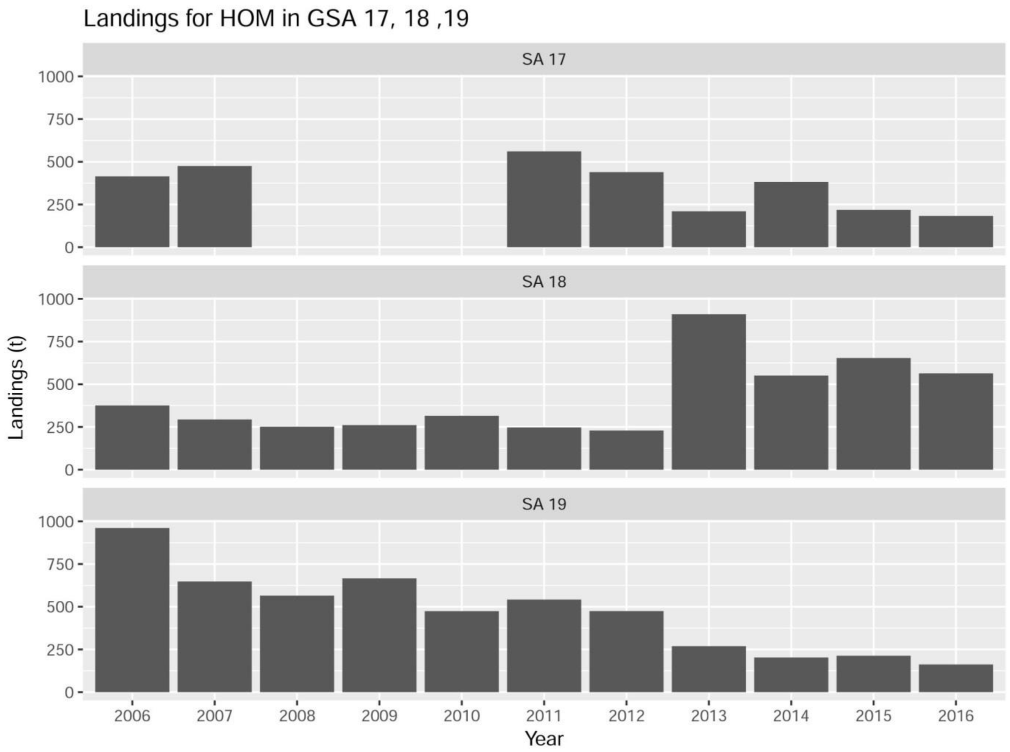


Figure 6.9.1.1.1 Atlantic horse mackerel in GSAs 17, 18 ,19 & 20. Total landings by year in GSAs 17- 19

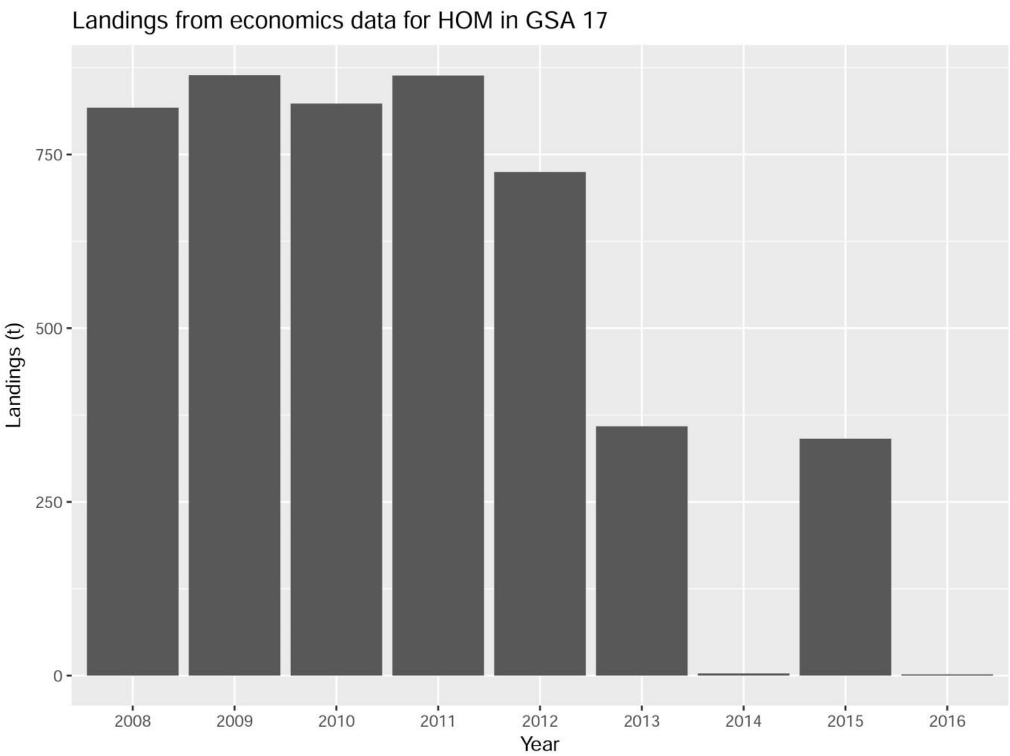


Figure 6.9.1.1.2 Atlantic horse mackerel in GSAs 17, 18, 19 & 20. Landings by year in GSAs 17 obtained from the economic data

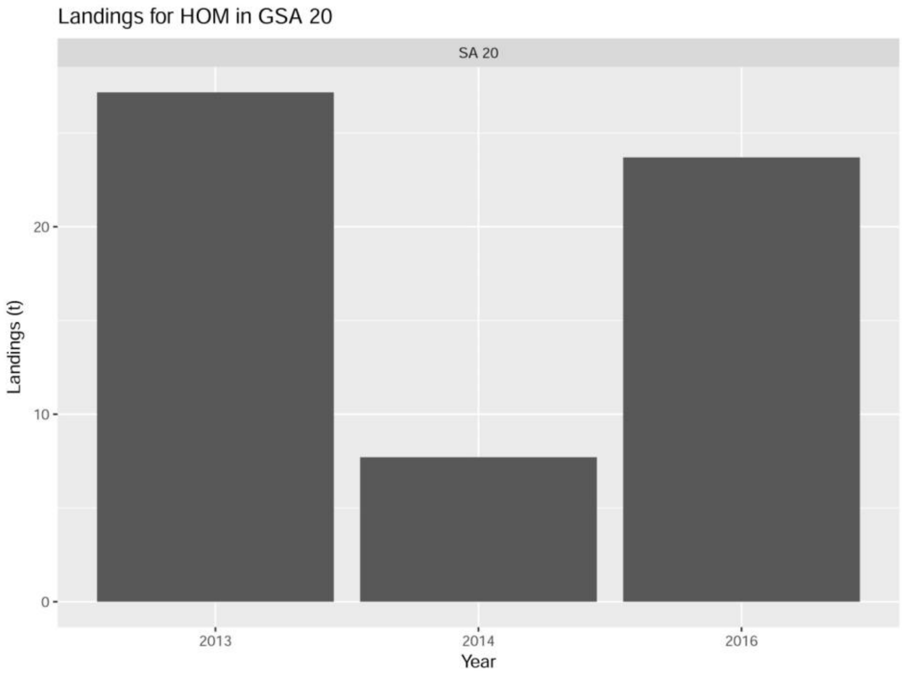
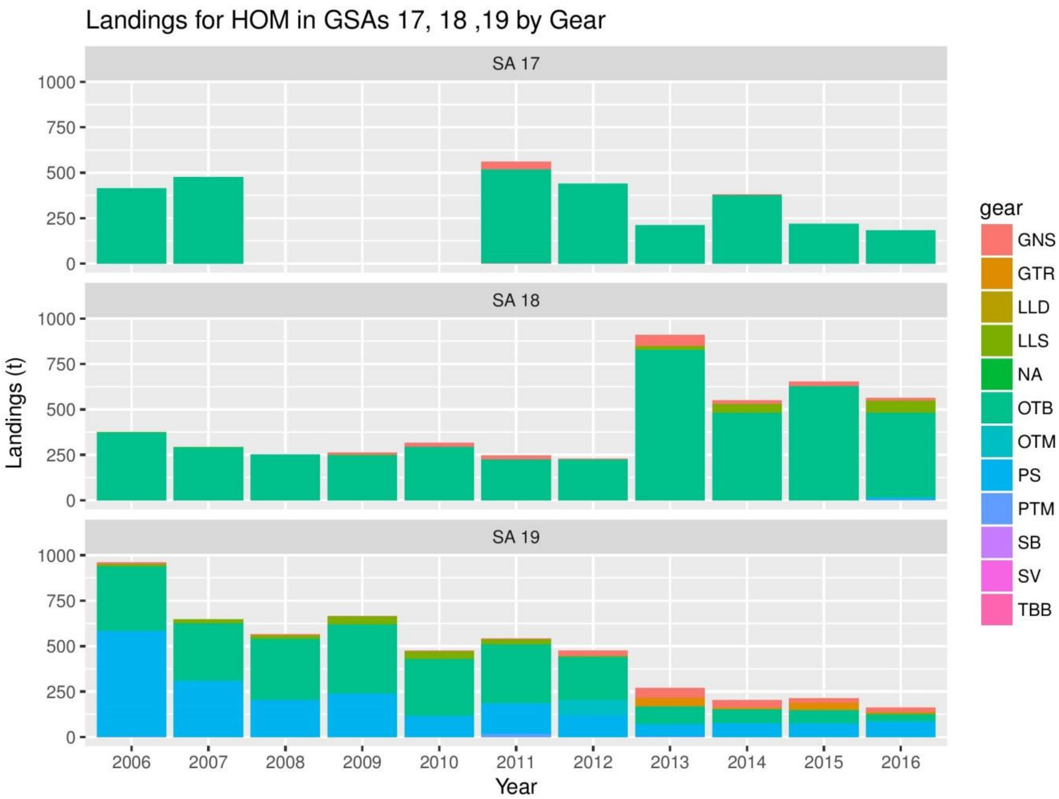
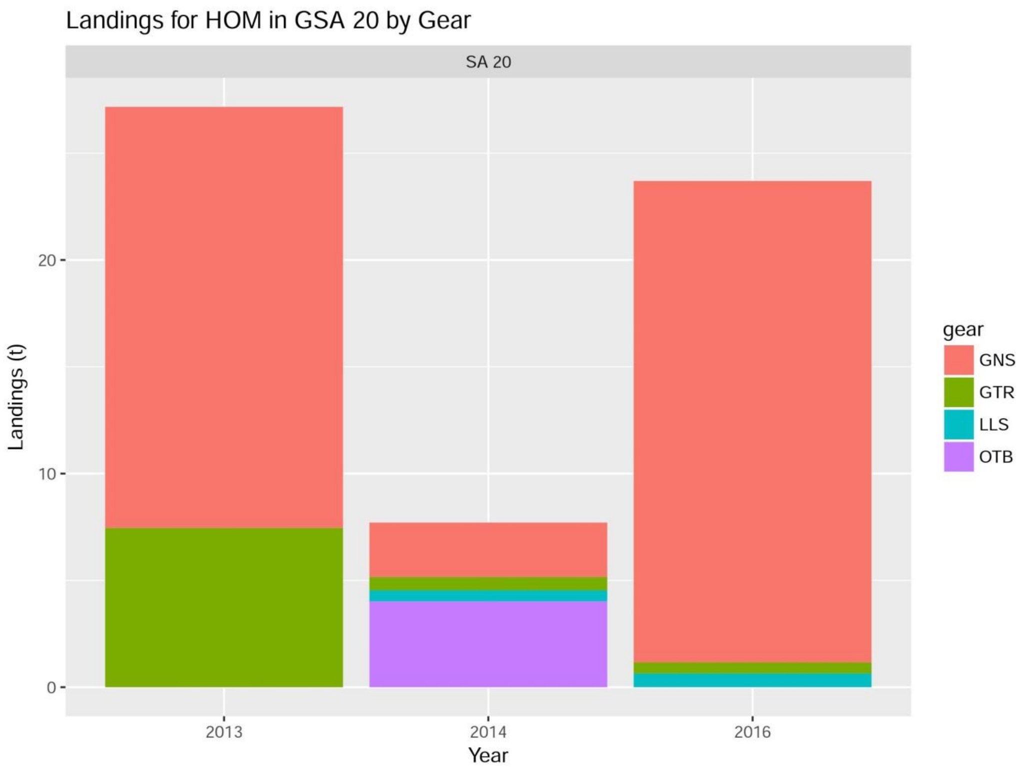


Figure 6.9.1.1.3 Atlantic horse mackerel in GSAs 17, 18, 19 & 20. Total landings by year in GSA20

Within investigated areas obtained landings were coming mainly from OTB, PS and other gears (GNS) (Figures 6.9.1.1.4, 6.9.1.1.5; Table 6.9.1.1.1).



Figures 6.9.1.1.4 Atlantic horse mackerel in GSAs 17, 18, 19 & 20. Total landings by year and fishing gear in the areas of GSAs 17-19.



Figures 6.9.1.1.5 Atlantic horse mackerel in GSAs 17, 18, 19 & 20.Total landings by year and fishing gear in the area of GSA20.

Table 6.9.1.1.1 Atlantic horse mackerel in GSAs 17, 18, 19 & 20. Year trend on total landings and per cent contribution by two main gears in the area of GSAs 17-19.

year	OTB	PS	total	%OTB	%PS
2006	1144.3	583.3	1751.6	65.3	33.3
2007	1084.2	310.9	1417.2	76.5	21.9
2008	587.9	205.2	816.9	72.0	25.1
2009	631.4	241.1	927.0	68.1	26.0
2010	609.7	116.8	789.6	77.2	14.8
2011	1065.0	168.2	1350.2	78.9	12.5
2012	465.1	120.2	1143.5	40.7	10.5
2013	1139.3	70.0	1389.3	82.0	5.0
2014	937.3	77.0	1135.3	82.6	6.8
2015	917.9	74.6	1084.7	84.6	6.9
2016	686.8	100.9	908.8	75.6	11.1

Overall, length frequency distribution of the reported landings for Atlantic horse mackerel went from 7 cm to 46 cm in the areas observed, although the most abundant length classis were in range 25-28 cm (Figures 6.9.1.1.6-9).

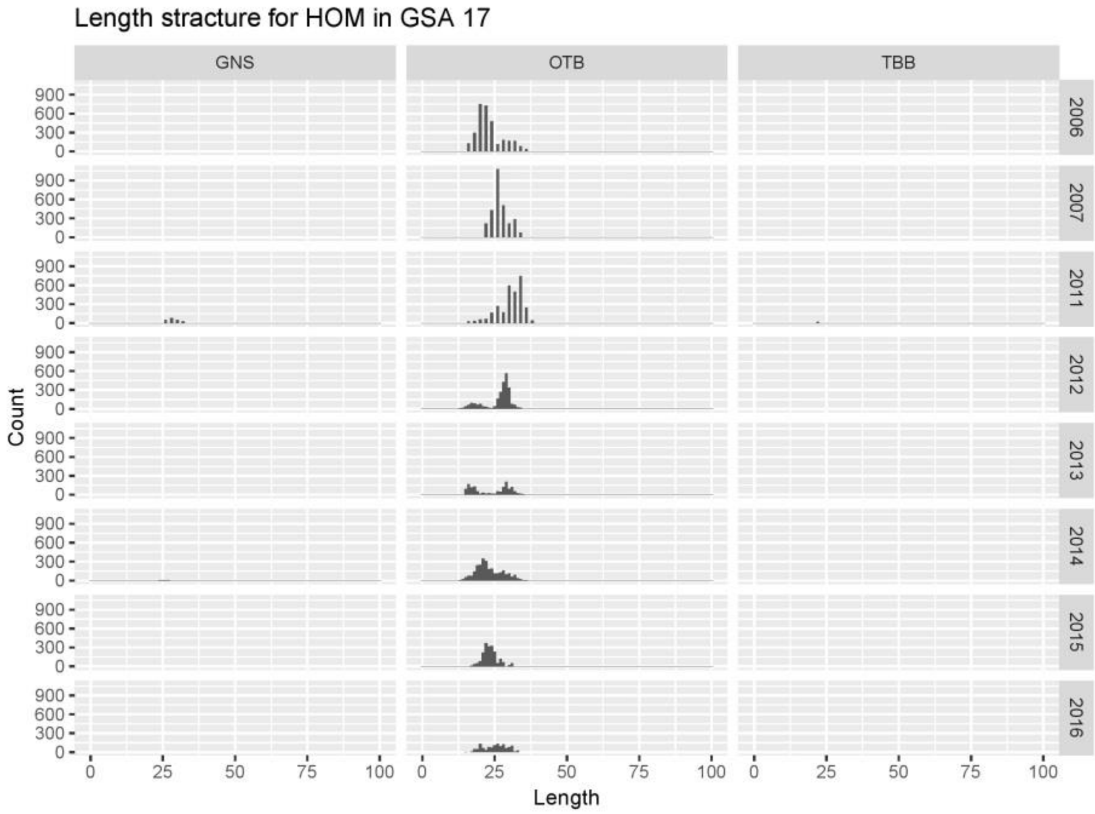


Figure 6.9.1.1.6 Atlantic horse mackerel in GSAs 17, 18, 19 & 20. Length distributions of the landings by year and main fishing gears in the area of GSA17

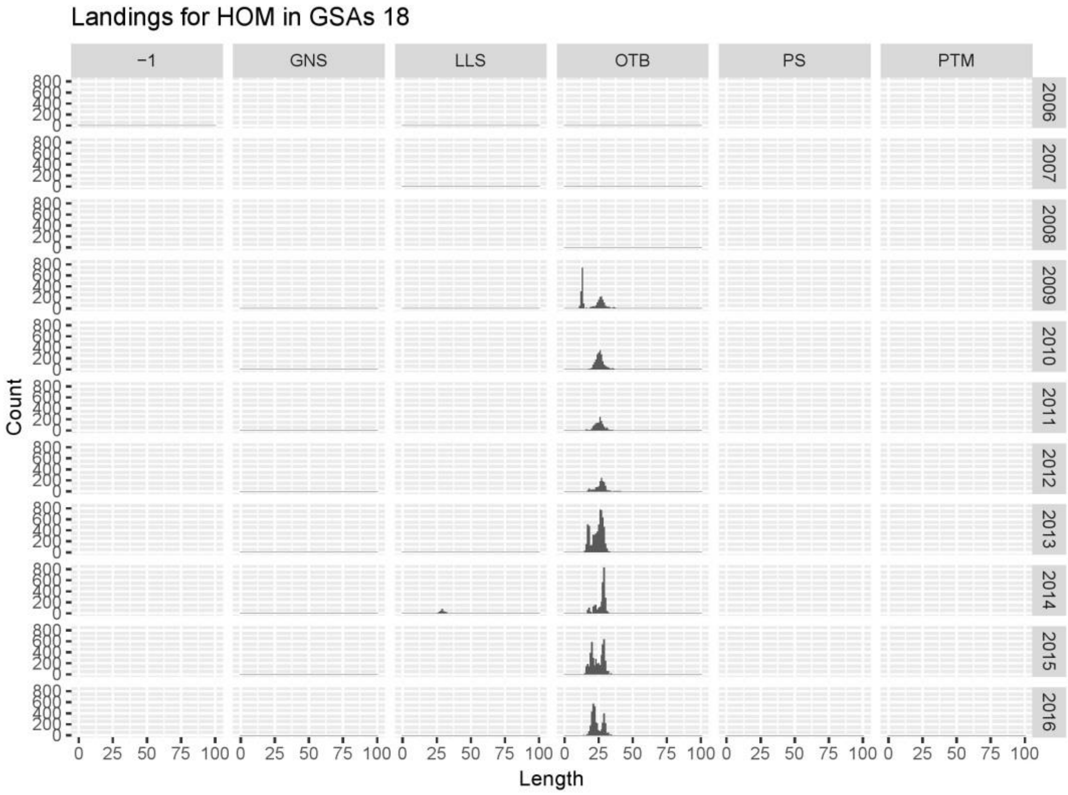


Figure 6.9.1.1.7 Atlantic horse mackerel in GSAs 17, 18, 19 & 20. Length distributions of the landings by year and main fishing gears in the area of GSA18

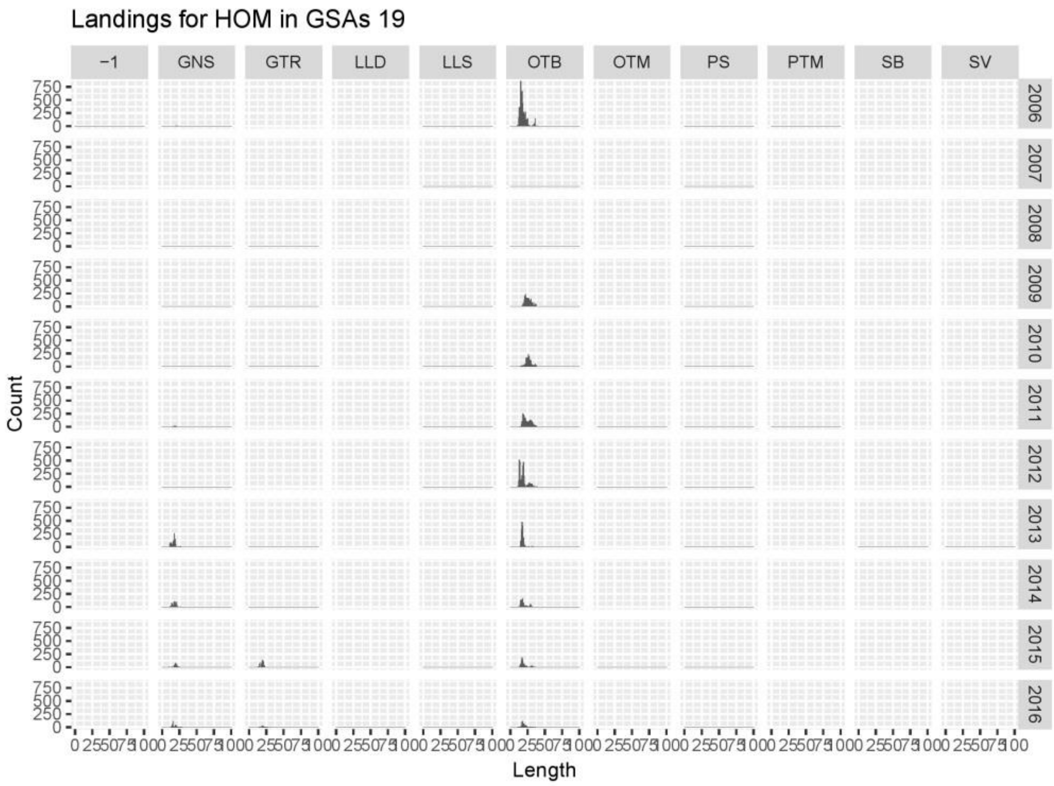


Figure 6.9.1.1.8 Atlantic horse mackerel in GSAs 17, 18, 19 & 20. Length distributions of the landings by year and main fishing gears in the area of GSA19

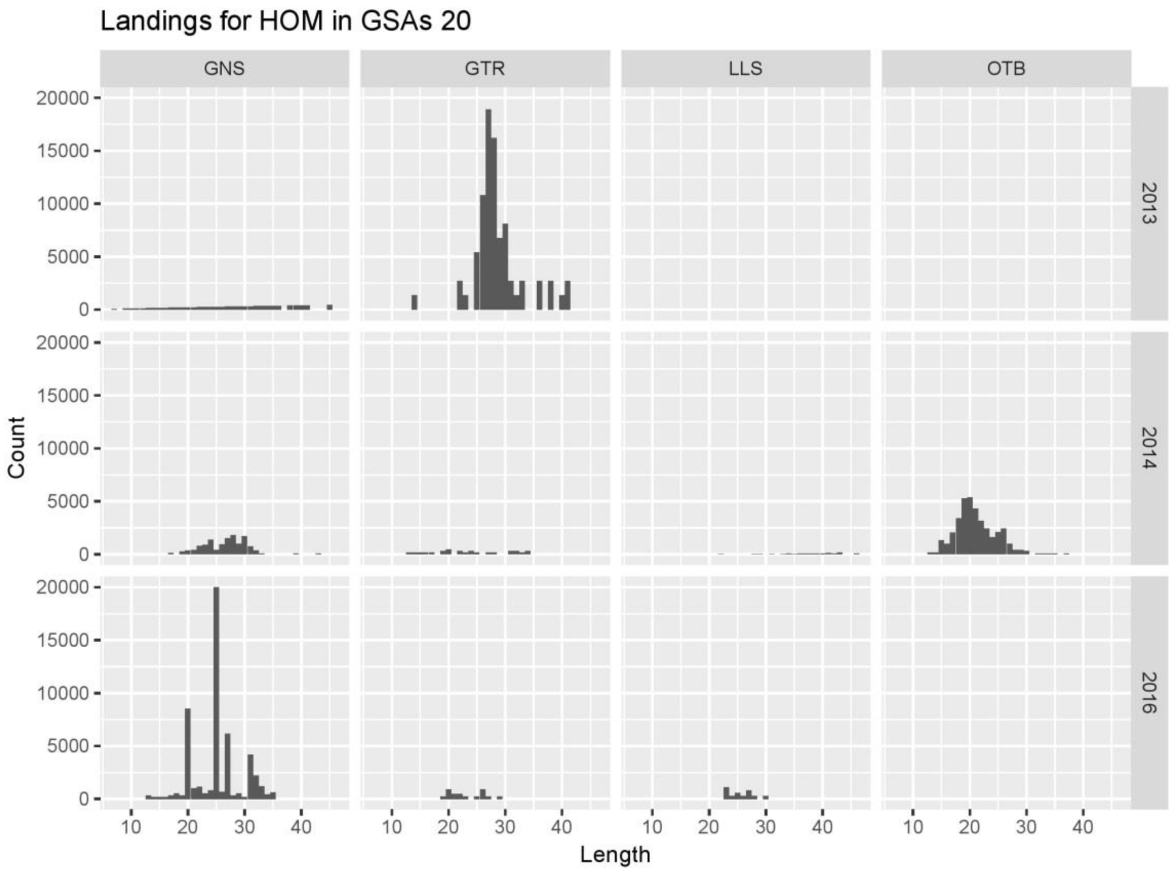


Figure 6.9.1.1.9 Atlantic horse mackerel in GSAs 17, 18, 19 & 20. Length distributions of the landings by year and main fishing gears in the area of GSA20

Discards

According to the official data submitted by the countries within the investigated area (GSAs17-20) in response to the DCF data call Atlantic horse mackerel is one of the species that was discarded. Those discards come mainly from the same fishing gear (OTB) that was catching it. Amount of the discarded Atlantic horse mackerel varied over the years and no clear trend was observed, beside the fact that was already noticed in landings – values of discard followed reverse trends over the years in GSA18 and GSA19 (Figure 6.9.1.1.10), while the lowest amount of discard is reported in GSA20 (Figure 6.9.1.1.11). Overall, the length of discarded Atlantic horse mackerel specimens ranged between 4 to 36 cm but majority of them were the juveniles with its length below 12 cm (Figures 6.9.1.1.12-15).

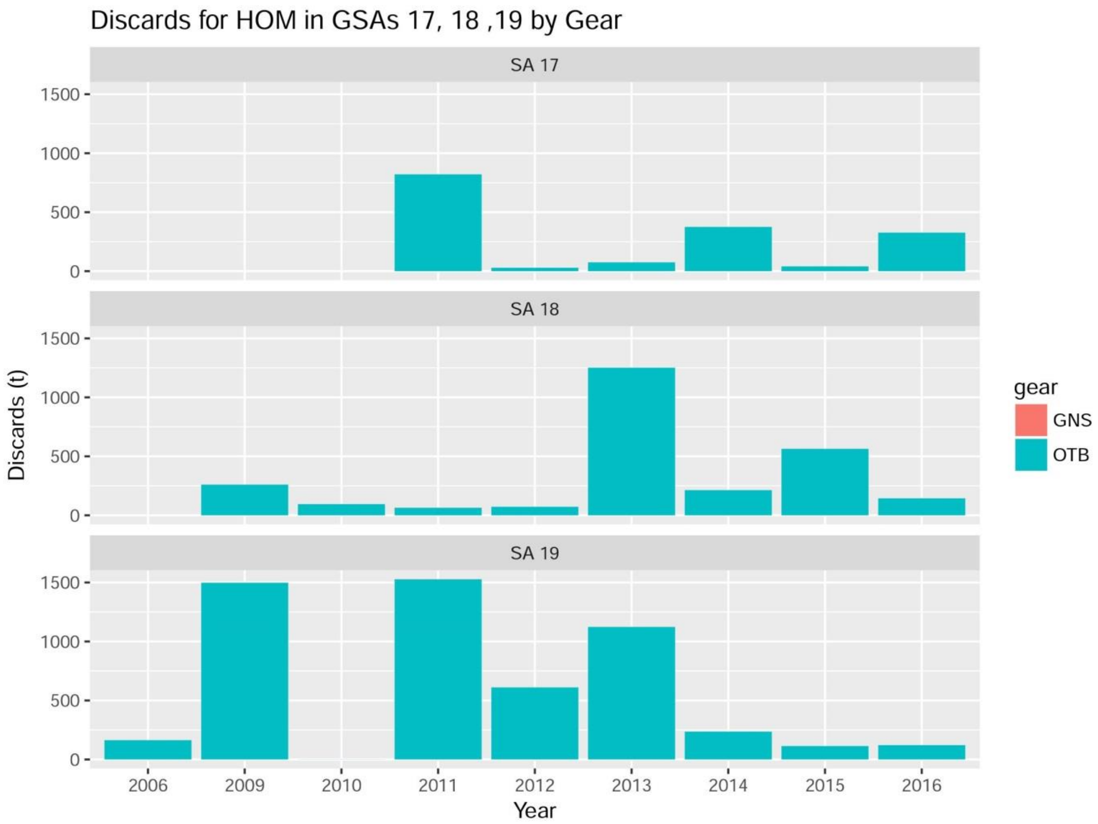


Figure 6.9.1.1.10 Atlantic horse mackerel in GSAs 17, 18, 19 & 20. Total discards by year and main fishing gear in the area of GSAs 17-19

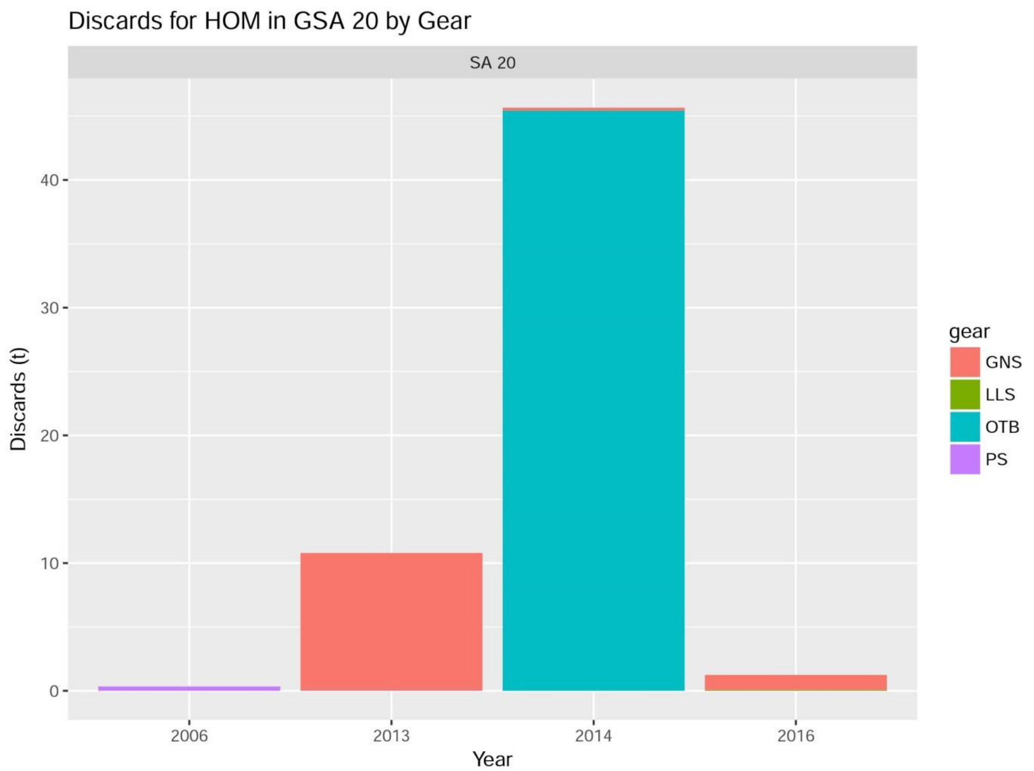


Figure 6.9.1.1.11 Atlantic horse mackerel in GSAs 17, 18, 19 & 20.. Total discards by year and main fishing gear in the area of GSA20

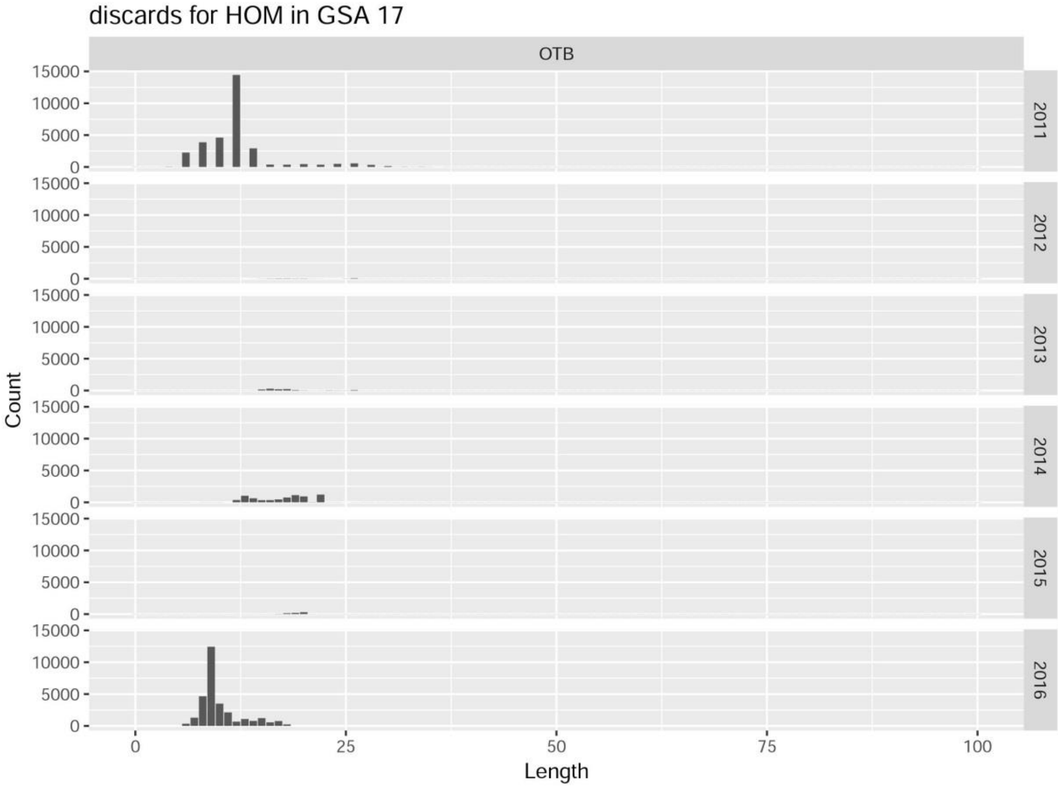


Figure 6.9.1.1.12 Atlantic horse mackerel in GSAs 17, 18, 19 & 20.. Length distribution of the discards by year and main fishing gears in the GSA 17

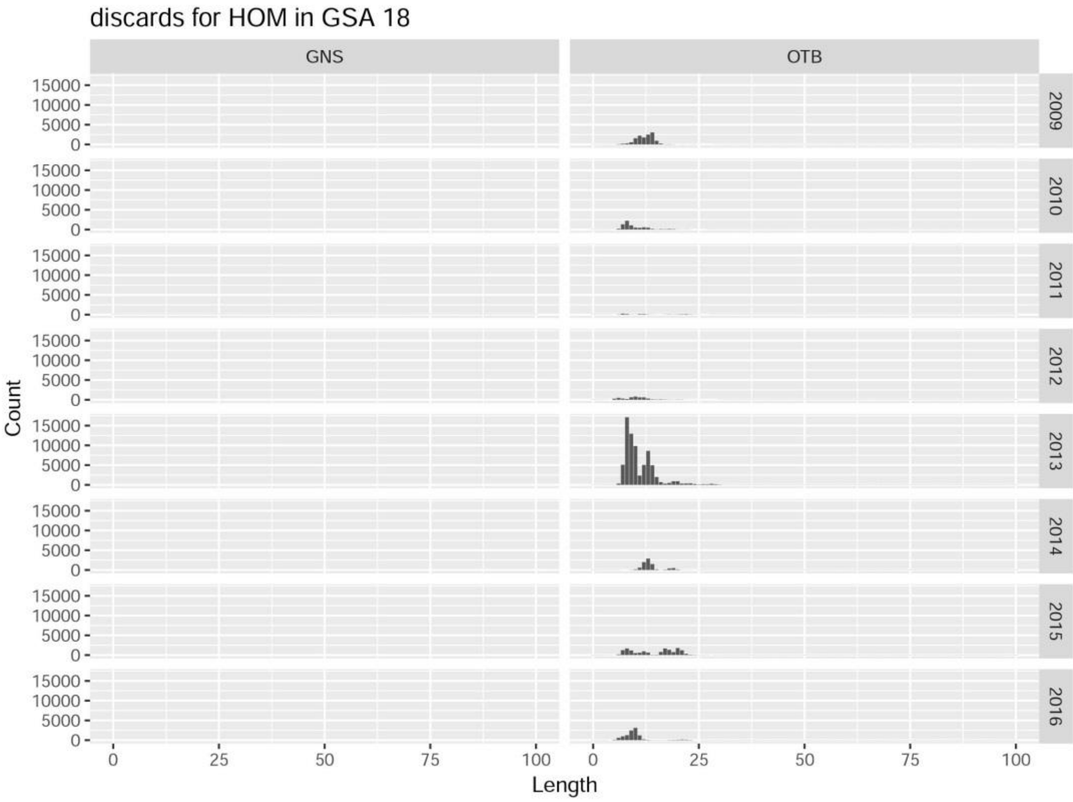


Figure 6.9.1.1.13 Atlantic horse mackerel in GSAs 17, 18, 19 & 20.. Length distribution of the discards by year and main fishing gears in the GSA 18

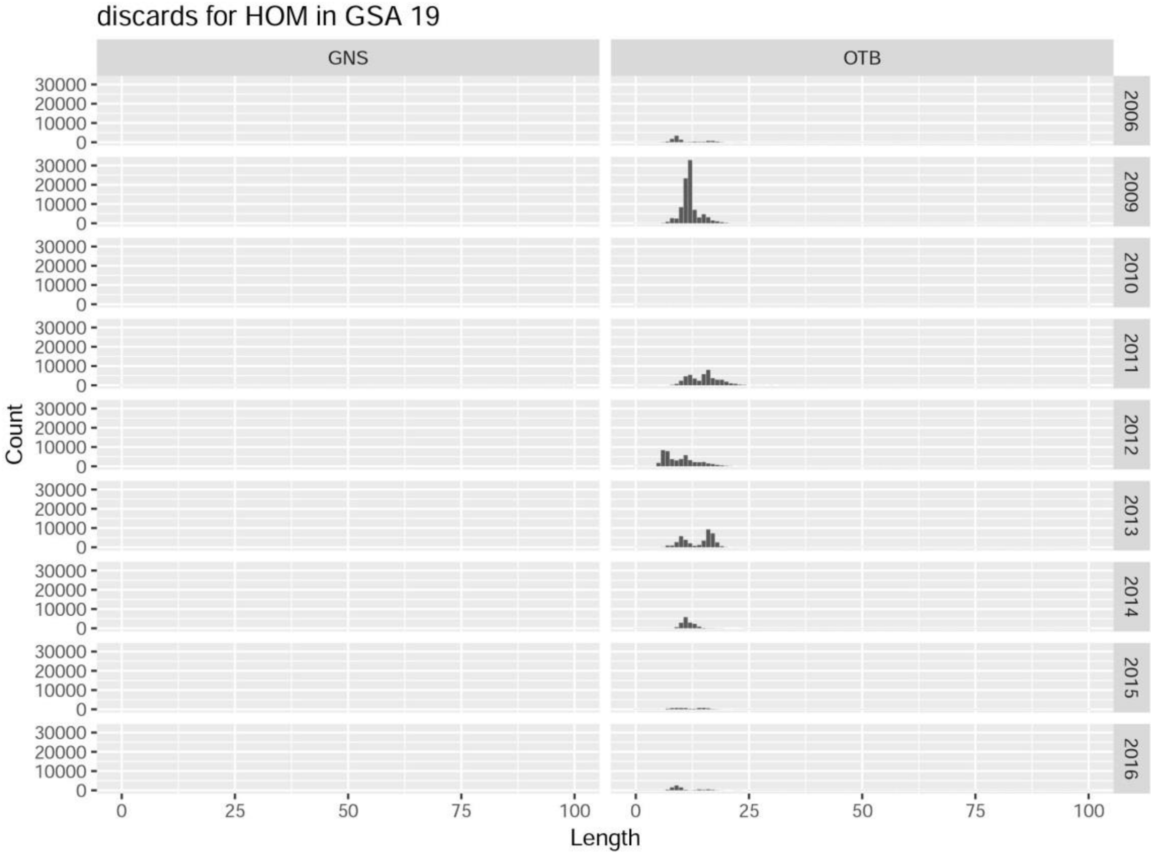


Figure 6.9.1.1.14 Atlantic horse mackerel in GSAs 17, 18, 19 & 20.. Length distribution of the discards by year and main fishing gears in the GSA 19

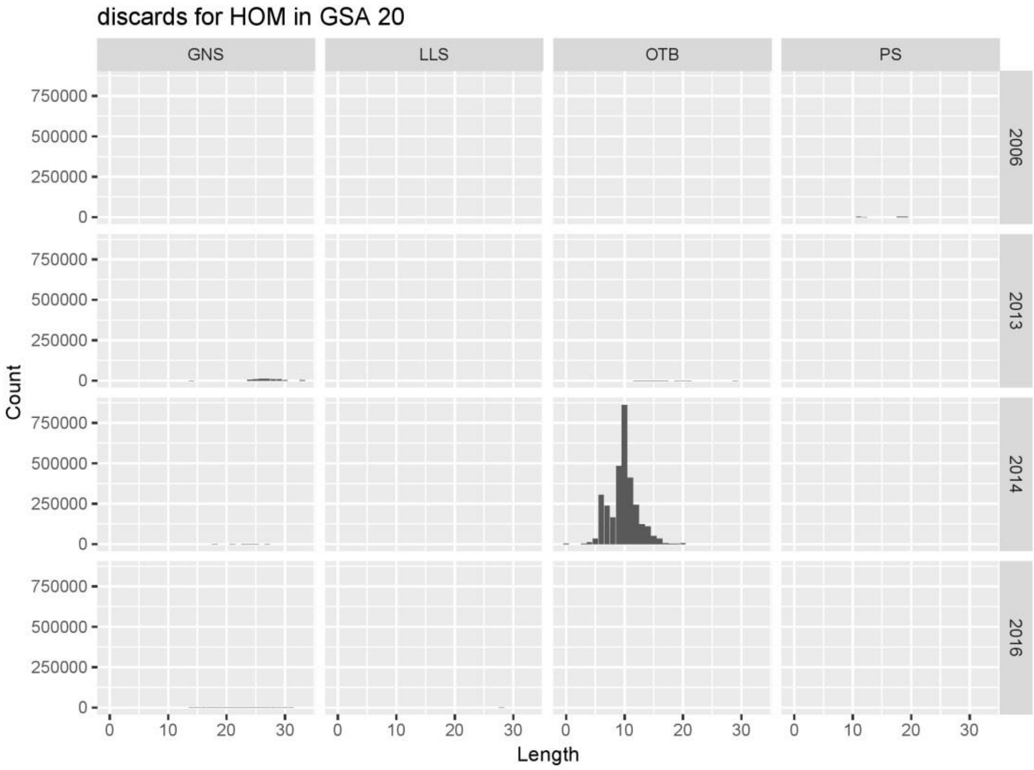


Figure 6.9.1.1.15 Atlantic horse mackerel in GSAs 17, 18, 19 & 20. Length distribution of the discards by year and main fishing gears in the GSA 20

6.9.1.2 EFFORT

According to previously given data concerning Atlantic horse mackerel it is obvious that this species is not a target one at least in here investigated areas (GSAs 17-20) where it is caught mostly by OTB, Atlantic horse mackerel could be define as discard or by-catch species. In that sense fishing effort data most probably will not indicate possible changes within Atlantic horse mackerel population inhabiting this area. Nevertheless, fishing effort data for GSAs 17, 18, 19, 20 were yearly presented as a number of days at sea (Figures 6.9.1.2.1, 6.9.1.2.2) and GT days at sea (Figures 6.9.1.2.3, 6.9.1.2.4). These parameters of fishing effort were also given by gear for each year available Overviewing all mentioned effort data it is obvious that fishing effort slightly fluctuated among the years but no specific trend was visible, despite in GSA17 where slight decrease of Days at sea was noticed.

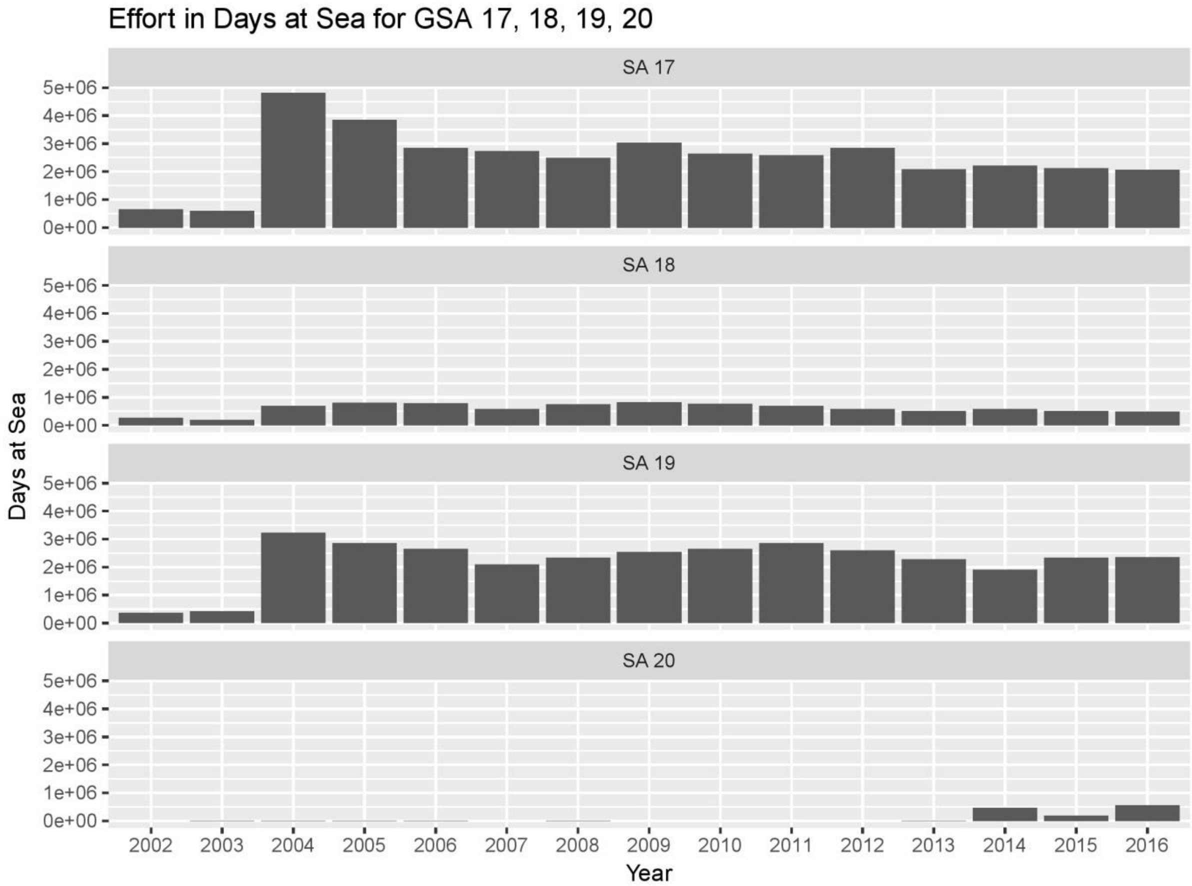


Figure 6.9.1.2.1 Atlantic horse mackerel in GSAs 17, 18, 19 & 20. Fishing effort in Days at sea by year in investigated area (GSAs 17 – 20).

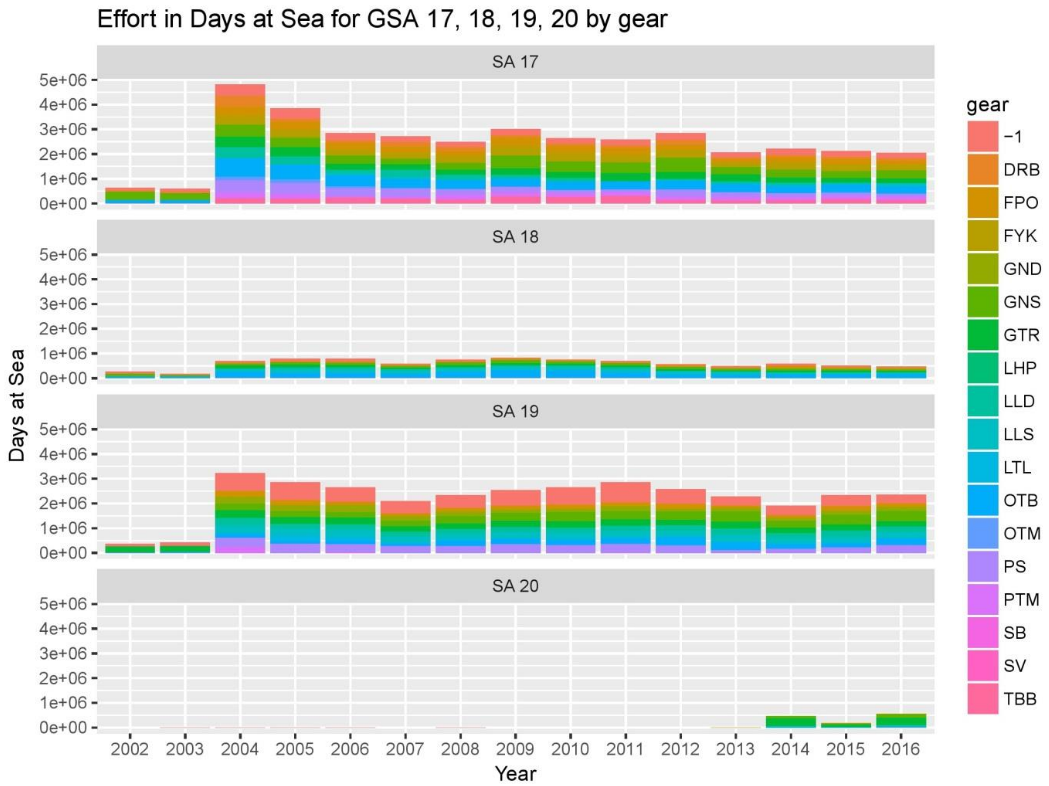


Figure 6.9.1.2.2 Atlantic horse mackerel in GSAs 17, 18, 19 & 20. Fishing effort in Days at sea by year and gear in investigated area (GSAs 17 – 20).

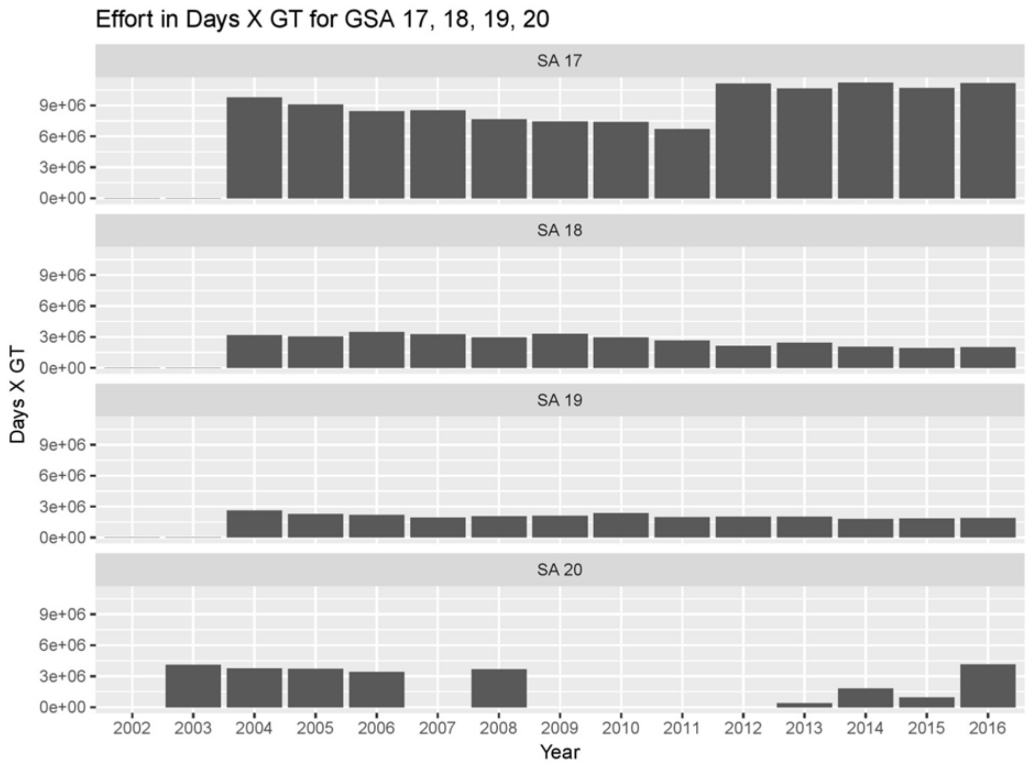


Figure 6.9.1.2.3 Atlantic horse mackerel in GSAs 17, 18, 19 & 20. Fishing effort in GT*Days at sea in investigated area (GSAs 17 – 20).

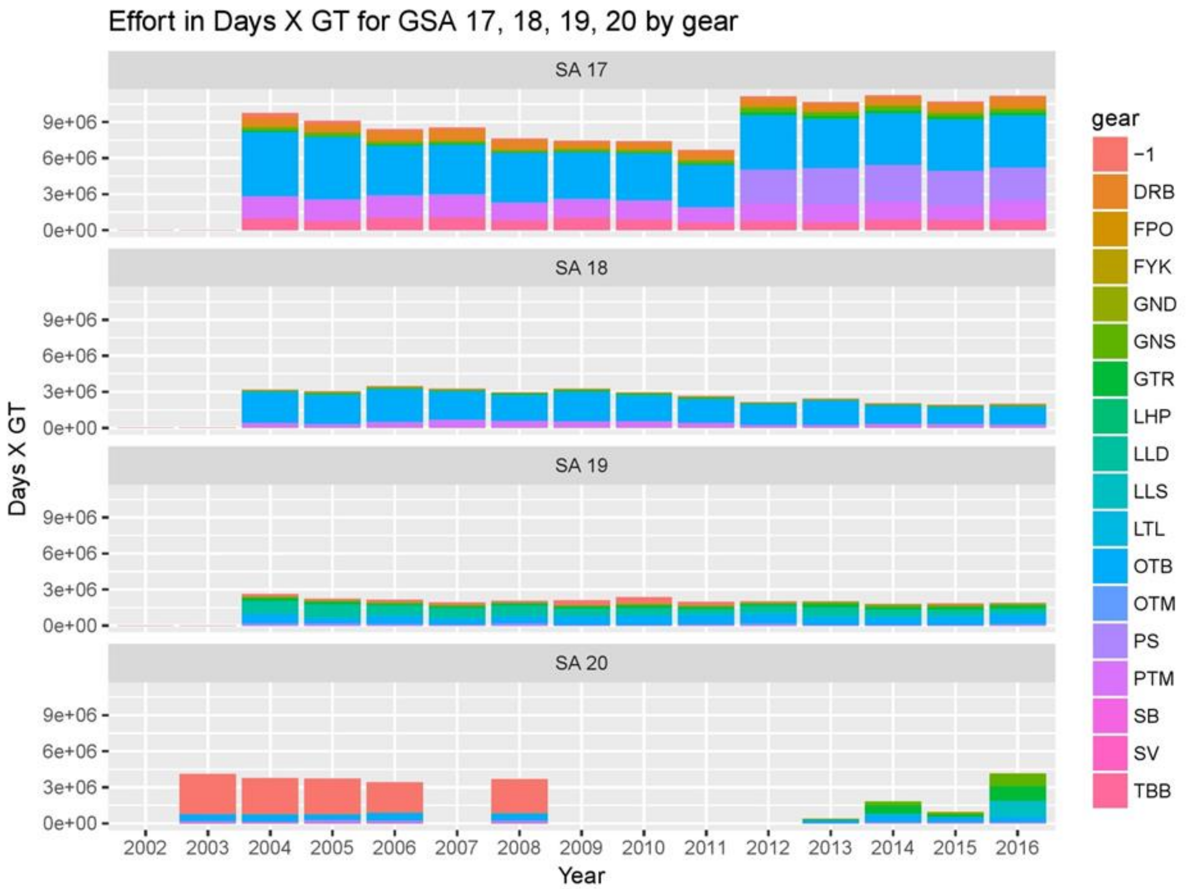


Figure 6.9.1.2.4 Atlantic horse mackerel in GSAs 17, 18, 19 & 20. Fishing effort in GT*Days at sea by fishing gear in investigated area (GSAs 17 – 20).

6.9.1.3 SURVEY DATA

Abundance and biomass indexes were obtained throughout MEDITS surveys. The MEDITS trend in abundance and biomass indices varied over the years in the area of GSAs 17-19, but two peaks (2004, 2014) in each investigated area were noticed (Figures 6.9.1.3.1, 6.9.1.3.2).

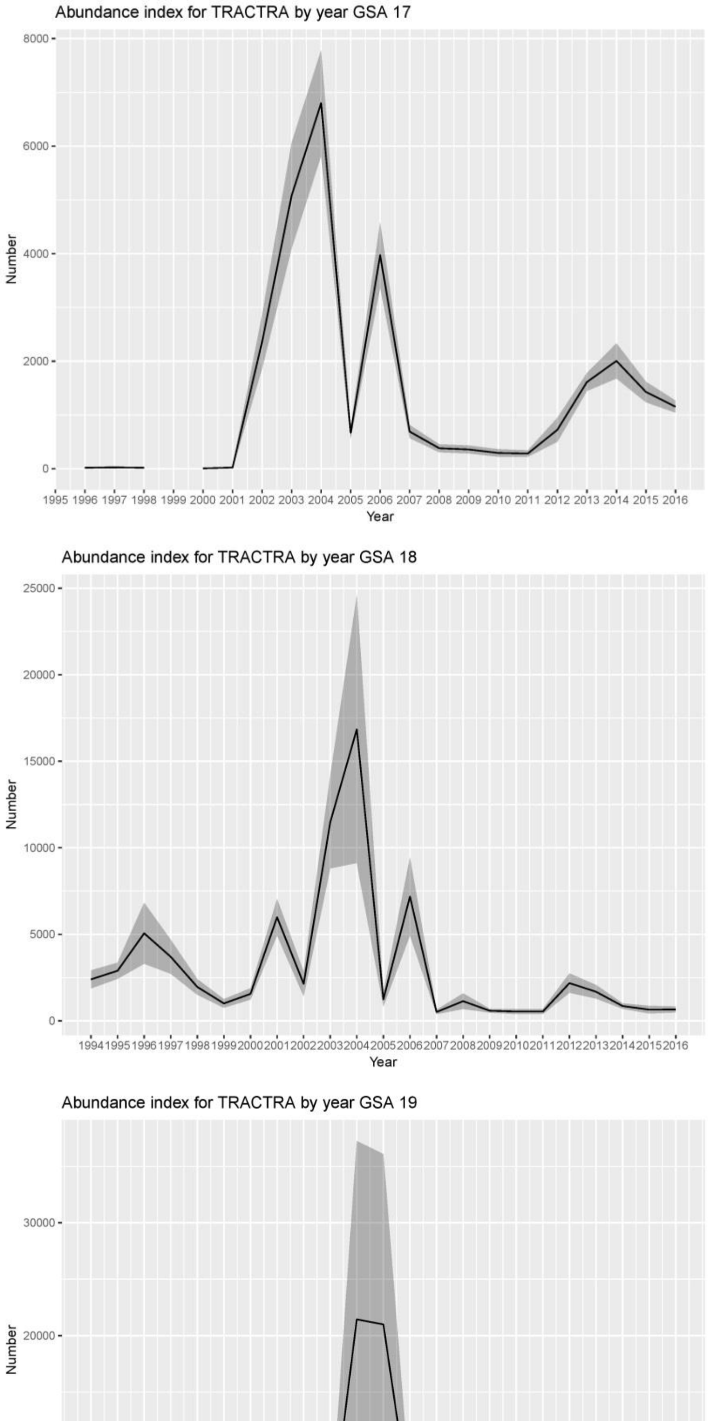


Figure 6.9.1.3.1 Atlantic horse mackerel in GSAs 17, 18, 19 & 20. Atlantic Horse Mackerel abundance index obtained during MEDITS survey in the area of GSAs 17-19.

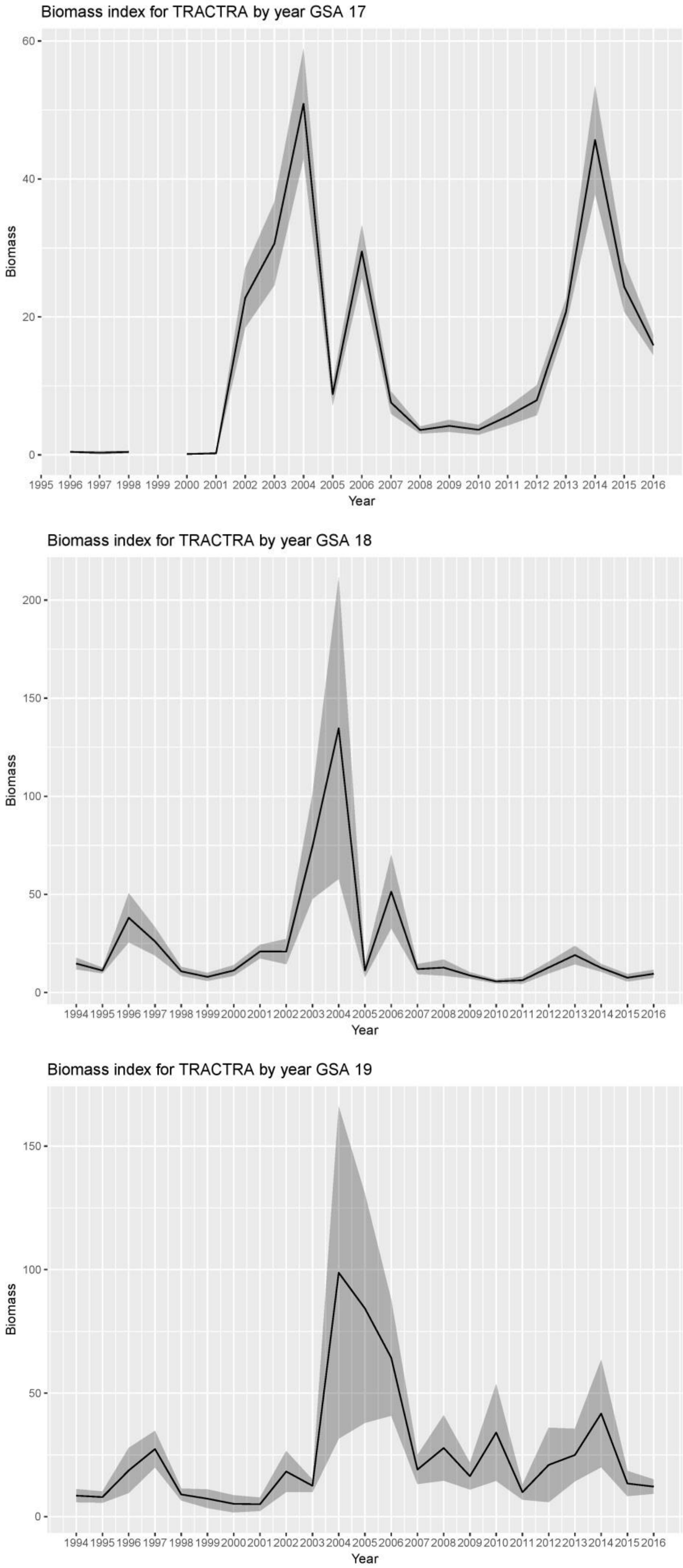
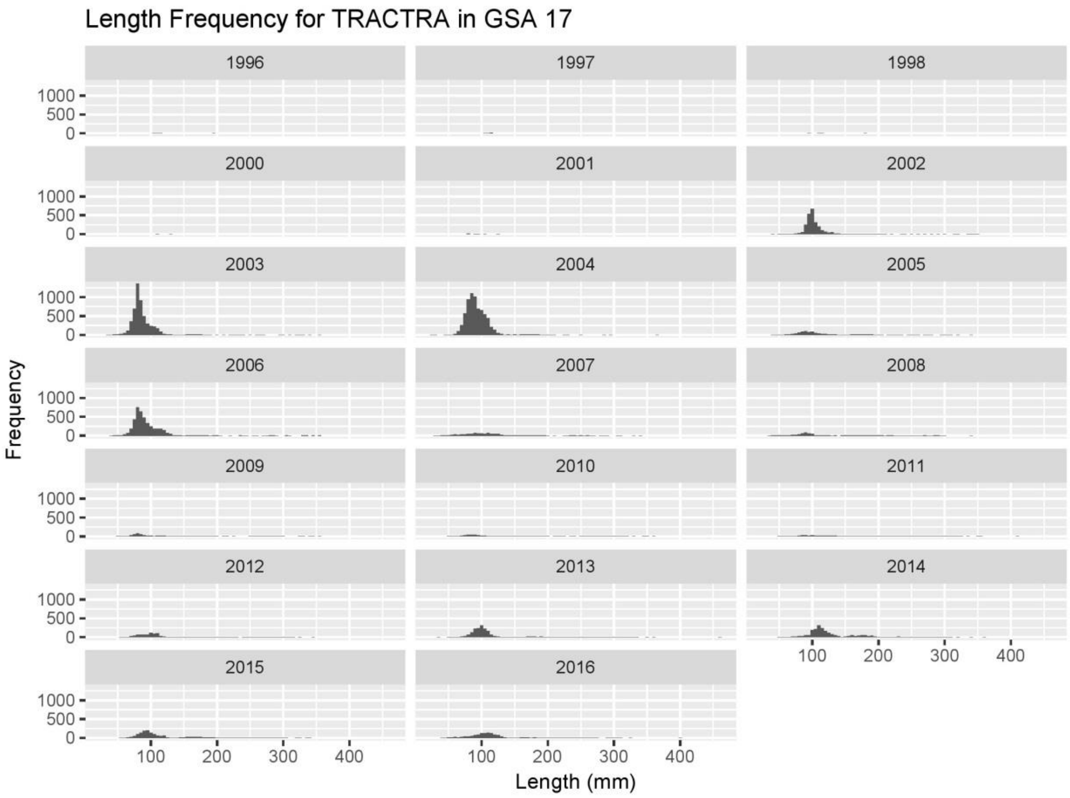
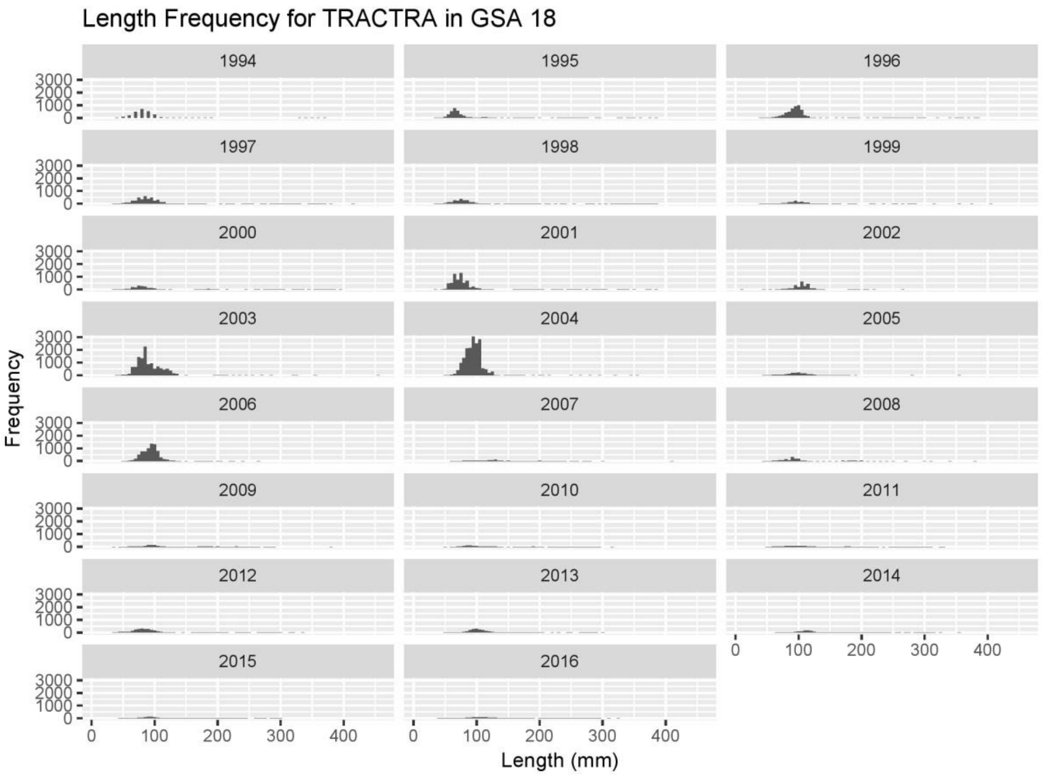


Figure 6.9.1.3.2 Atlantic horse mackerel in GSAs 17, 18, 19 & 20. Atlantic Horse Mackerel biomass index obtained during MEDITS survey in the area of GSAs 17-19.


Length Frequency for TRACTRA in GSA 17
1996
1997
1998
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Frequency
1000
500
0
100
200
300
400
Length (mm)


Length Frequency for TRACTRA in GSA 18
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Frequency
3000
2000
1000
0
100
200
300
400
Length (mm)

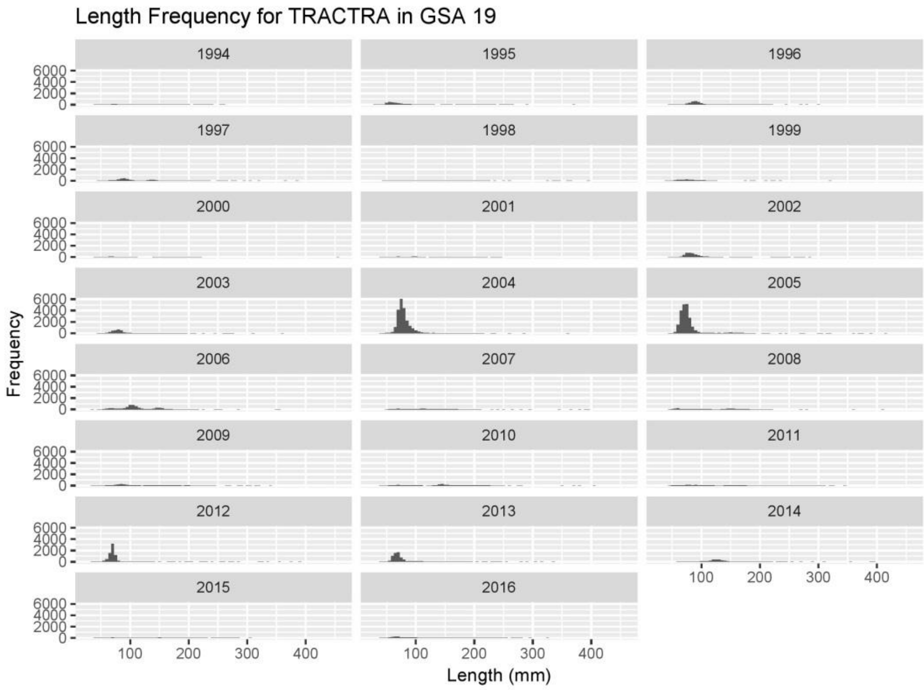


Figure 6.9.1.3.3 Atlantic horse mackerel in GSAs 17, 18, 19 & 20. Size structure of Atlantic Horse Mackerel specimens collected within the MEDITS surveys in areas of GSAs 17-19.

From shown length frequencies of Atlantic horse mackerel collected during the MEDITS surveys in each area and overall it was obvious that majority of caught specimens were juveniles with its body length below 15 cm.

6.9.2 STOCK ASSESSMENT

After comprehensive analysis of the data provided throughout the DCF data call by the countries for this area GSAs 17-20 some inconsistency were noticed. First of all, landing data on Atlantic horse mackerel were missing for some years; especially in the area of GSA 20 (before 2013) while in GSA17 landed data were not consistent with the data given within economic data call. The observed issues with the landing data are most probably link to the fact that the landings of this species in all observed GSAs referees not only to *Trachurus trachurus* but also to *Trachurus spp.* and/or *Trachurus mediterraneus,* though there is also evidence that specific gears may have been omitted from the reported biological data*.* Due to length frequency distribution reported by biological sampling and ones obtained by MEDITS survey pointed out that majority of collected specimens of Atlantic horse mackerel were juveniles. This is in line with the fact that this species is mainly caught with OTB in all the area – meaning that studied species is not target one at least for this fishing gear what was obvious as amount of the landed values were lower than discarded ones in some years. Therefore, information concerning the effort most probably will not reveal us expected oscillation of this pelagic fish species. Thus the landings / catch data is not considered to be suitable for an assessment model.

The available survey data (MEDITS) is dominated by the presence of intermittently occurring recruits. There is no basis for determining if these are a strong signal for abundance or just random encounters but there is no obvious link to resulting catches, suggesting that it is more likely a random encounter effect. Therefore the survey does not appear to be suitable to provide a stock index.

Taking into account all of this EWG was unable to evaluate the status of Atlantic horse mackerel stock in GSAs 17-20.

6.9.3 REFERENCE POINTS

Reference points are not available.

6.9.4 SHORT TERM FORECASTS AND CATCH OPTIONS

No short term forecasts are possible.

6.9.5 DATA DEFICIENCIES

The STECF EWG 17-17 was not possible to apply any assessment methodology to assess the status of horse mackerel in the joint areas of GSA 17-18-19-20 for the following reasons.

Large gaps and inconsistencies were detected in the Greek, Italian and Croatian catch data.

Landings

There were gaps in the landings data for GSA 17, for the years 2008 – 2010. An attempt to fill the missing data from the landings data submitted through the Fleet-Economic Performance data call, failed due to the inconsistencies between these two datasets. In particular the values in the economic landings data were two-fold than the ones in the landings coming from the Mediterranean Data Call submissions, due to unreported data for midwater trawl. Furthermore, there were misreported landings in the economic data for the years 2014 and 2016. For GSA 20 the only years that appeared in the Mediterranean Data Call submissions were 2013, 2014 and 2016 with the amount of landings being at least 10 times less than what was reported in the other GSA areas. Also values submitted for year 2013, referred only to the 4th quarter of the year. As a result, working on the maximum value among the three years, does not allow for making any reasonable assumption on the data.

Discards

The same gaps observed in the landings data were also apparent in the discards data, making any attempt for reconstructing missing years an impossible task. An additional problem in identifying trends in discards data was the fact that *Trachurus trachurus* and *Trachurus mediterraneus*, are often being misidentified and mixed up in the reported discards due to similarities between species, especially in smaller specimens.

Effort

Effort data seemed the only consistent data, excluding GSA 20 where numerous gaps were observed between the years 2007 and 2012.

Survey Data:
Due to absence of Greek MEDITS experimental survey data prior to 2014 the EWG decided to send an urgent request to the member state national correspondent to upload all MEDITS data. The request was served within 4 days.

After merging all GSA data, it was discovered that the full dataset (GSA 17-18-19-20) suffered of great inconsistencies and is of low quality for conducting a proper assessment. MEDITS survey is conducted in GSA 17, 18, 19 since 1994 but no corresponding information on landings exists prior to 2002. As for the GSA20 the existence of the same gaps reported in landings/discards data left us with no other alternative than considering the data as misreported and inconsistent.

6.10 STOCK ASSESSMENT ON ANCHOVY IN GSAs 22 & 23

Stock Identity and Biology

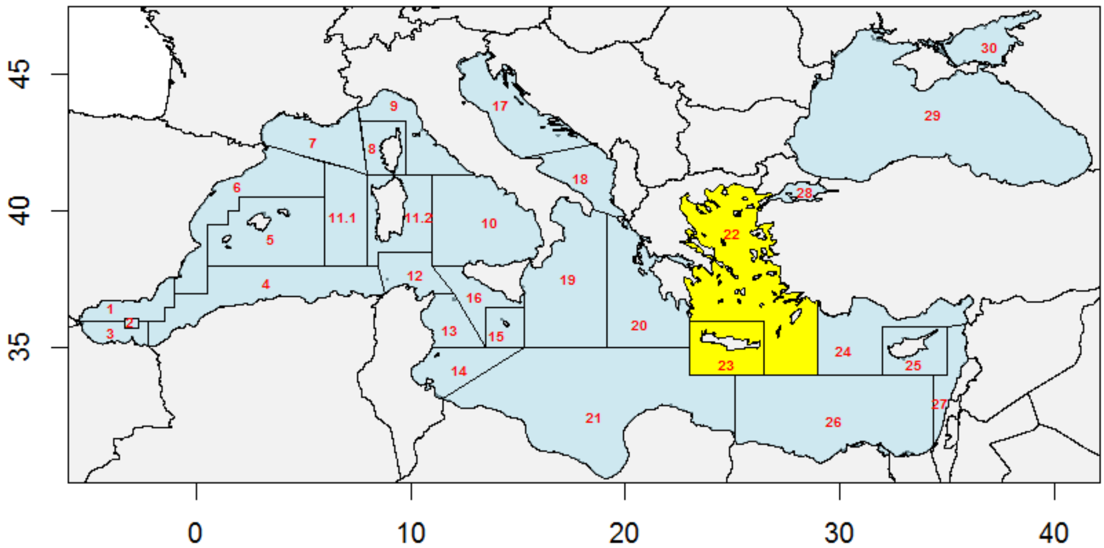


Figure 6.10.1 Geographical location of GSAs 22 & 23

6.10.1 DATA

Analysis of the DCF data provided in the STECF EWG 1907 is presented below.

6.10.1.1 Catch (landings and discards)

Figure 6.10.1.1.1. European anchovy in GSAs 22 & 23. Anchovy DCF landings by the Greek fleet in GSA 22 (left) and GSA 23 (right) by gears. Years 2007 and 2009-2012 are missing, while data from 2013 and 2015 come only from the fourth quarter. Note that scales for GSA 22 and 23 are different.

Table 6.10.1.1.1. European anchovy in GSAs 22 & 23. Anchovy DCF landings in tonnes by the Greek fleet in GSA 22 and GSA 23 from different gears. Years 2007 and 2009-2012 are missing, while data from 2013 and 2015 (*) came only from the fourth quarter.

Year	Area	Gear	Landings	Total landings
2003	SA 22	PS	14056.18	14056.18
2004	SA 22	PS	15613.44	15613.44
	SA 22	NA	30.82399	
2005	SA 22	OTB	3.016	16130.41
	SA 22	PS	16096.57	
	SA 22	NA	371.535	
2006	SA 22	OTB	17.395	23871.75
	SA 22	PS	23482.82	
2008	SA 22	PS	24979.12	24979.12
2013*	SA 22	OTB	7.5	791.9833
	SA 22	PS	784.4833	
	SA 22	GNS	26.66893	
2014	SA 22	OTB	418.6608	7001.343
	SA 22	PS	6556.013	
2015*	SA 22	PS	3046.864	3046.864
	SA 22	GNS	29.6	
2016	SA 22	GTR	0.01	12509.79
	SA 22	PS	12480.18	

2014	SA 23	PS	1.25227	1.25227
2015	SA 23	PS	7.474	7.474
2016	SA 23	PS	10.32	10.32

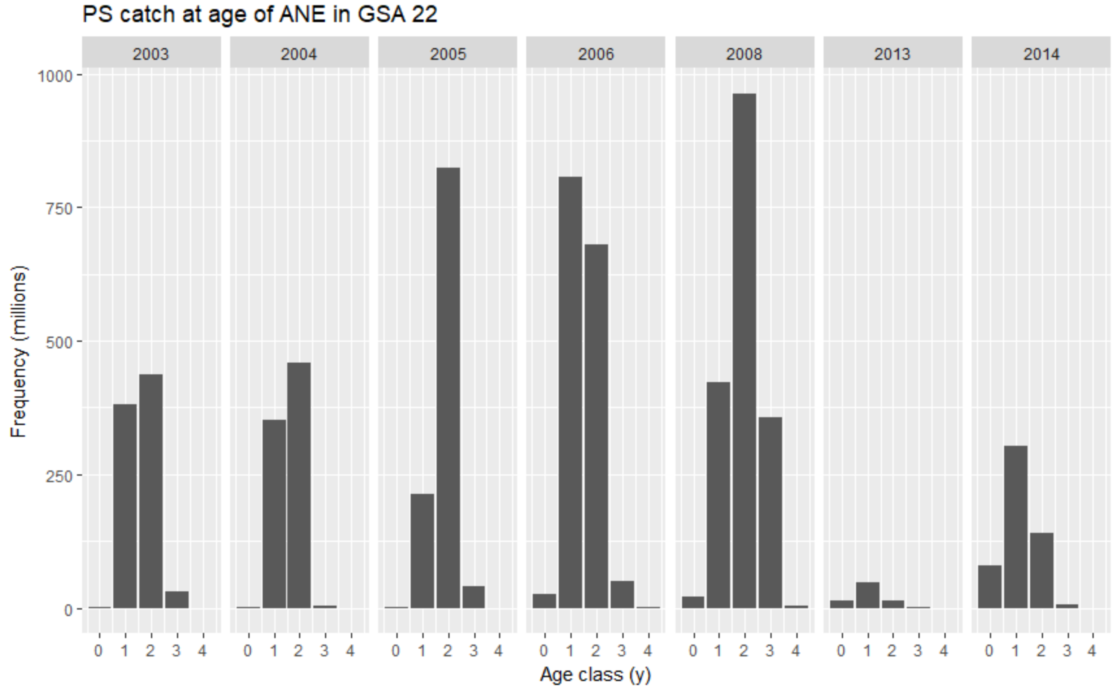


Figure 6.10.1.1.2. European anchovy in GSAs 22 & 23. Anchovy landings at age by the Greek fleet in GSA 22 from different gears. Years 2007, 2009-2012 and 2015-2016 are missing, while data from 2013 came only from the fourth quarter.

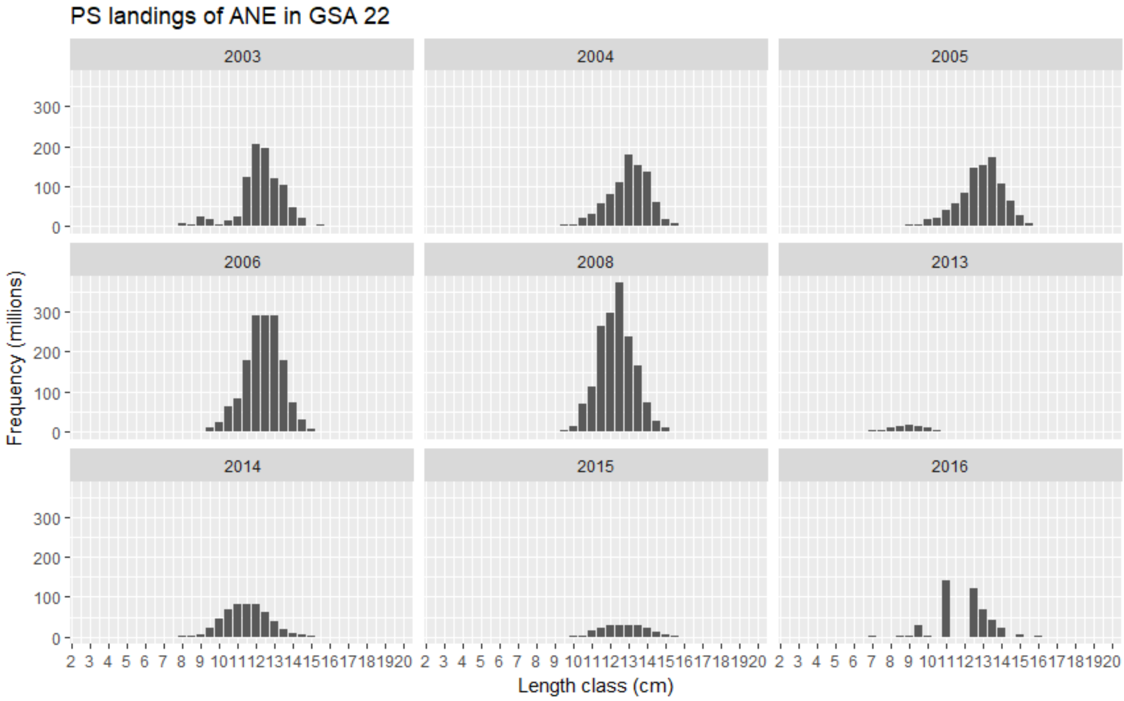


Figure 6.10.1.1.3. European anchovy in GSAs 22 & 23. Anchovy length frequency distribution of landings by the Greek fleet in GSA 22 from PS. Years

2007 and 2009-2012 are missing, while data from 2013 and 2015 came only from the fourth quarter.

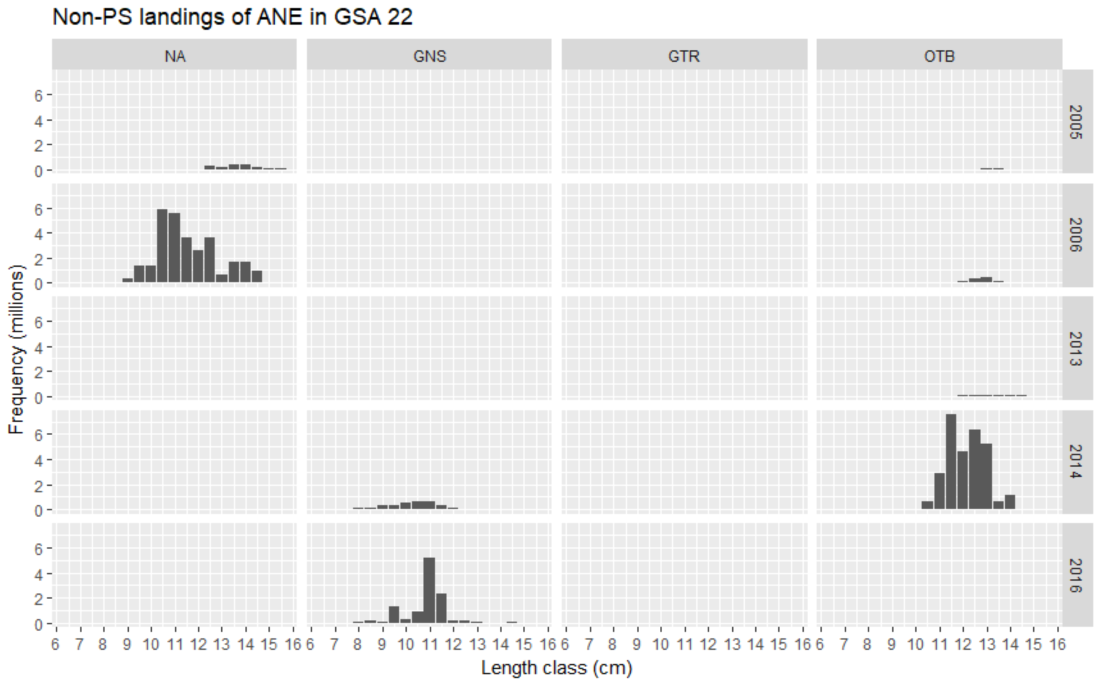


Figure 6.10.1.1.4. European anchovy in GSAs 22 & 23. Anchovy length frequency distribution of DCF landings by the Greek fleet in GSA 22 from gears other than PS. Years 2007 and 2009-2012 are missing, while data from 2013 and 2015 came only from the fourth quarter.

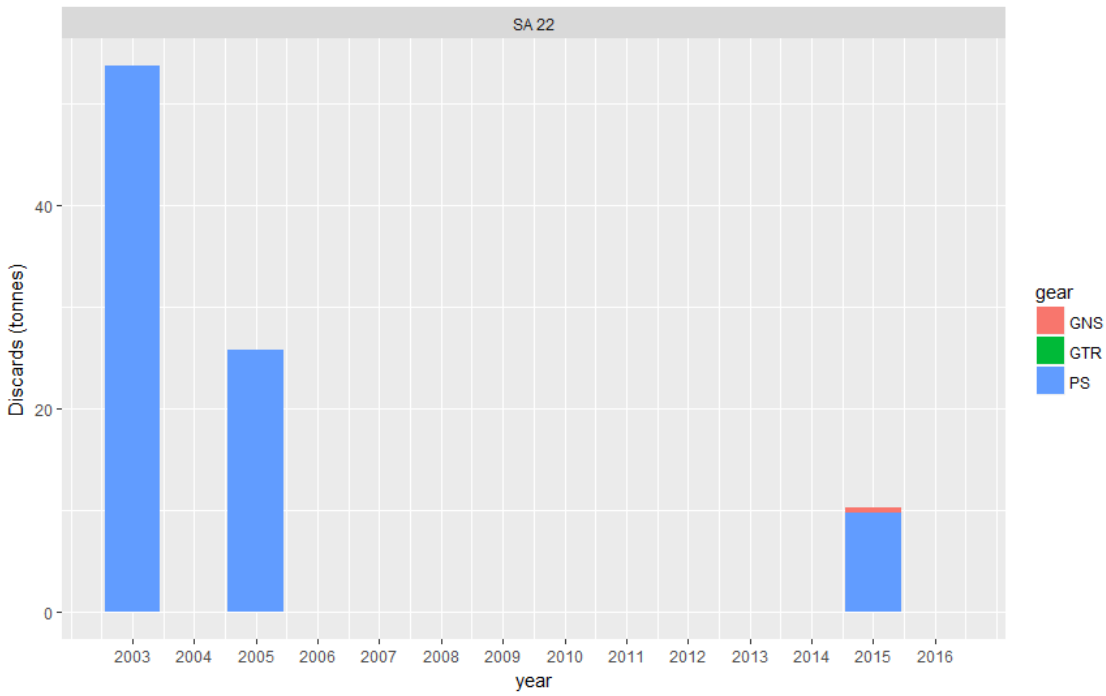


Figure 6.10.1.1.5. European anchovy in GSAs 22 & 23. Anchovy discards by the Greek fleet in GSA 22.

Table 6.10.1.1.2. European anchovy in GSAs 22 & 23. Anchovy discards in tonnes by the Greek fleet in GSA 22 as reported by the DCF.

Year	Area	Gear	Discards	Total Discards
2003	SA 22	PS	53.61721	53.61721
2005	SA 22	PS	25.79578	25.79578
2013	SA 22	PS	0.07846	0.07846
2015	SA 22	GNS	0.467	10.24827
		PS	9.78127	
2016	SA 22	GTR	0.029	0.029

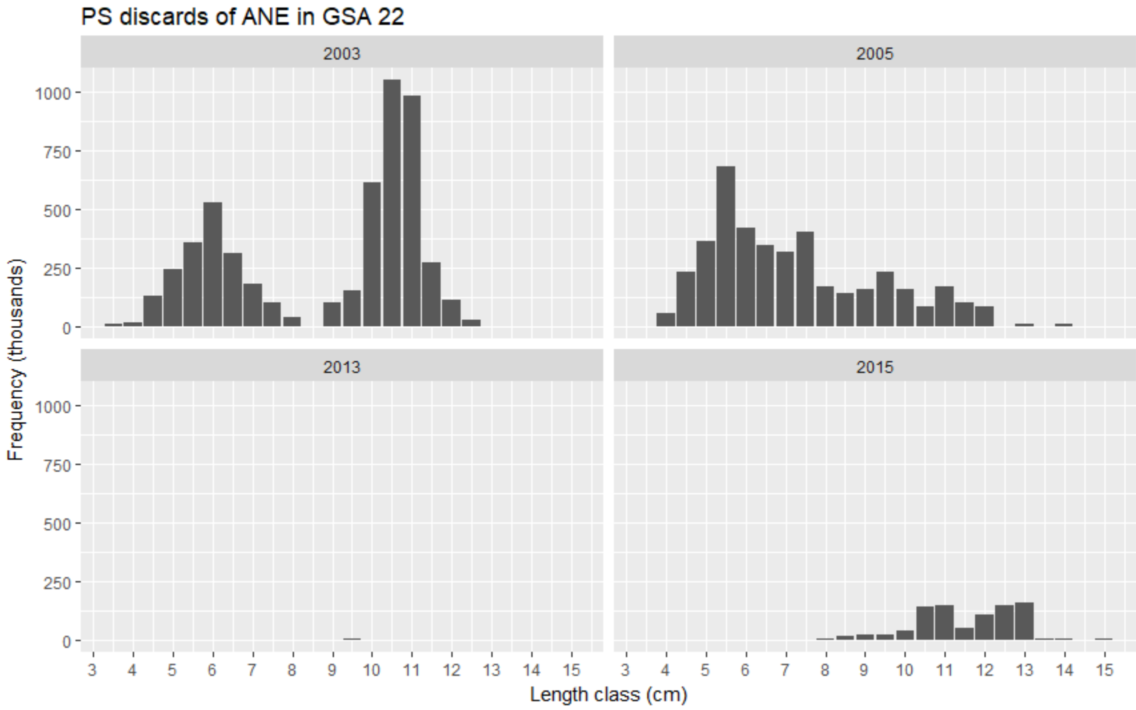


Figure 6.10.1.1.6. European anchovy in GSAs 22 & 23. Anchovy discards length frequency distribution by the Greek fleet in GSA 22 from PS.

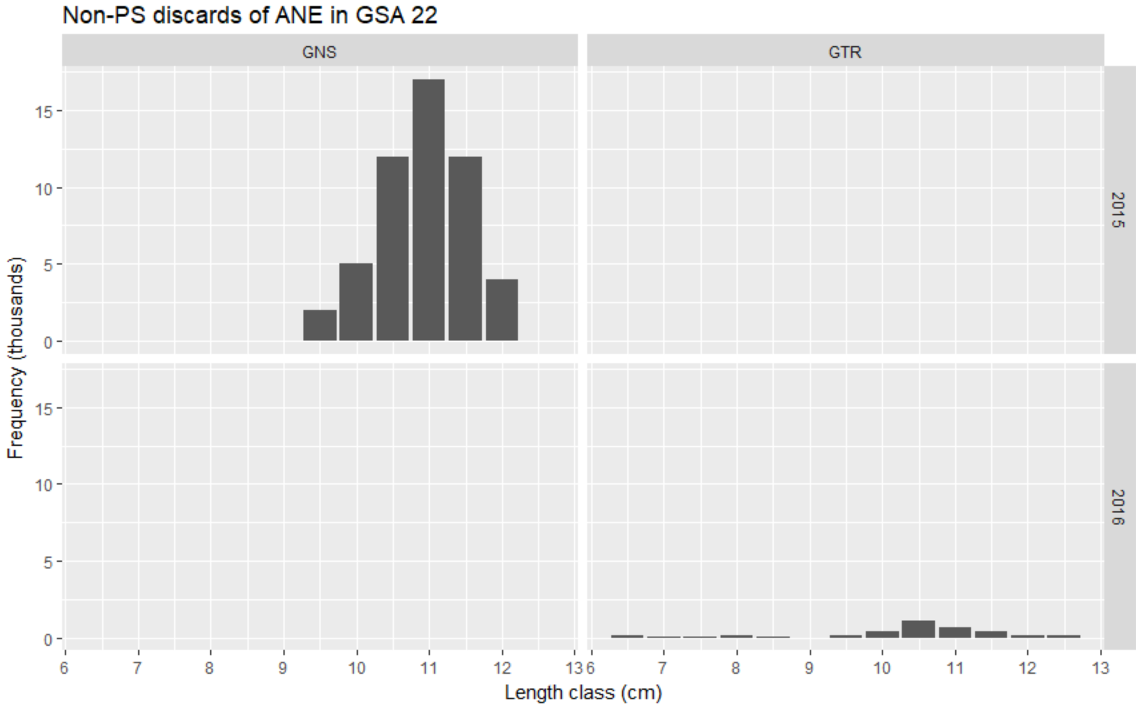


Figure 6.10.1.1.7. European anchovy in GSAs 22 & 23. Anchovy DCF discards length frequency distribution by the Greek fleet in GSA 22 from gears other than PS.

6.10.1.2 EFFORT

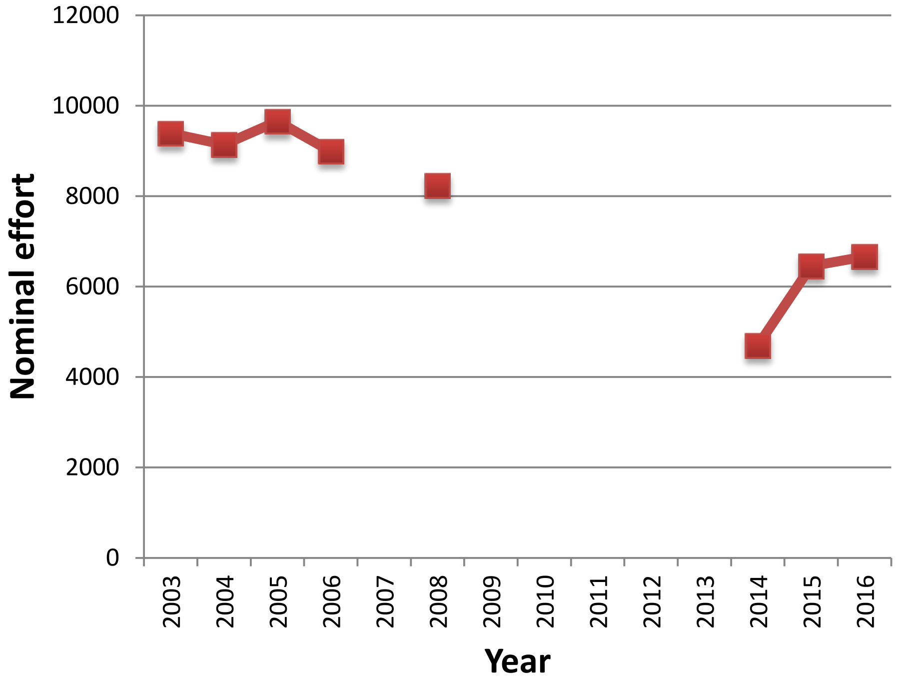


Figure 6.10.1.2.1 European anchovy in GSAs 22 & 23. Nominal effort (days at sea) of purse seines in GSA 22 as reported by DCF.

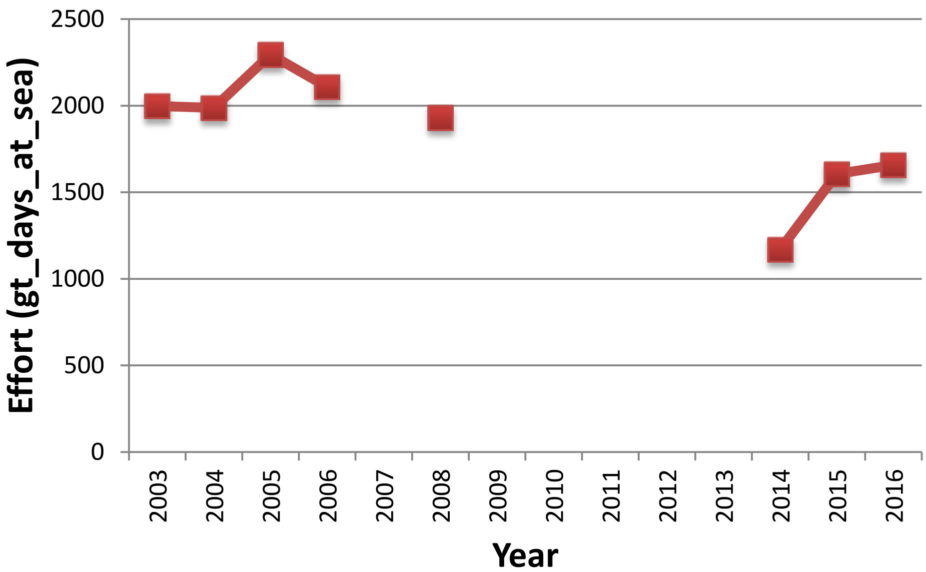


Figure 6.10.1.2.2 European anchovy in GSAs 22 & 23. Effort (gt * days at sea) of purse seines in GSA 22 as reported by DCF.

6.10.1.3 SURVEY DATA

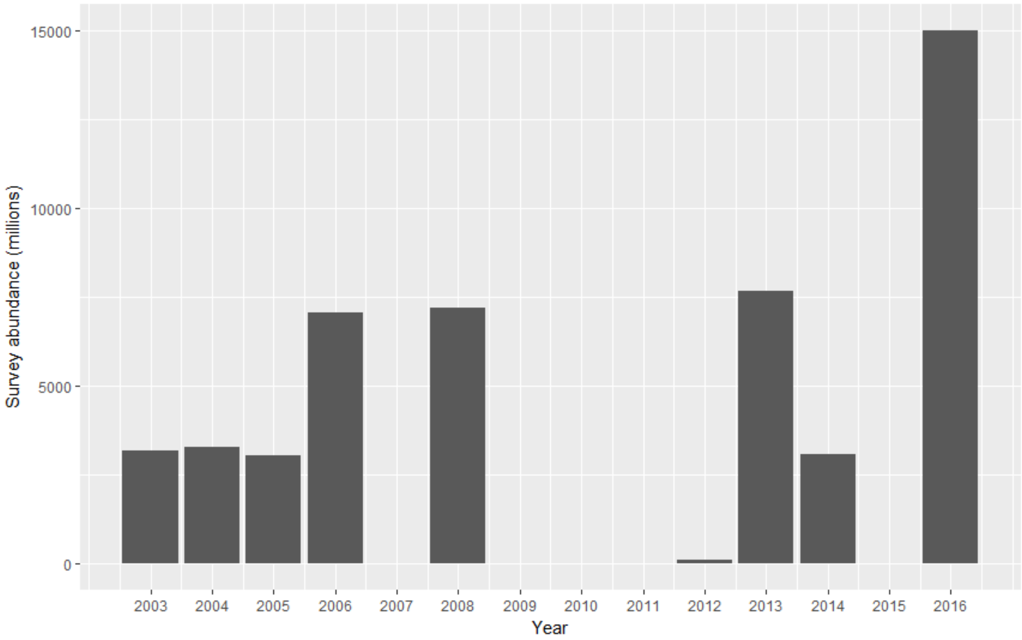


Figure 6.10.1.3.1. European anchovy in GSAs 22 & 23. Acoustic survey abundance index of anchovy in GSA 22 as reported by DCF. No survey was carried out in 2007, 2009-2011 and 2015. The survey was carried out in June/July except for 2012 when it was carried out in December and 2013 when it was carried out in September.

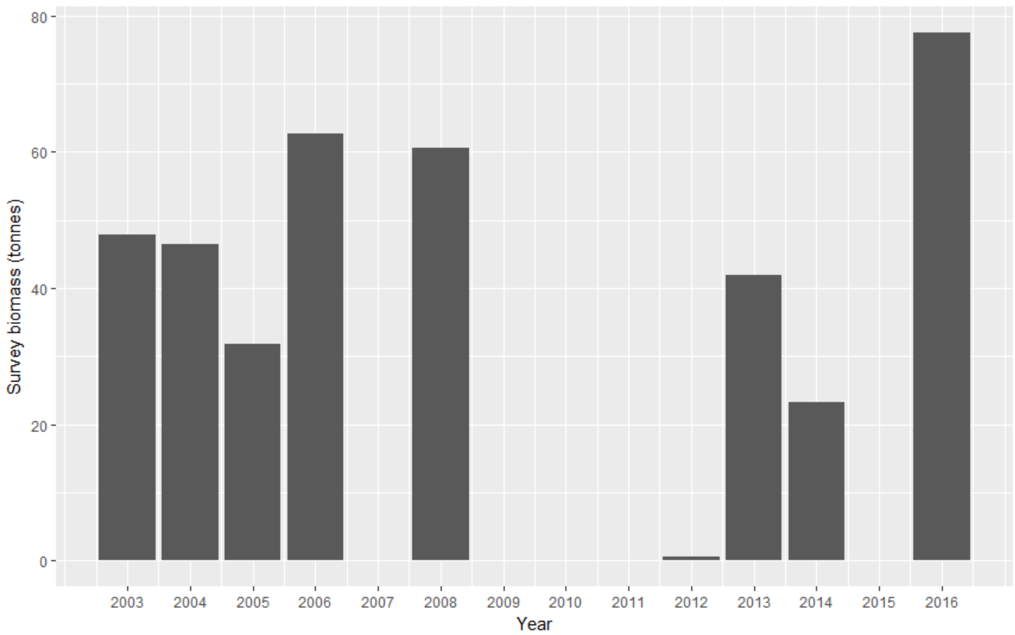


Figure 6.10.1.3.2. European anchovy in GSAs 22 & 23. Acoustic survey biomass index of anchovy in GSA 22 as reported by DCF. No survey was carried out in 2007, 2009-2011 and 2015. The survey was carried out in June/July except for 2012 when it was carried out in December and 2013 when it was carried out in September.

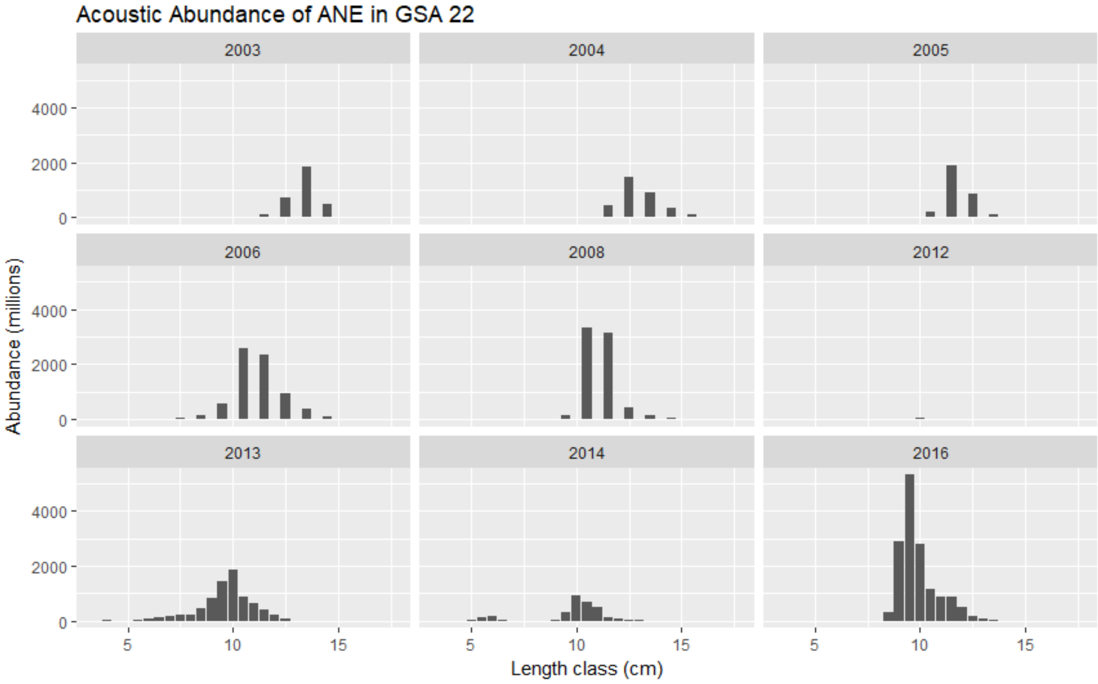


Figure 6.10.1.3.3. European anchovy in GSAs 22 & 23. Length frequency distribution of the acoustic survey abundance index of anchovy in GSA 22 as reported by DCF. No survey was carried out in 2007, 2009-2011 and 2015. The survey was carried out in June/July except from 2012 when it was carried out in December and 2013 when it was carried out in September.

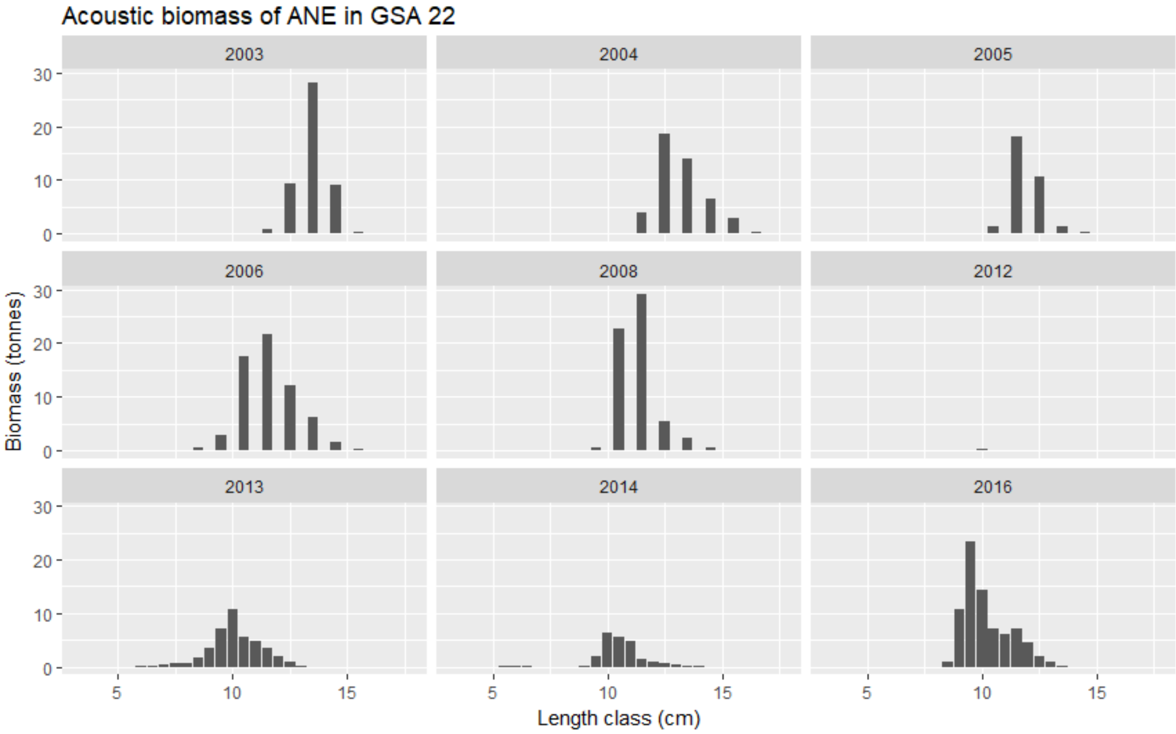


Figure 6.10.1.3.4. European anchovy in GSAs 22 & 23. Length frequency distribution of the acoustic survey biomass index of anchovy in GSA 22 as reported by DCF. No survey was carried out in 2007, 2009-2011 and 2015. The

survey was carried out in June/July except from 2012 when it was carried out in December and 2013 when it was carried out in September.

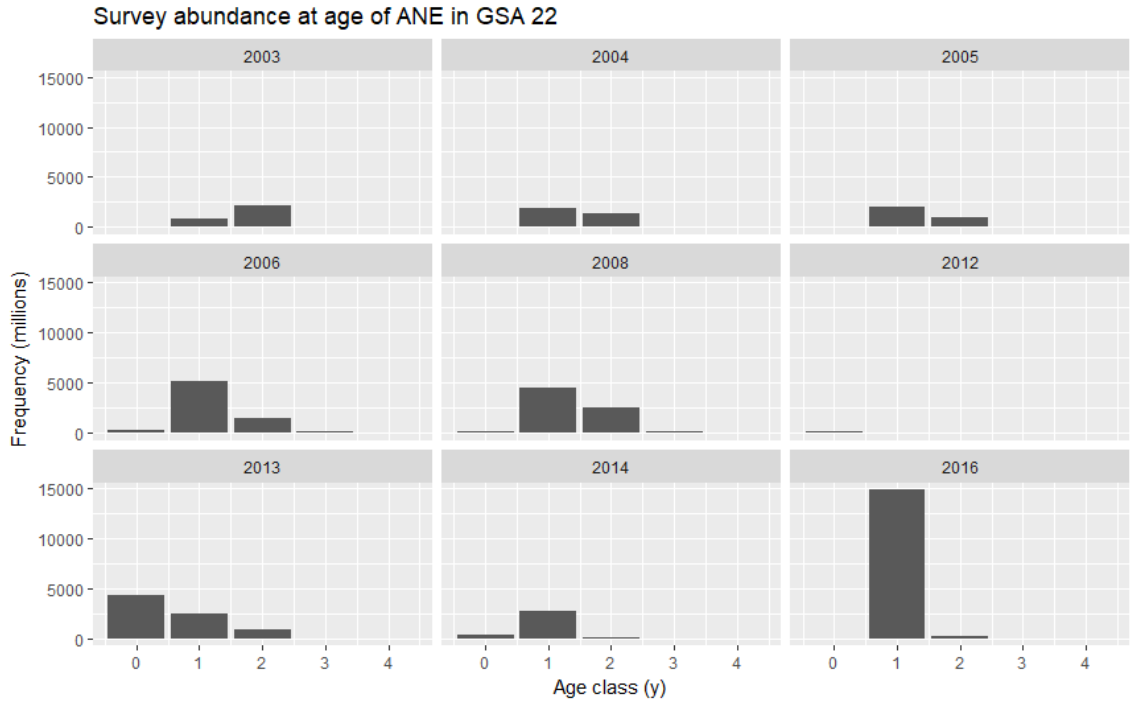


Figure 6.10.1.3.5. European anchovy in GSAs 22 & 23. Age frequency distribution of the acoustic survey abundance index of anchovy in GSA 22 as reported by DCF. No survey was carried out in 2007, 2009-2011 and 2015. The survey was carried out in June/July except from 2012 when it was carried out in December and 2013 when it was carried out in September.

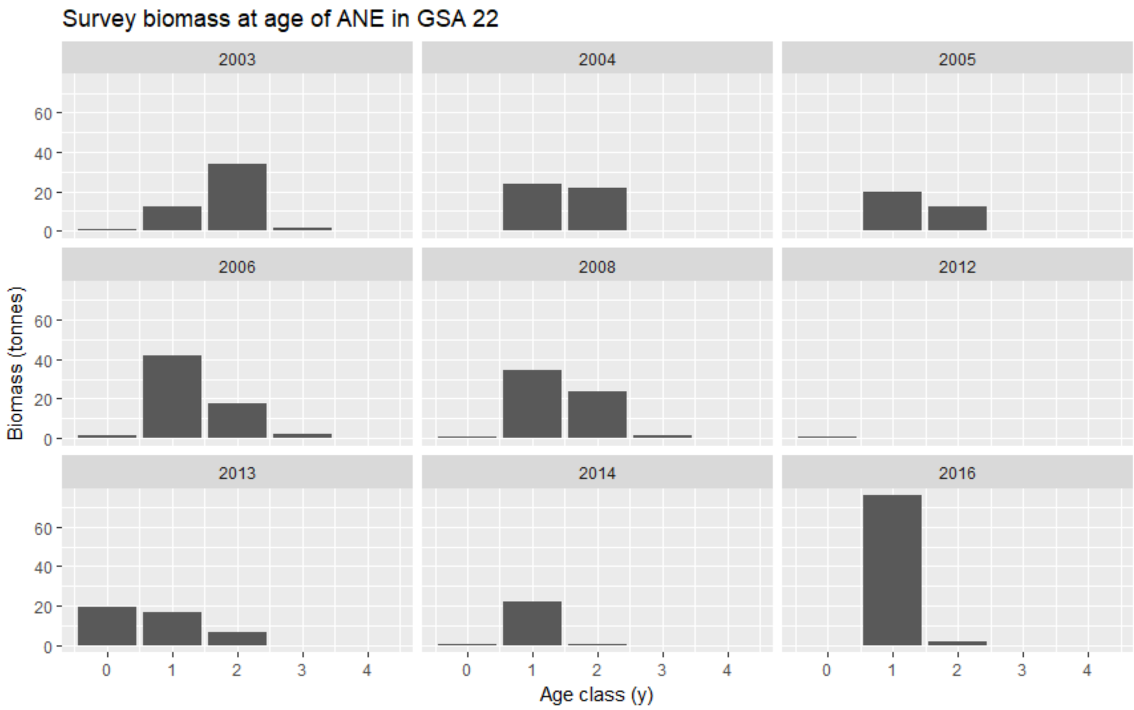


Figure 6.10.1.3.6. European anchovy in GSAs 22 & 23. Age frequency distribution of the acoustic biomass index of anchovy in GSA 22 as reported by DCF. No survey was carried out in 2007, 2009-2011 and 2015. The survey was

carried out in June/July except from 2012 when it was carried out in December and 2013 when it was carried out in September.

6.10.2 STOCK ASSESSMENT

Age based methods : a4a and SAM

Two statistical catch-at-age analysis methods were used for this stock. Such methods utilize catch-at-age data to derive estimates of historical population size and fishing mortality. However, unlike VPA, model parameters estimated using catch-at-age analysis are done so by working forward in time and analyses do not require the assumption that removals from the fishery are known without error. Data typically used are: catch, , statistical sample of age composition of catch and abundance index. Specifically, for anchovy stock in GSA 22 we used a) the Assessment for All Initiative (a4a) (Jardim et al., 2015) and b) the State-space Assessment Model (SAM) (Nielsen et al., 2014) in FLR environment. Assessment was performed with version 1.0.2 of FLSAM and 1.1.2 of FLa4a, together with version 2.6.4 of the FLR library (FLCore).

A single tuning fleet was used in both methods based on the biomass at age estimates from summer acoustic surveys conducted in the Greek part of GSA 22 (2003 to 2016 with gaps in 2007, 2009-2013 and 2015) as reported in the DCF.

The analysis was carried out for the ages 0 to 3+ class for the SAM and ages 0 to 4 for the a4a. Concerning the Fbar, the age range used was 1-3 age groups for both methods.

The analysis was restricted to GSA 22, as reported landings from GSA 23 were negligible and the survey does not cover GSA 23.

Input data

Anchovy (*Engraulis encrasicolus*) is one of the most important target species for the purse seine fishery in GSA 22. Anchovy is being exploited only by the purse seine fishery. Pelagic trawls are banned and bottom trawls are allowed to fish small pelagics in percentages less than 5% of their total catch. Commonly anchovy is caught from shallow waters about 30 m to 100 m depth.

Growth

Natural mortality (M) was estimated using Gislason (2010) and is shown in Table 6.10.2.1. The input parameters used were Linf = 19.1 cm, k = 0.385, t0 =-1.559. The values of M vector were the used in the last approved assessment for anchovy in GSA 22 and compiled in the STECF EWG-11-20 (2012).

Table 6.10.2.1 European anchovy in GSAs 22. Natural mortality estimates per age for anchovy in GSA 22.

Age	Age0	Age1	Age2	Age3	Age4
M	1.55	0.89	0.72	0.66	0.55

Maturity

The following maturity at age ogive was used for assessments in GSA 22 estimated from biological sampling and the DEPM surveys (Somarakis et al., 2004; Somarakis et al., 2007). Length at first maturity is estimated approximately at 105mm (Somarakis et al., 2004; Somarakis et al., 2007) in Aegean Sea. The anchovy spawning period in GSA 22 extends from May to August with a peak in June-July.

Table 6.10.2.2 European anchovy in GSA 22. Proportion of mature fish by age.

Age 0	Age 1	Age 2	Age 3	Age 4
0.5	0.99	1	1	1

Catch Data

The time series of total PS landings for the Greek part of GSA 22 as estimated in the STECF EWG 16-14 (2016) was used for the period 2000-2014 (Figure 6.10.3.3.1). For 2013 and 2015 the DCF reported landings referred only to the last trimester thus the HELSTAT officially reported landings to FAO GFCM were used. The DCF reported landings were used for 2016. Based on the DCF reported discards as well as on Tsagarakis et al., (2014) discards were considered very low and were added as a 2% percentage in the landings reported data. Thus for the assessment catch was considered equal to reported landings and discards no further additions were made.. The total catch data used for assessment are reported Table 6.10.2.3.

PS catch at age data for the period 2000-2008 were those reported and used in the last approved assessment for anchovy in GSA 22 and compiled in the STECF EWG-11-20 (2012). No DCF data collection was carried out in 2007, 2009-2012. DCF covered only the fourth quarter in 2013 and 2015. Thus for the a4a method, NA (non available) was used for the catch at age data in the years that no DCF was carried out. As, the SAM model does not allow gaps in the catch at age information, for the years that no DCF was carried out the catch at age was estimated based on the length frequency available in the years before and after the non reported period (e.g. LF for 2009 and 2010 similar to 2008, LF for 2012 similar to the one in 2013 and 2014). Age structure of the catch data used for assessment is the DCF reported data taking into account the Hellenic Centre for Marine Research age readings (Figure 6.10.2.1).

Table 6.10.2.3 European anchovy in GSA 22. Observed catch data in tonnes used as input for the a4a and SAM assessment.

Year	Catches	Year	Catches
2000	9776	2009	20746

2001	8581	2010	15139
2002	8579	2011	10451
2003	14013	2012	10548
2004	16114	2013	10437
2005	16376	2014	14386
2006	22355	2015	13058
2007	21558	2016	12736
2008	24565		

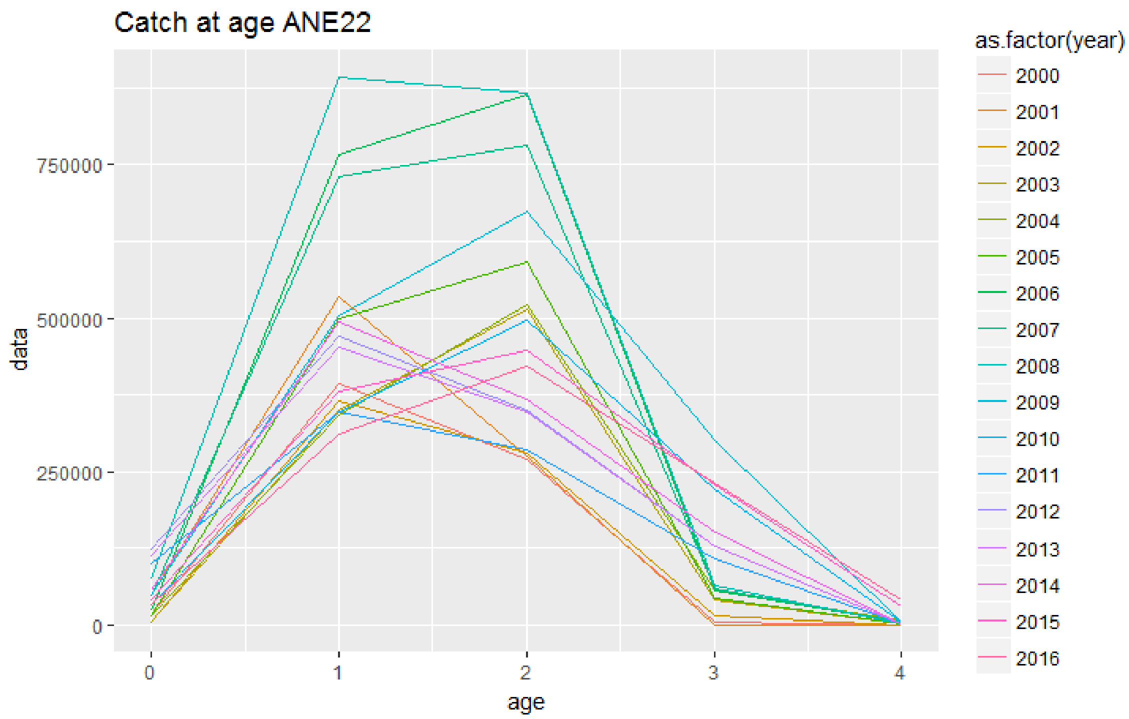


Figure 6.10.2.1 European anchovy in GSA 22. Age structure of the catch data used in the a4a and SAM assessments. Note that for the a4a NAs were used for years 2007, 2009-2012.

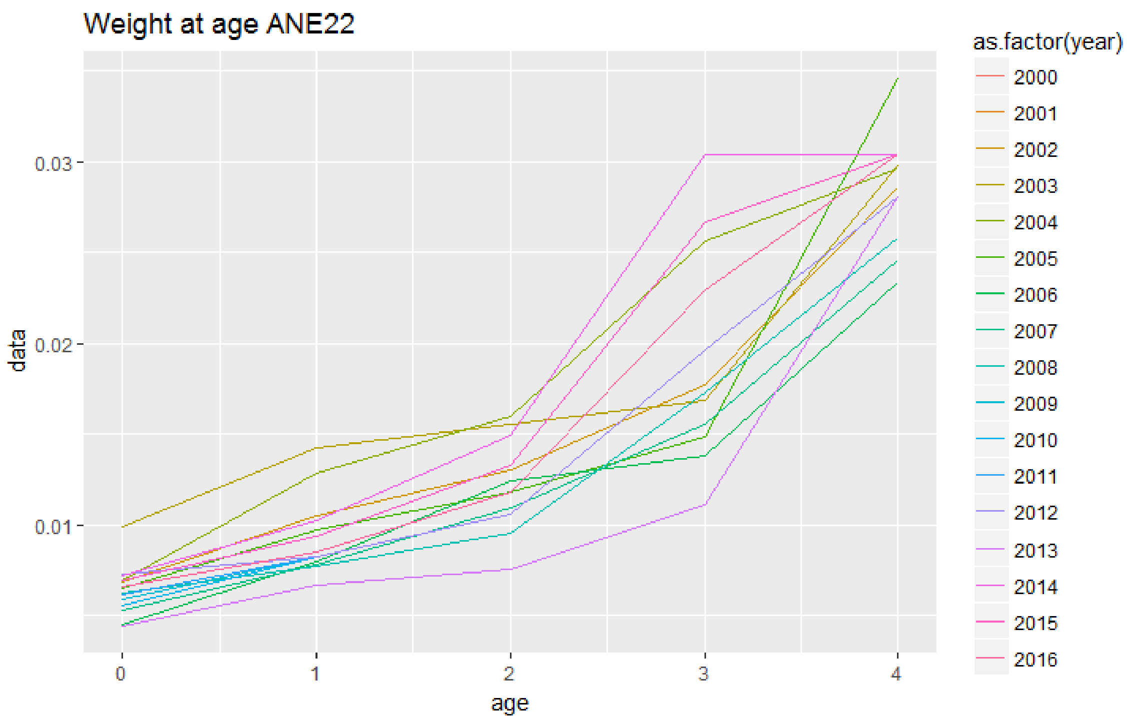


Figure 6.10.2.2. European anchovy in GSA 22. Weight at age in the stock.

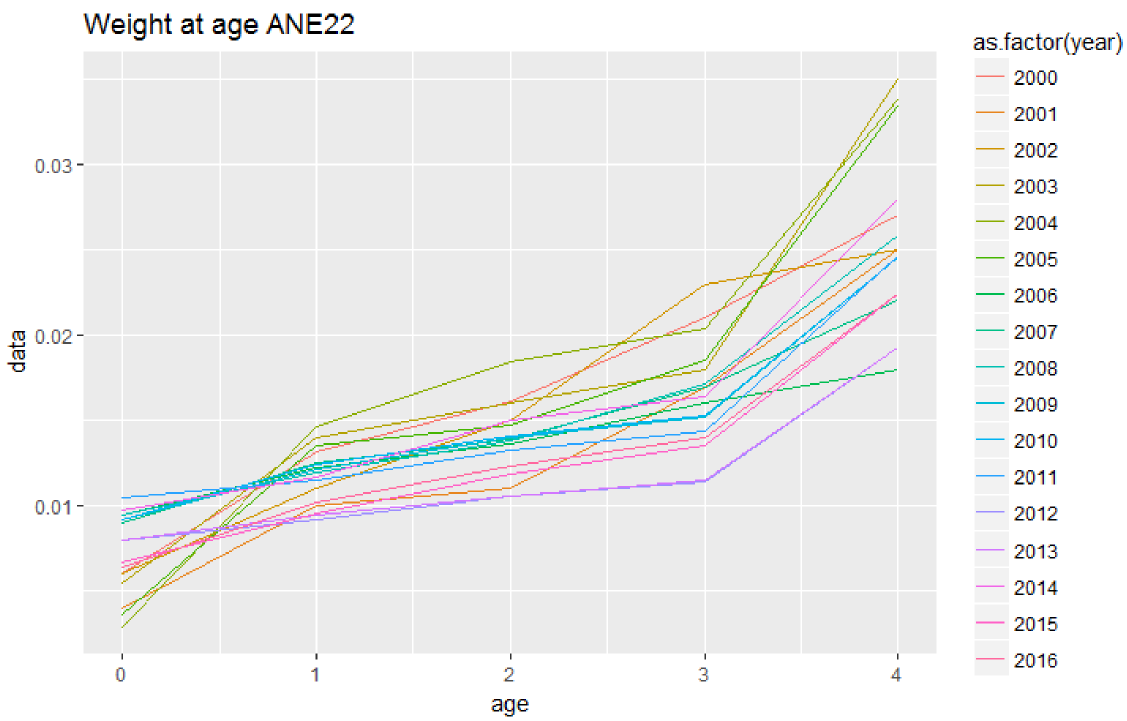


Figure 6.10.2.3. European anchovy in GSA 22. Weight at age in the catch.

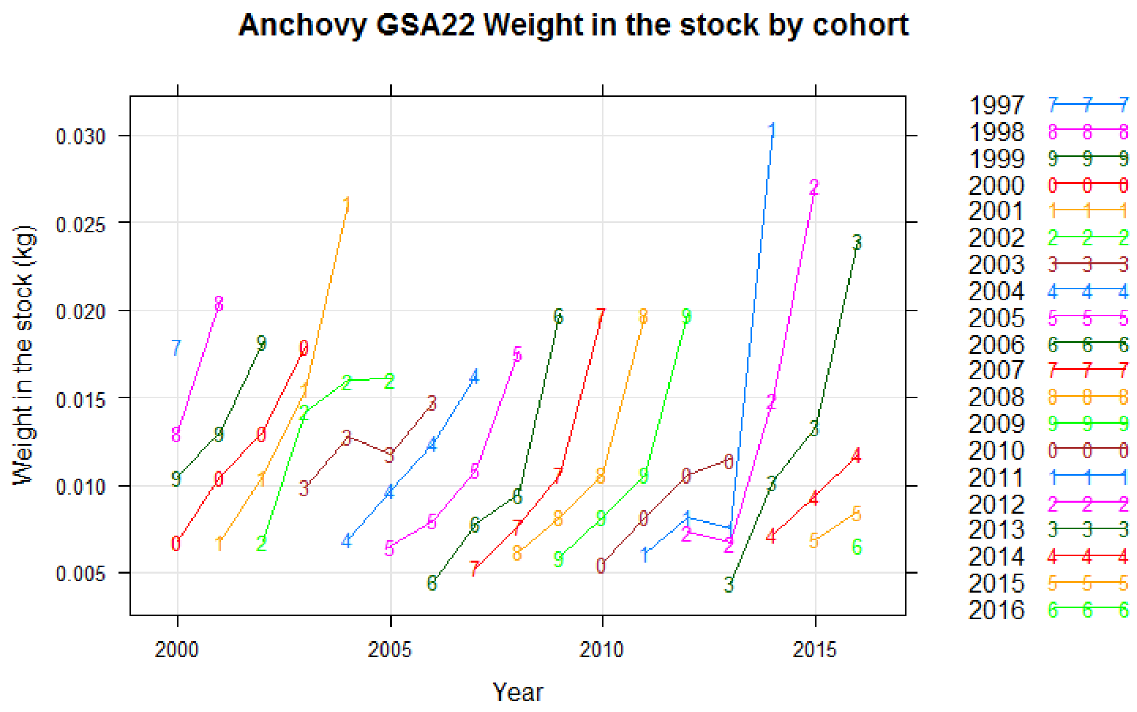


Figure 6.10.2.4 European anchovy in GSA 22. Weight at age in the stock by cohort.

Discards

Discards data were reported to STECF EWG 17-09 through the DCF. Age structure of the discards is missing for all the years and gears. Discards although considered negligible they were taken into account for the assessment as a 2% percentage to reported landings. The fishery is multispecies and fishermen tend to avoid schools of undersized anchovies due to sorting difficulties (blocking of the mess) and low price, practically by using nets of bigger mesh size, targeting mostly mackerels or horse mackerels.

Survey Indices of abundance and biomass by year and size/age

Acoustic surveys

We used reported data to STECF EWG 17-09 through the DCF concerning the evaluations of the acoustic surveys for 2003 to 2016 of total biomass, abundance, length and age composition for anchovy in GSA 22.

Acoustic surveys methodology

Acoustic echoes were registered continuously along 70 pre-defined transects in the study area in June 2003, 2004, 2005, 2006 and 2008, 2014 with a Biosonics Split Beam 38 kHz DT-X echosounder. The survey in 2016 was carried out with a Simrad Split Beam EK80 at 38 kHz. No acoustic survey took place in 2007, 2009-2011 and 2015. Survey in 2012 was held in December covering a very small part of the monitored area and the survey in 2013 was held in September. The acoustic survey in GSA 22 is part of the Mediterranean Acoustic Survey (MEDIAS) since 2008 and follows the MEDIAS protocol. Echo trace classification was applied based on a) echogram visual scrutinisation and direct allocation of school marks that characterise anchovy as well as b) allocation on account of representative fishing stations that were held along transects (Simmonds and MacLennan, 2005).

Trends in abundance and biomass

Abundance and biomass indexes were reported to STECF EWG 17-09 through DCF. European Anchovy time series of abundance and biomass indices from acoustic surveys in GSA 22 are shown and described in the following figure.

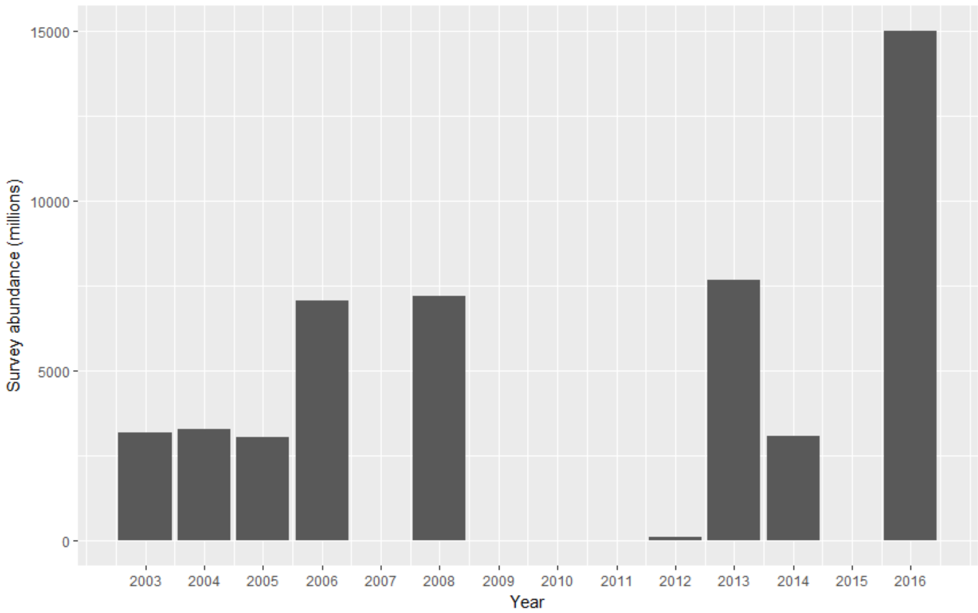


Figure 6.10.2.5 European anchovy in GSA 22. Acoustic survey abundance index of anchovy in GSA 22 as reported by DCF and used for assessment. No survey was carried out in 2007, 2009-2011 and 2015. The survey was carried out in June/July except from 2012 when it was carried out in December and 2013 when it was carried out in September.

Trends in abundance and biomass by length or age

Abundance and biomass indexes were reported to STECF EWG 17-09 through DCF. European Anchovy time series of abundance and biomass indices from acoustic surveys in GSA 22 are shown and described in the following figure.

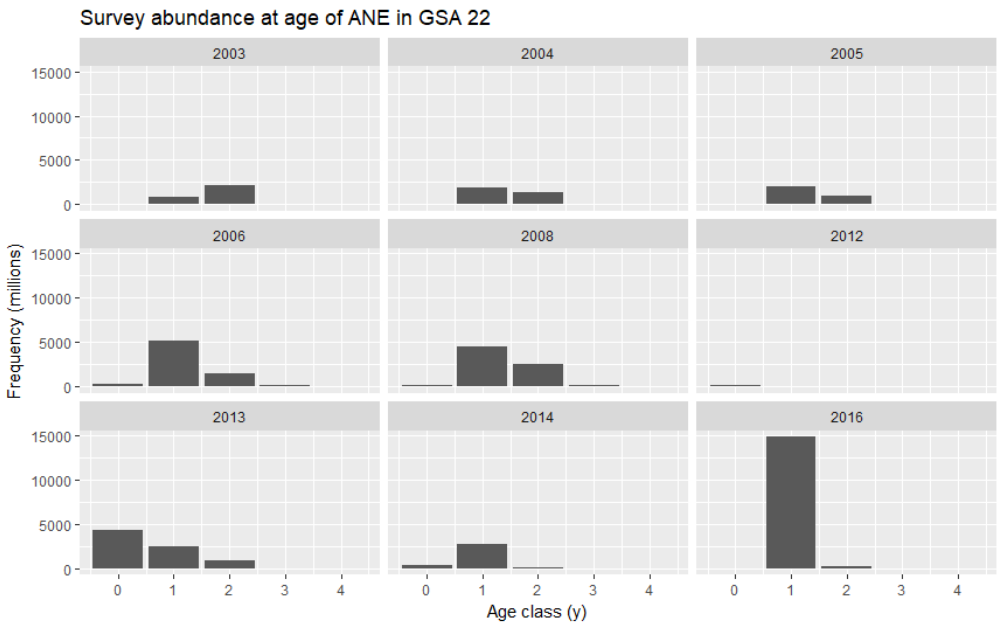


Figure 6.10.2.6 European anchovy in GSA 22. Age frequency distribution of the acoustic survey abundance index of anchovy in GSA 22 as reported by DCF and used for assessment. No survey was carried out in 2007, 2009-2011 and 2015. The survey was carried out in June/July except from 2012 when it was carried out in December and 2013 when it was carried out in September.

Assessment results

Method a4a

Different a4a models were performed (combination of different f, q). The best model (according to a combination of AIC, BIC and residuals) included:

f~s(replace(age, age>2,2), k=2)+s(year, k=4)+s(year, k = 4, by = as.numeric(age==0))

q~factor(age)

sr~geomean(CV=0.5)

Results are shown in Figures 6.10.2.7-6.10.2.14

Based on the a4a results, the anchovy SSB fluctuated over the time period examined (2000-2016) from 23333 tons (in 2000) to 74802 tons in 2016. A drop in SSB was observed in the years 2009 to 2013. This is generally in accordance with the SAM results that estimate SSB at 67546 tons in 2016. The assessment shows an increasing trend in the number of recruits between 2001 and 2007. The recruitment (age 0) reached a maximum of 26.5 million individuals in 2016 and a minimum value of 9.4 million individuals in 2000. Fbar (1-3) shows a decreasing trend since 2000, presenting an average around 1.092 for the period 2007 to 2013. Since 2013, F is decreasing with a value at 0.46 in 2016.

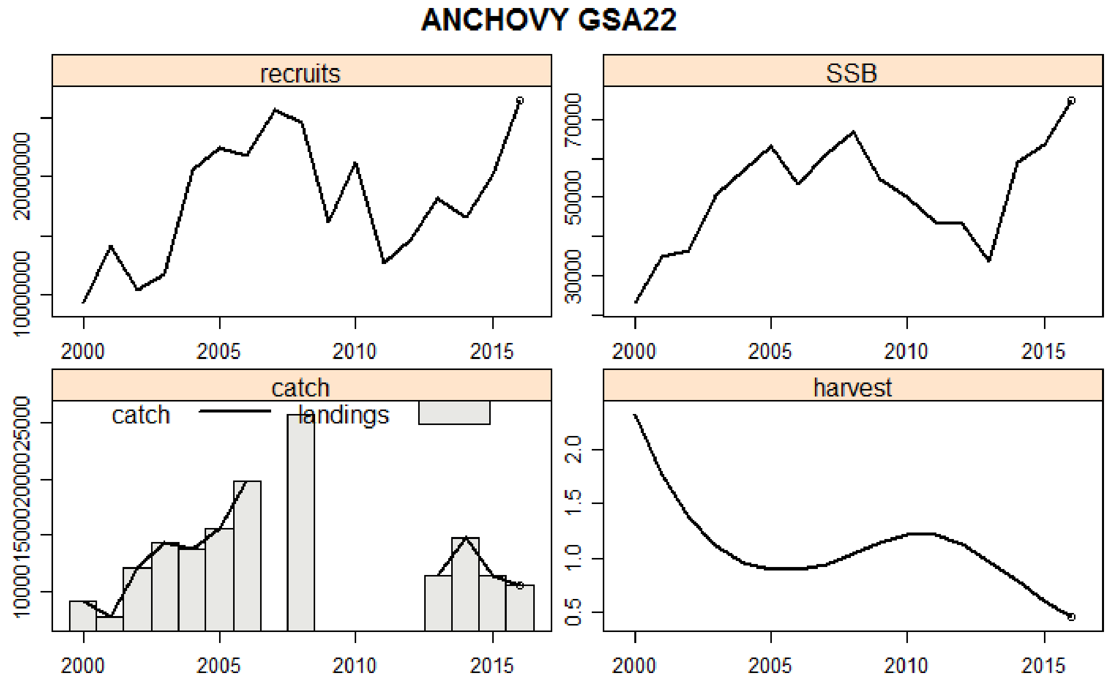


Figure 6.10.2.7 European anchovy in GSA 22. Stock summary from the a4a model for anchovy in GSA 22, recruits, SSB (Stock Spawning Biomass), catch (model output for catch and landings) and harvest (fishing mortality for ages 1 to 3).

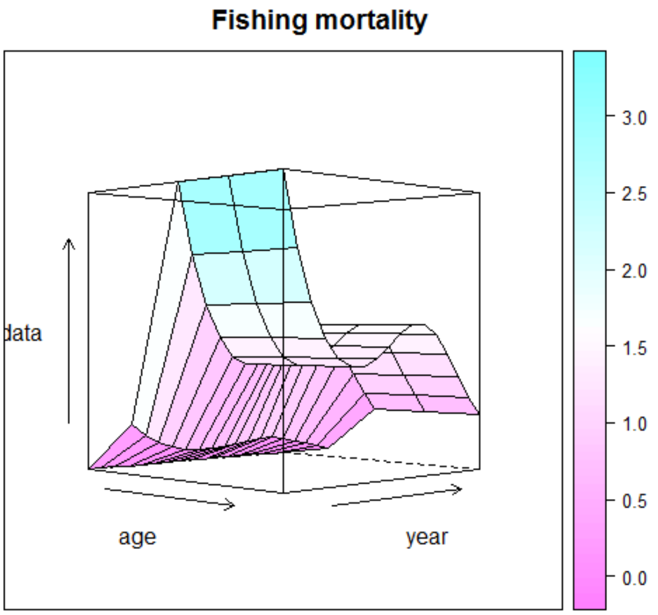


Figure 6.10.2.8 European anchovy in GSA 22. 3D contour plot of estimated fishing mortality at age and year

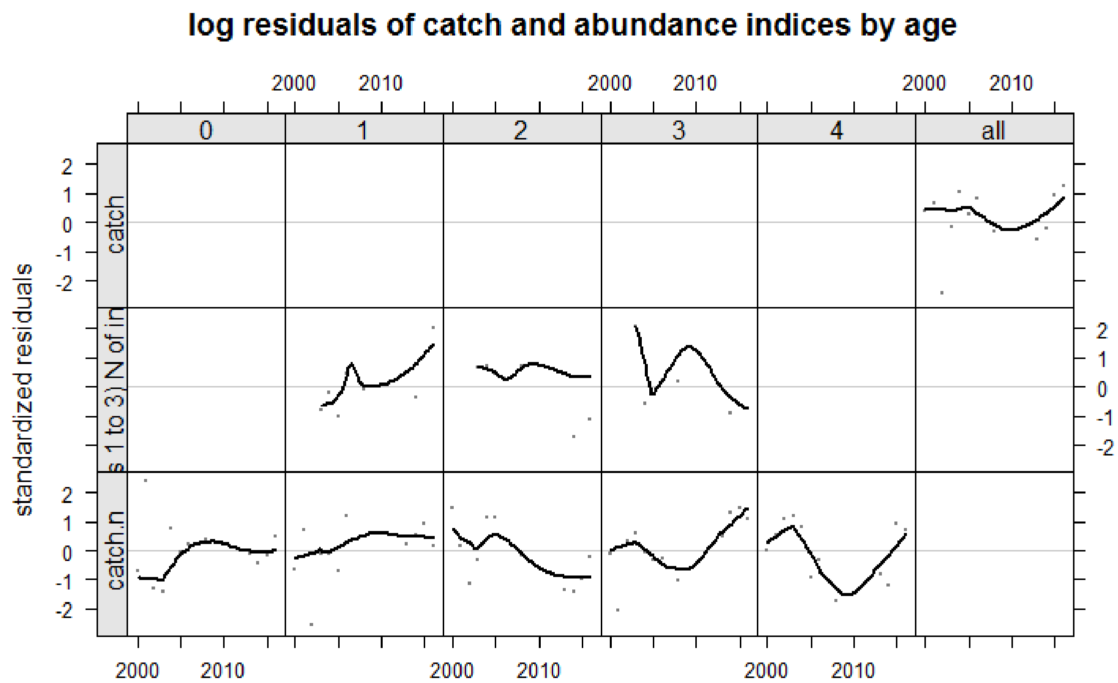


Figure 6.10.2.9 European anchovy in GSA 22. Standardized residuals for abundance indices (acoustic surveys) and for catch numbers (catch.n). Each panel is coded by age class, dots represent standardized residuals and lines a simple smoother.

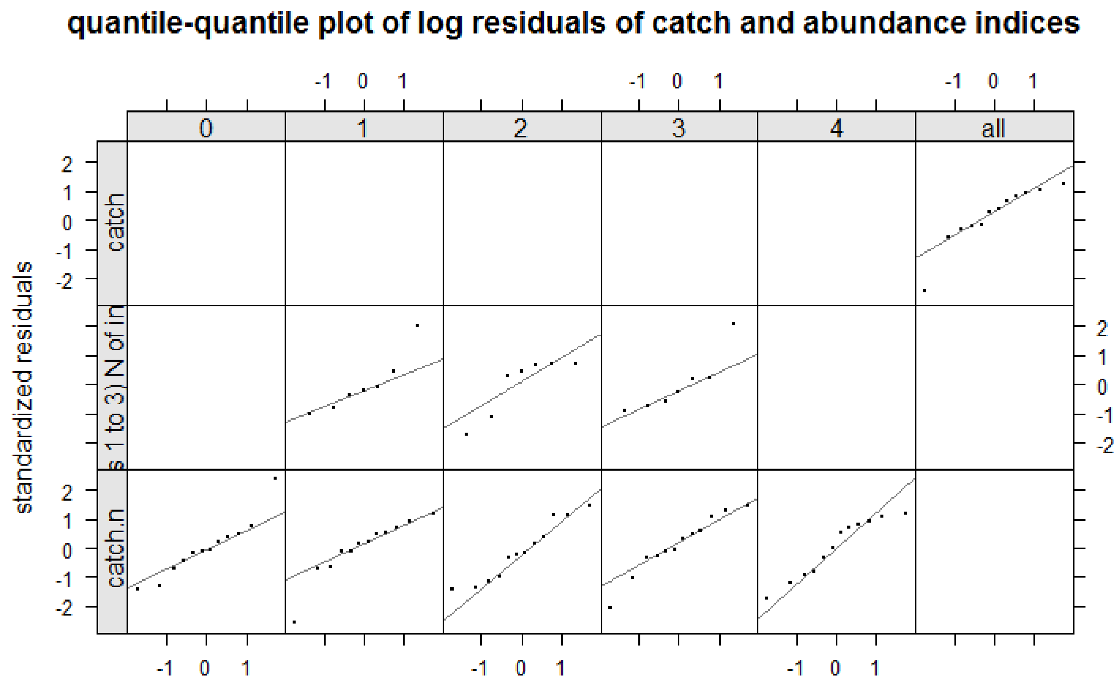


Figure 6.10.2.10 European anchovy in GSA 22. Quantile-quantile plot of standardized residuals for abundance indices (acoustic surveys) and for catch numbers (catch.n). Each panel is coded by age class, dots represent standardized residuals and lines the normal distribution quantiles.

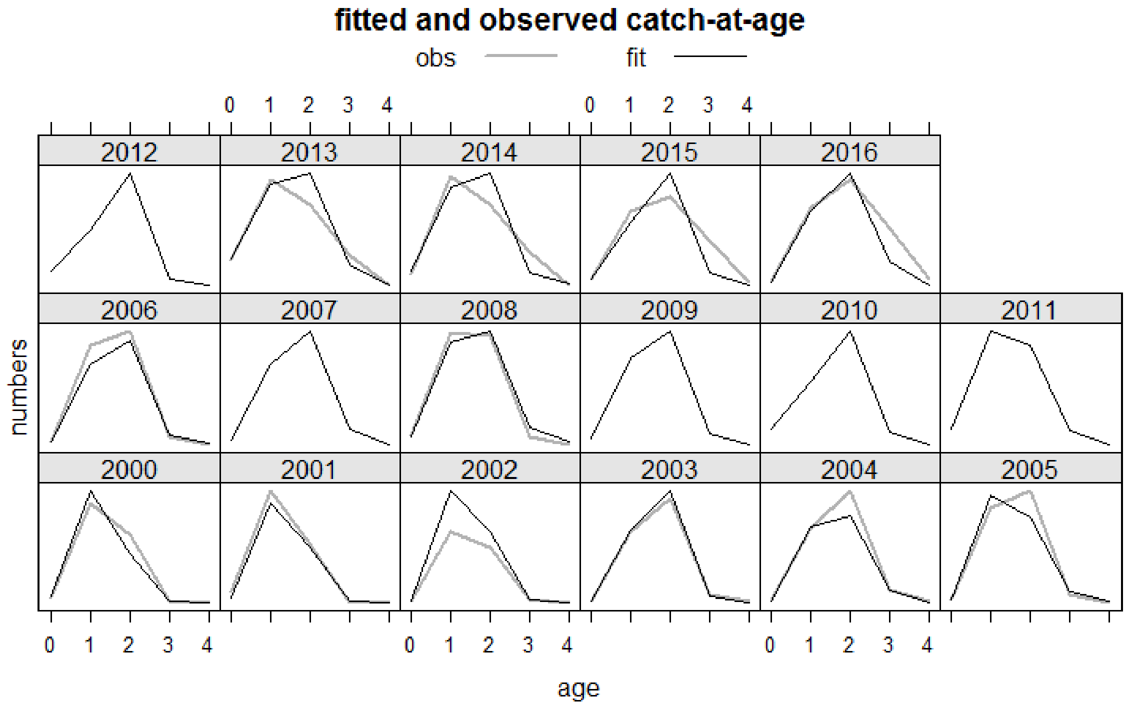


Figure 6.10.2.11 European anchovy in GSA 22. Fitted and observed catch at age

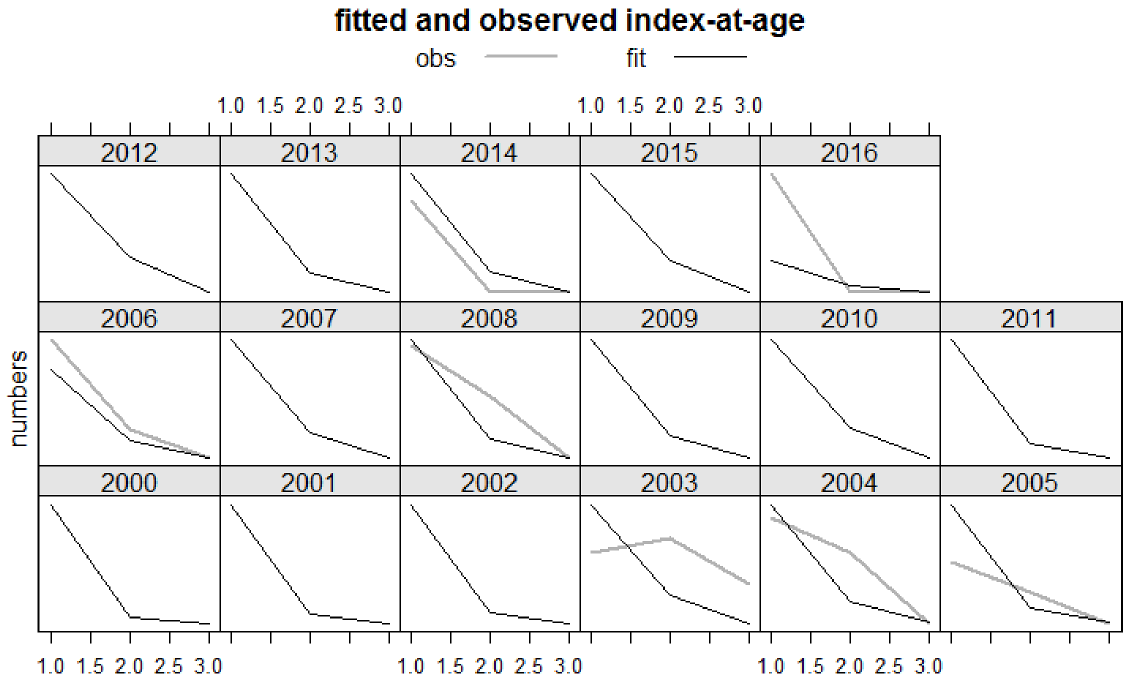


Figure 6.10.2.12 European anchovy in GSA 22. Fitted and observed index at age

Retrospective

The retrospective analysis was applied up to 3 years back. Models results were quite stable (Figure 6.10.2.13).

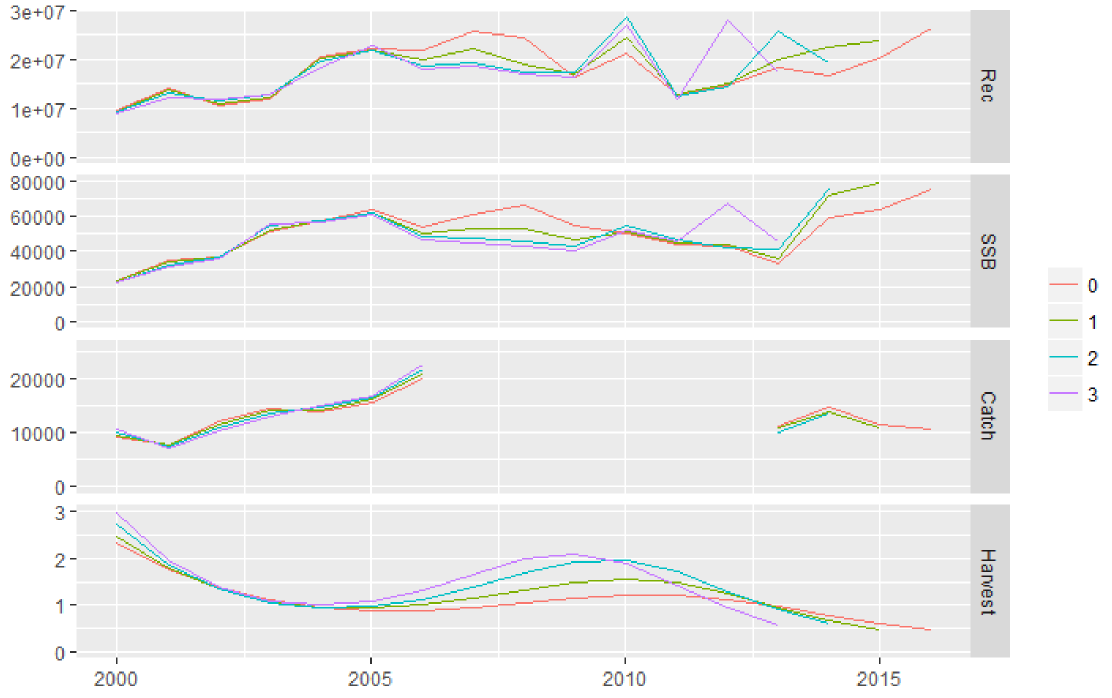


Figure 6.10.2.13 European anchovy in GSA 22. Retrospective analysis output for the a4a model.

Simulations

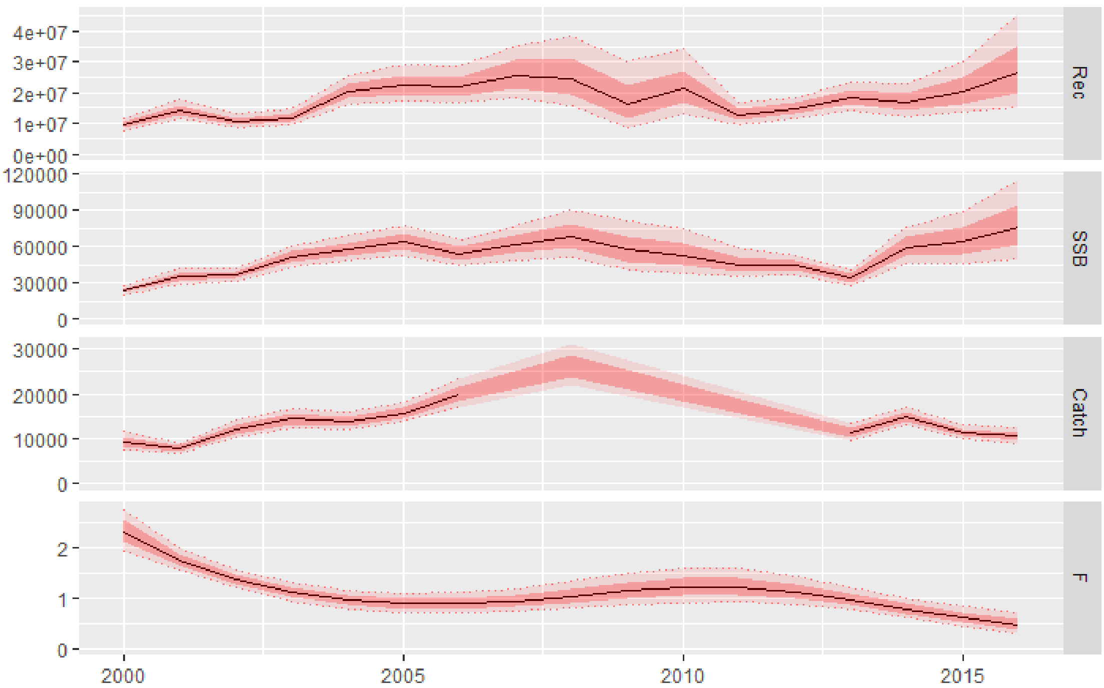


Figure 6.10.2.14 European anchovy in GSA 22. Stock summary of the simulated and fitted data for the a4a model.

The EWG 17-09 concluded that the output of this model was suitable to provide an indication of the current status of the stock. However due to the lack of surveys and catch-at-age data for a big part of the time series since 2009 the EWG 17-09 agreed not to provide forward projections and catch advice based on this assessment. Overall this modelling approach where missing data are dealt with correctly in the model is preferred to the other models described below.

Method SAM

The SAM model differs from the a4a model in that missing catch data are estimated outside the model and are therefore not fully correctly represented in the model fits and model uncertainty. The summary output of the SAM model for anchovy stock in GSA 22 is shown in Figure 6.10.2.15

Based on the model results anchovy stock SSB fluctuated over the time period examined (2000-2016) from 25883 tons (in 2000) to 67546 tons in 2016. A drop in SSB was observed in the years 2009 to 2013. This is generally in accordance with the a4a results. An increasing trend was shown in the number of recruits between 2001 and 2007. The recruitment (age 0) reached a maximum of 21.4 in 2006 (million individuals) and a minimum value of 10.8 million individuals in 2000. A second peak was registered in 2013, with a value of 20 million individuals. Since then, recruitment slightly decreases until 2016 (18 million individuals). Concerning the state of exploitation, the Fbar (1-3) showed a decreasing trend since 2007 reaching a value at 0.345 in 2016.

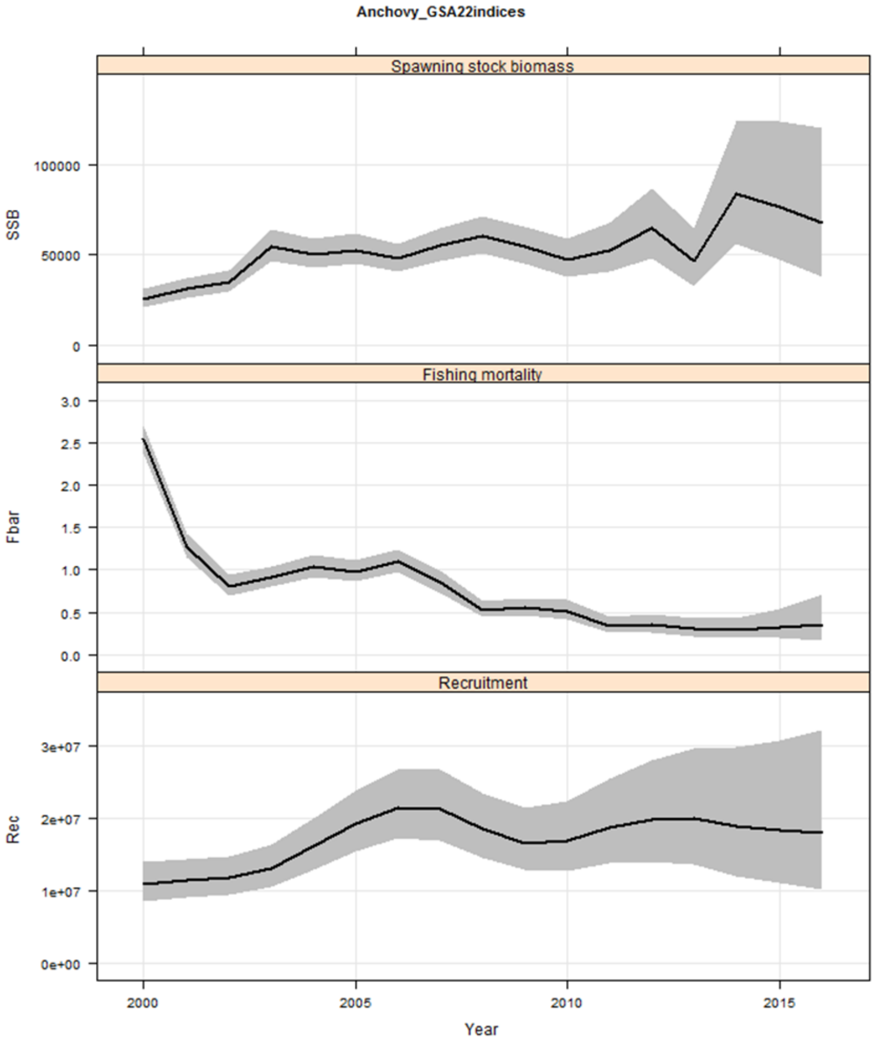


Figure 6.10.2.15 European anchovy in GSA 22. Output for the SAM model. Stock Biomass (SSB) in tons (on top). F (age 1 to 3) (middle); recruitment (as thousands individuals) (bottom); 95% confidence intervals are shown.

Due to the very short time series of the tuning index (2003-2016) and especially the gaps in the tuning index (2007, 2009-2013, 2015) no retrospective analysis was run.

Selection pattern (F/Fbar) by age class is plotted in Figure 6.10.2.16. The plots show a rather constant pattern in selectivity in all the pentads in the time series of data.

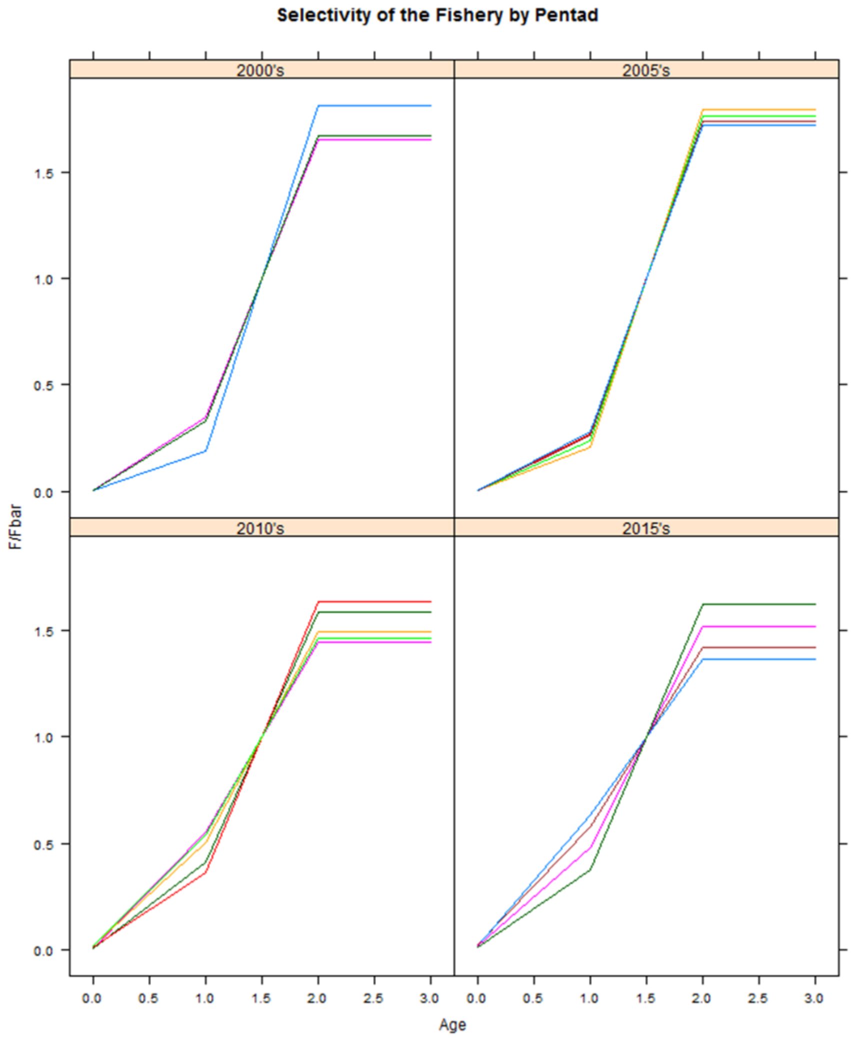


Figure 6.10.2.16 European anchovy in GSA 22. Selectivity at age by pentads as estimated by the SAM model.

In general, catch residuals did not show any apparent trend. As concerns survey data, all ages presented high residuals in 2014 and 2016. This was especially apparent for the age 3 residuals in 2016. (Figure 6.10.2.17 and 6.10.2.18).

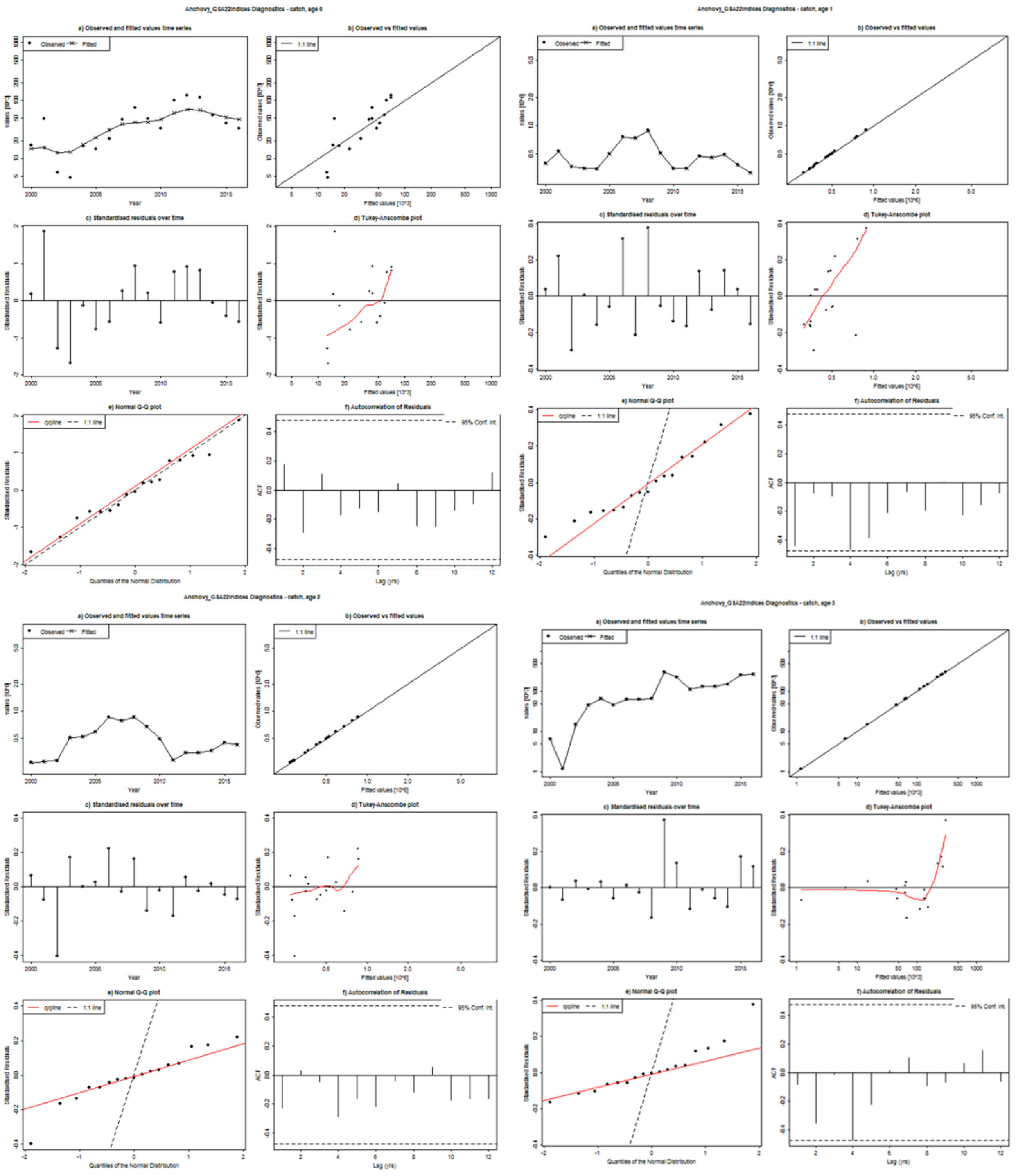


Figure 6.10.2.17 European anchovy in GSA 22. Diagnostic in the catch at age structure residuals for ages 0, 1, 2, 3.

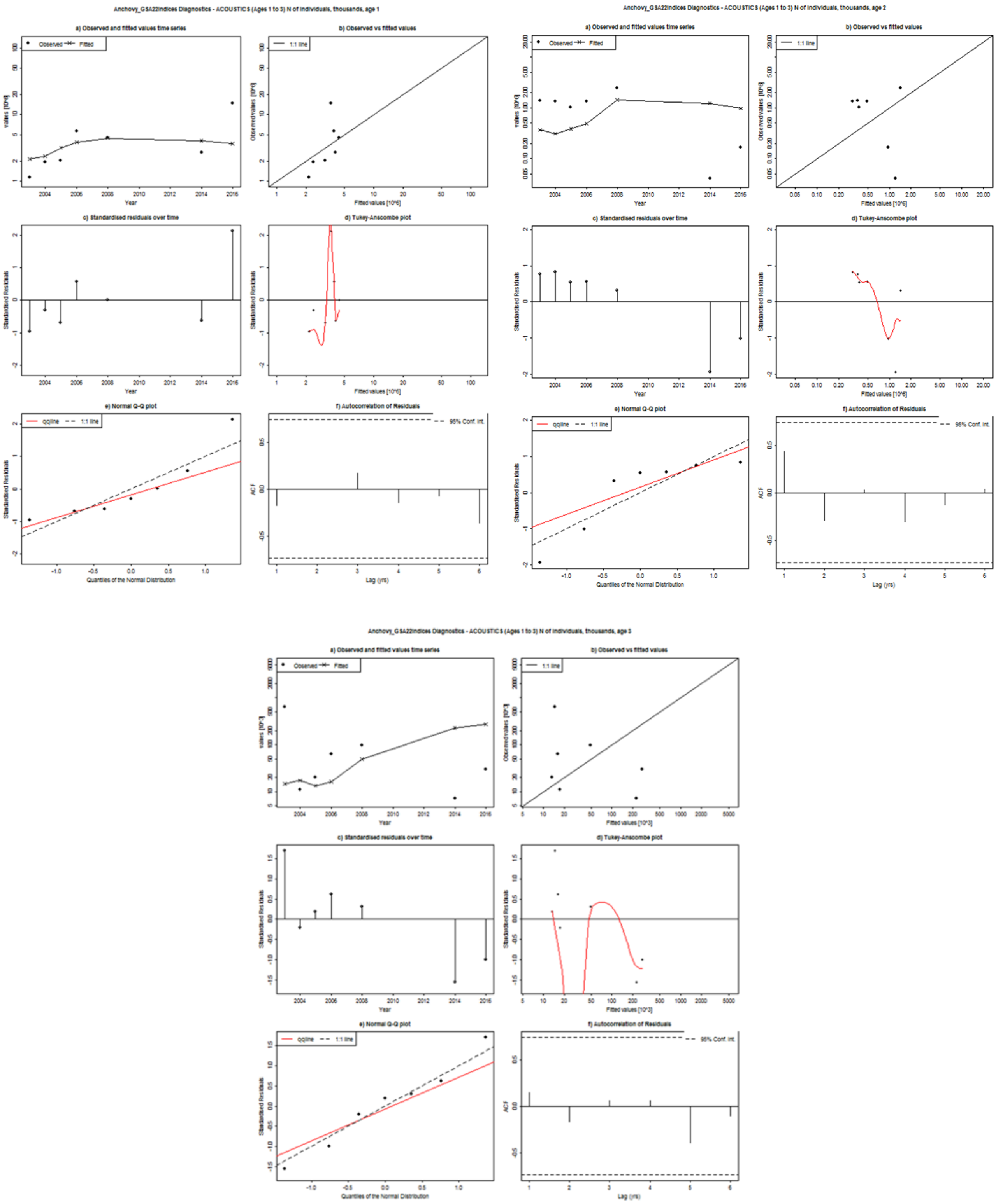


Figure 6.10.2.18 European anchovy in GSA 22. Diagnostic in the survey index structure residuals for ages 1, 2 and 3.

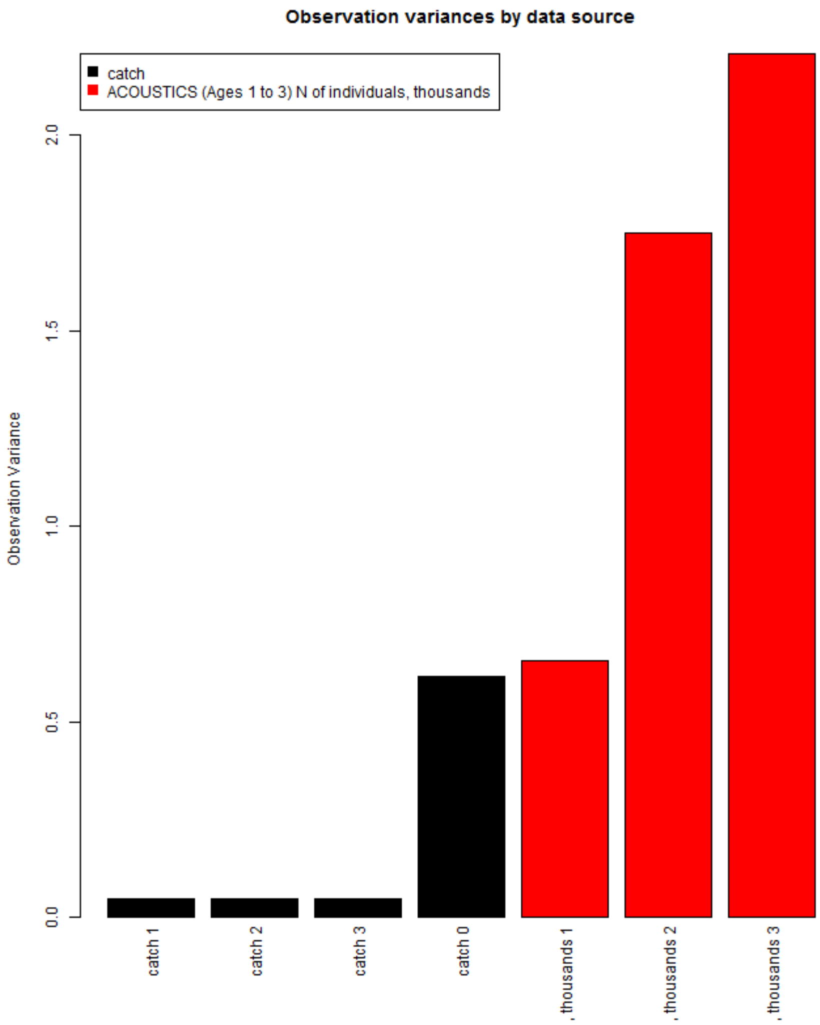


Figure 6.10.2.19 European anchovy in GSA 22. Plot of the observation variances by input data.

Observation variances by input data (Figure 6.10.2.19) showed that model is fitting most closely to the catch data, and among the survey data, age 3 is practically not used as the variability is very high.

The EWG 17-09 concluded that also the output of this model was indicative of the current status of the stock but the lack of surveys and catch-at-age data for a big part of the time series since 2009 and the need to apply assumptions for the age structure of the catch the EWG 17-09 considered that the preferred model is a4a given above. However it is noted that the general conclusions of stock status from this model are in accordance with the a4a model.

Surplus Production Method: SPICT

The Surplus Production in Continuous time (SPiCT) assessment method is fully described in Pedersen and Berg (2017). SPiCT is available as an R (R Core Team 2015) package in the github online repository: https://github.com/mawp/spict.

SPiCT requires a time series of catches and one (or more) time series of tuning index (CPUE or biomass). The expected output include management reference points F/Fmsy and B/Bmsy that quantify the exploitation rate and stock status. A forecasting period and a fishing management scenario can be tested by changing the multiplication factor that is applied to the current fishing mortality and projecting to the future. Main advantages of SPiCT are:

1. All estimated reference points (MSY, Fmsy, Bmsy) are reported with uncertainties.

2. The model can be used for short-term forecasting and management strategy evaluation.

3. The model is fully stochastic in that observation error is included in catch and index observations, and process error is included in fishing and stock dynamics.

4. The model is formulated in continuous-time and can therefore incorporate arbitrarily sampled data.

Input data

Catches

The official reported landings from the entire Aegean Sea (GSA 22) were used as reported in the FishStat J from the GFCM Database. The catch data from 1985 to 2015 (latest available year) was used. Data prior to 1985 were excluded because they were considered unreliable because of the very low landings from Turkey.

Biomass

The biomass from acoustics surveys that were conducted in the Greek part of the Aegean Sea was used as tuning index. Acoustics data were available by DCF from 2003 onwards (with gaps in 2007, 2009-2012 and 2015). Acoustic estimates in 1995 and 1996 from the Greek part of North Aegean Sea were based on a past research project (Tsimenides et al, 1996; Machias et al., 1997) provided by Marianna Giannoulaki.

Table 6.10.2.4 European anchovy in GSA 22. Official landings (tons) for anchovy in GSA 22 (GFCM database, Greece and Turkey together).

Year	Greek landings (t)	Turkish landings (t)
1985	17114	1151
1986	17714	163
1987	24648	178
1988	19133	618
1989	14669	1420
1990	13366	1999
1991	12967	1703
1992	10502	5238
1993	13226	2555
1994	16451	2679
1995	12669	2566
1996	13980	2907
1997	12597	4213
1998	14996	12231
1999	15369	2237
2000	9049	4344
2001	10110	9386
2002	9424	10940
2003	13355	8652
2004	13195	9972
2005	11111	4136
2006	13932	12935
2007	15846	8390
2008	15736	5430
2009	14182	7782
2010	11603	7885
2011	8110	8509
2012	8352	11141
2013	8383	8407
2014	9355	10965
2015	13515	10965

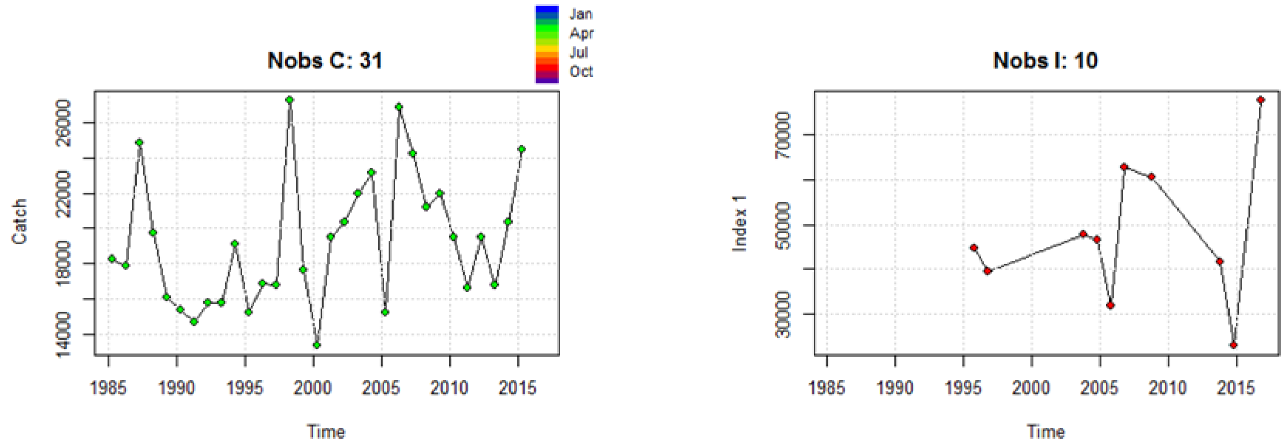


Figure 6.10.2.20 European anchovy in GSA 22. Official landings (tons) for anchovy in GSA 22 (GFCM database, Greece and Turkey together) and biomass index based on acoustic surveys used for assessment in GSA 22.

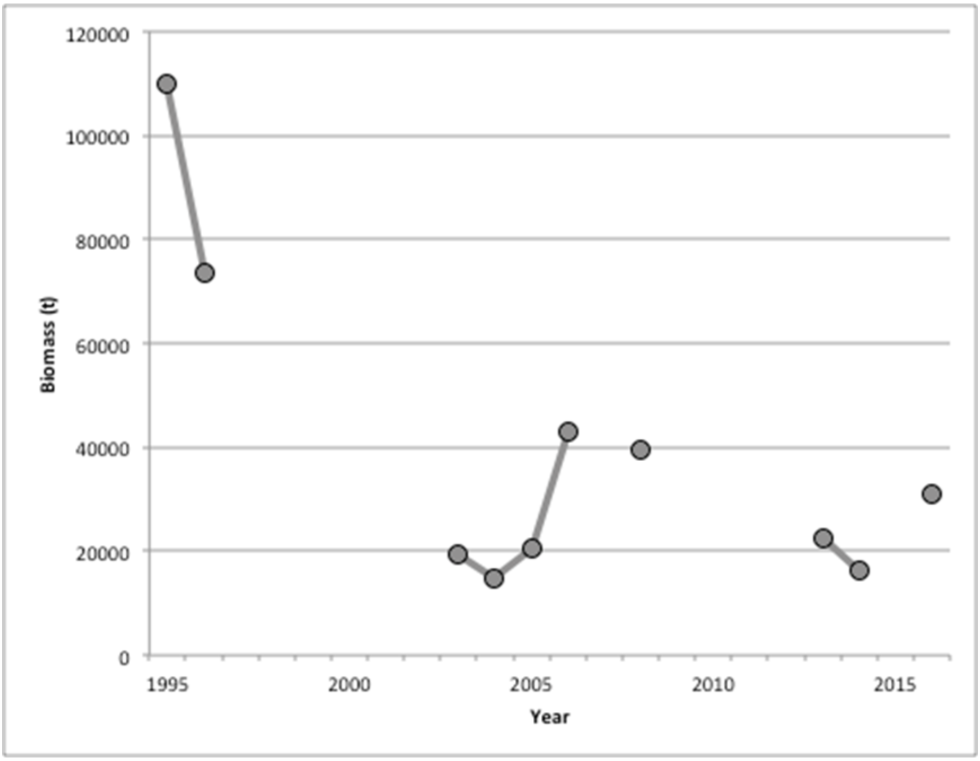


Figure 6.10.2.21 European anchovy in GSA 22. Acoustic index as biomass (tons) for anchovy in GSA 22.

Bayesian priors

The model needed priors in the carrying capacity (K) and in the Fbar/Fmsy. Thus the carrying capacity (K) had been set as twice the highest acoustic estimation for anchovy (at 300000 tons), and a prior for Fbar/Fmsy of 0.53 had been set in year 2006. This value corresponds to last reliable assessment of the anchovy stock (STECF SG-MED 09-02) (Fbar1-3=0.30) and Fmsy=0.57 the equivalent of the F corresponding to the E=0.4 (Exploitation rate as an empirical reference point defined in STECF EWG 09-02).

Assessment results

Stock summary

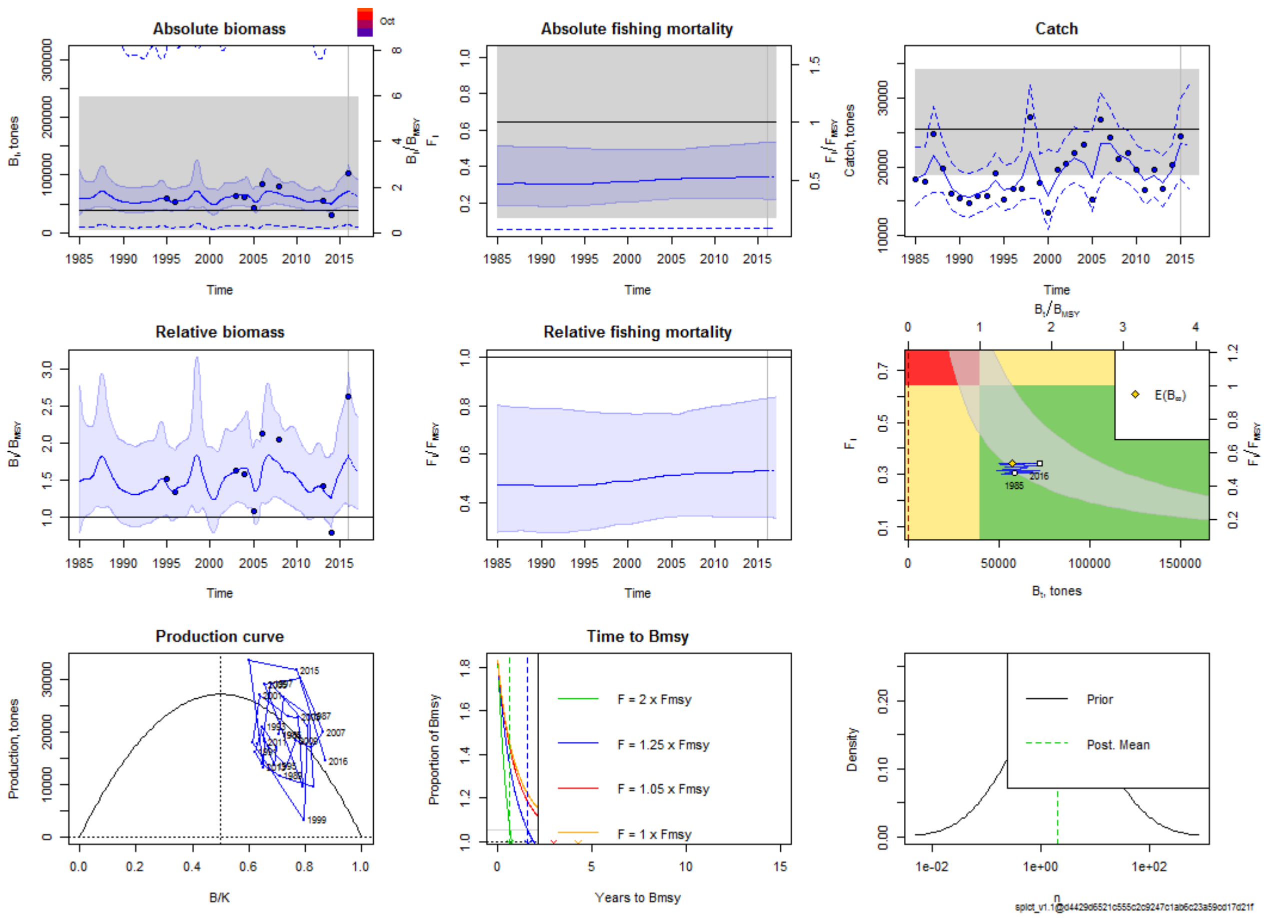


Figure 6.10.2.22 European anchovy in GSA 22. Summary of the final SPiCT model fit and output. Absolute and relative Biomass and Fishing mortality, state of the stock in F/B space and relative to estimated production.

The output of the model (Model estimates, reference points and summaries are reported below) is summarised below.

[1] "Convergence: 0 MSG: relative convergence (4)"

[2] "Objective function at optimum: 11.0322273"

[3] "Euler time step (years): 1/16 or 0.0625"

[4] "Nobs C: 31, Nobs I1: 10"

[5] "Catch/biomass unit: tones "

[6] ""

```
 [7] "Priors"
 [8] "     logn  ~  dnorm[log(2), 2^2]"
 [9] " logalpha  ~  dnorm[log(1), 2^2]"
[10] "  logbeta  ~  dnorm[log(1), 2^2]"
[11] "     logK  ~  dnorm[log(3e+05), 1^2]"
[12] " logFFmsy  ~  dnorm[log(0.53), 0.2^2]"
[13] ""
[14] "Fixed parameters"
[15] "   fixed.value  "
[16] " n           2  "
[17] ""
[18] "Model parameter estimates w 95% CI "
[19] "            estimate        cilow        ciupp    log.est  "
[20] " alpha  1.086124e+00 1.578288e-01 7.474340e+00  0.0826157  "
[21] " beta   3.309672e+00 5.496307e-01 1.992961e+01  1.1968490  "
[22] " r      1.306072e+00 2.382313e-01 7.160371e+00  0.2670243  "
[23] " rc     1.306072e+00 2.382313e-01 7.160371e+00  0.2670243  "
[24] " rold   1.306072e+00 2.382313e-01 7.160371e+00  0.2670243  "
[25] " m      2.715321e+04 1.986957e+04 3.710684e+04 10.2092507  "
[26] " K      8.315992e+04 1.576174e+04 4.387570e+05 11.3285207  "
[27] " q      7.463632e-01 1.321231e-01 4.216206e+00 -0.2925429  "
[28] " sdb    2.394922e-01 5.534550e-02 1.036336e+00 -1.4292342  "
[29] " sdf    3.656720e-02 7.261300e-03 1.841487e-01 -3.3086028  "
[30] " sdi    2.601184e-01 1.326599e-01 5.100379e-01 -1.3466185  "
[31] " sdc    1.210255e-01 5.123860e-02 2.858624e-01 -2.1117538  "
[32] " "
[33] "Deterministic reference points (Drp)"
[34] "           estimate        cilow        ciupp    log.est  "
[35] " Bmsyd 4.157996e+04 7.880868e+03 2.193785e+05 10.6353736  "
[36] " Fmsyd 6.530361e-01 1.191157e-01 3.580185e+00 -0.4261228  "
[37] " MSYd  2.715321e+04 1.986957e+04 3.710684e+04 10.2092507  "
[38] "Stochastic reference points (Srp)"
[39] "          estimate        cilow        ciupp   log.est rel.diff.Drp  "
[40] "Bmsys 3.956708e+04 6.635737e+03 2.359276e+05 10.585753  -0.05087259  "
[41] "Fmsys 6.420674e-01 1.156769e-01 3.563812e+00 -0.443062  -0.01708344  "
[42] "MSYs  2.538265e+04 1.889956e+04 3.408963e+04 10.141821  -0.06975479  "
[43] ""
[44] "States w 95% CI (inp$msytype: s)"
[45] "                   estimate        cilow        ciupp    log.est  "
[46] " B_2016.00      7.243655e+04 1.468266e+04 3.573639e+05 11.1904663  "
[47] " F_2016.00      3.419805e-01 5.938830e-02 1.969255e+00 -1.0730015  "
[48] " B_2016.00/Bmsy 1.830728e+00 1.138108e+00 2.944857e+00  0.6047136  "
```

```
[49] " F_2016.00/Fmsy 5.326240e-01 3.420129e-01 8.294667e-01 -0.6299395  "
[50] ""
[51] "Predictions w 95% CI (inp$msytype: s)"
[52] "                 prediction       cilow        ciupp    log.est  "
[53] " B_2016.00      7.243655e+04 1.468266e+04 3.573639e+05 11.1904663  "
[54] " F_2016.00      3.419805e-01 5.938830e-02 1.969255e+00 -1.0730015  "
[55] " B_2016.00/Bmsy 1.830728e+00 1.138108e+00 2.944857e+00  0.6047136  "
[56] " F_2016.00/Fmsy 5.326240e-01 3.420129e-01 8.294667e-01 -0.6299395  "
[57] " Catch_2016.00  2.310758e+04 1.681315e+04 3.175850e+04 10.0479161  "
[58] " E(B_inf)       5.729904e+04          NA           NA 10.9560392  "
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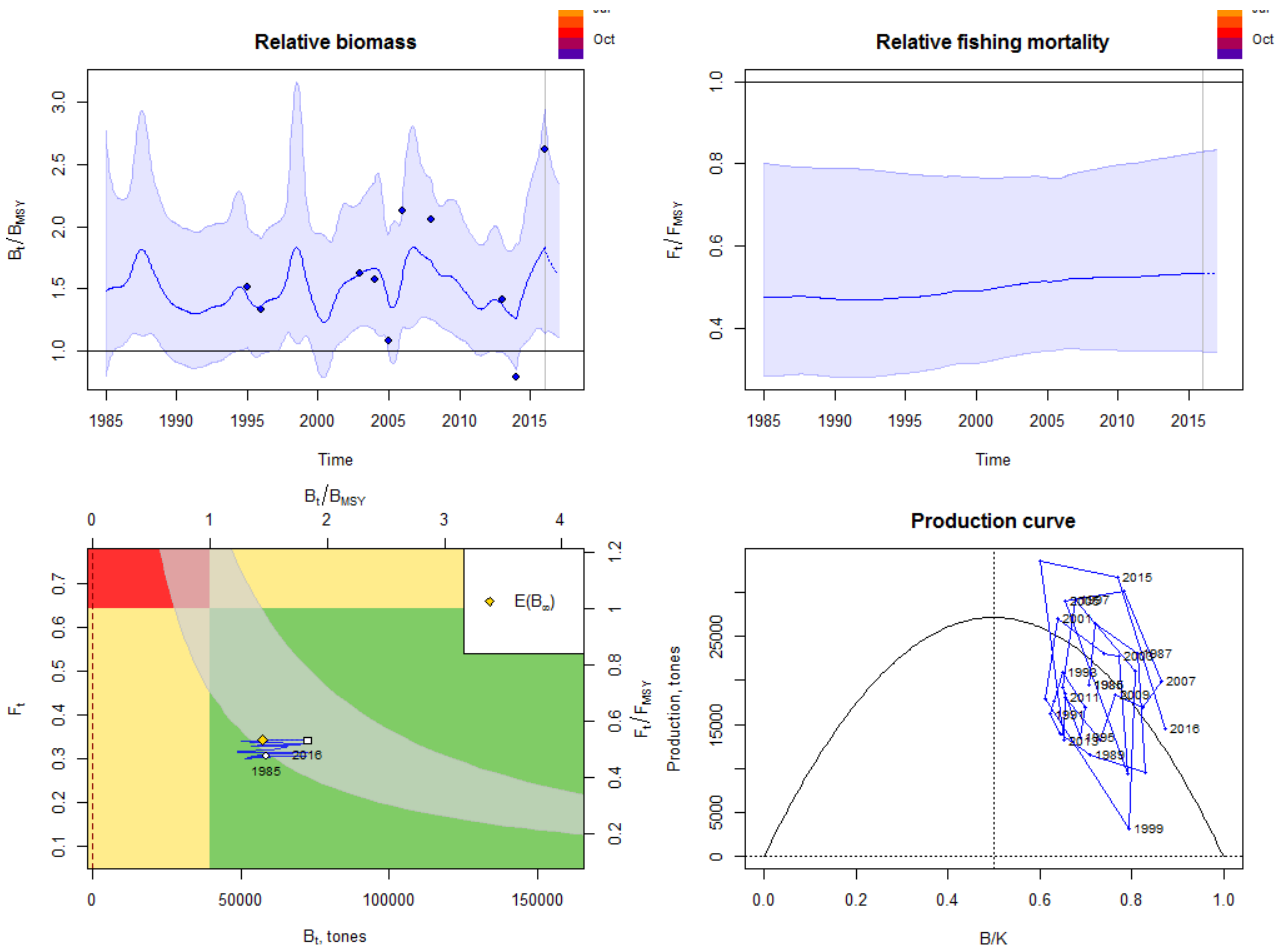


Figure 6.10.2.23 European anchovy in GSA 22. Relative biomass and fishing mortality, F/B plot and production curve as given by the SPiCT model for anchovy in GSA 22.

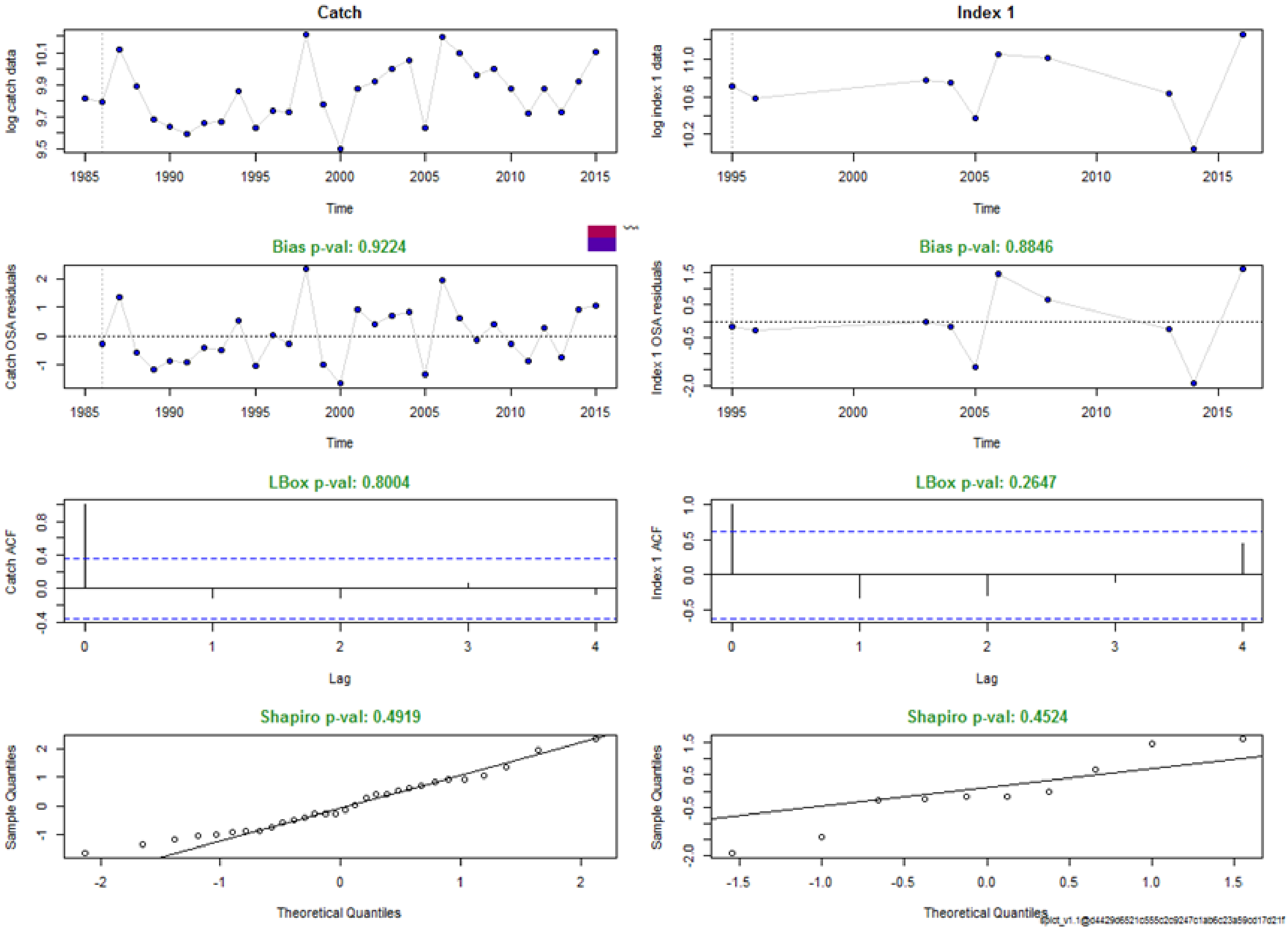


Figure 6.10.2.24 European anchovy in GSA 22. Diagnostics from SPiCT model for anchovy in GSA 22.

Retrospective analysis

A retrospective analysis was run with 4 retro years. The retrospective patterns are consistent across in terms of B/Bmsy but results in poorer performance when F/Fmsy is concerned.

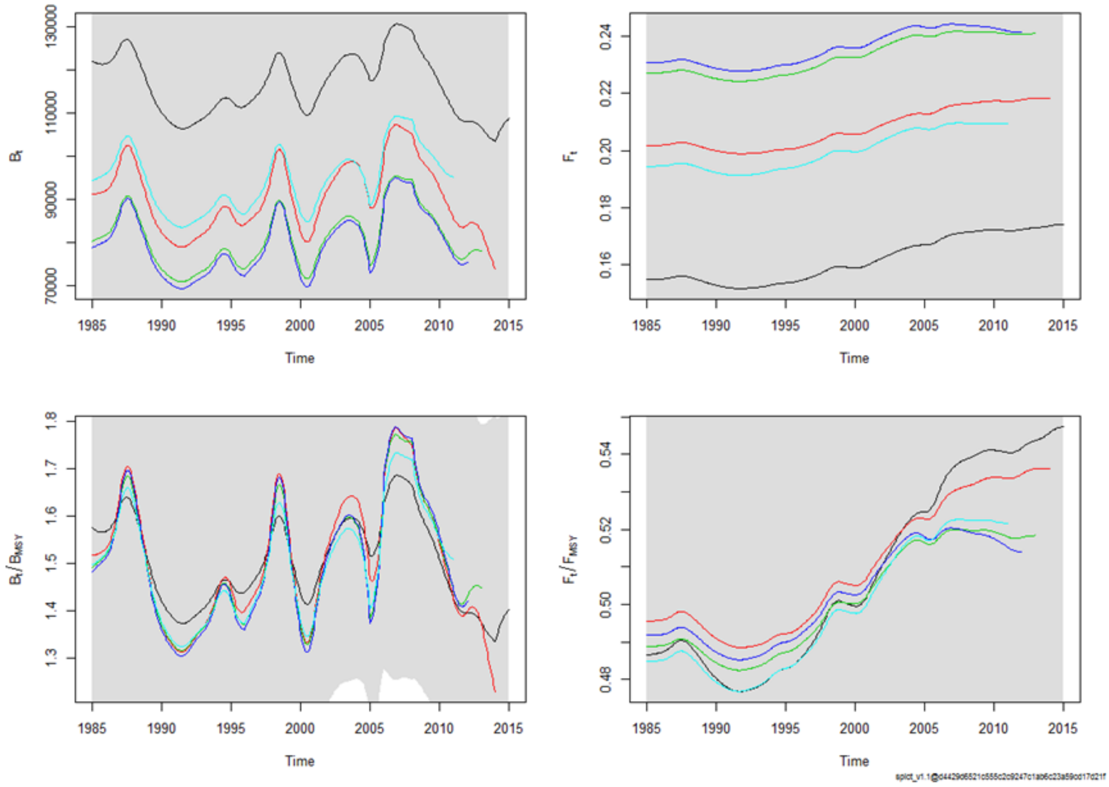


Figure 6.10.2.25 European anchovy in GSA 22. Diagnostics for model from anchovy in GSA 22.

Sensitivity

As the SPiCT required Bayesian priors in order to converge successfully, we also examined the sensitivity of the model in the values and the CV of the priors used.

Results of sensitivity tests (Figure 6.10.2.26) showed that the output of the SPiCT varies greatly depending almost directly on the value of the prior "FFmsy in 2006" used. The CV of this prior might also affect the output but in a lesser degree.

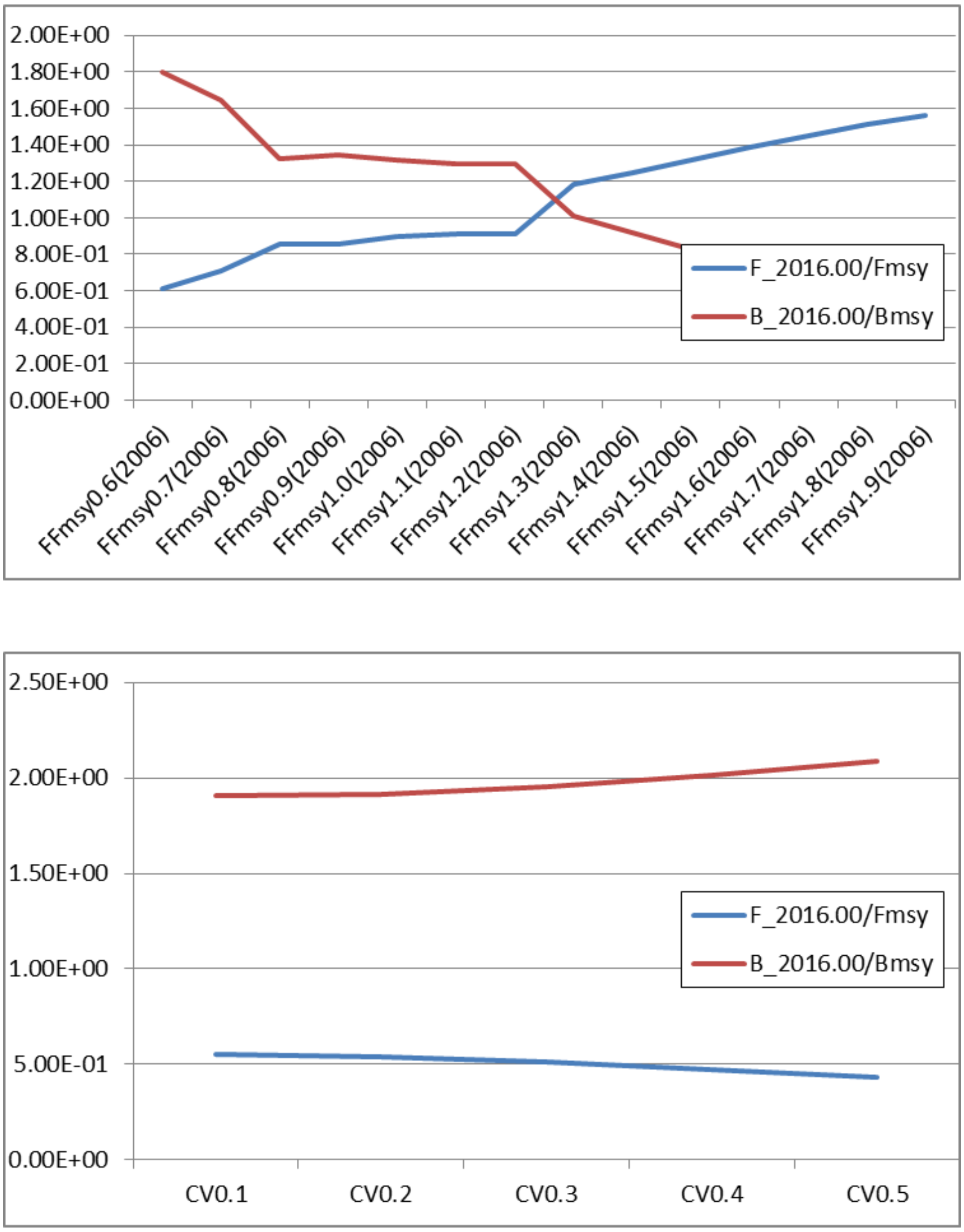


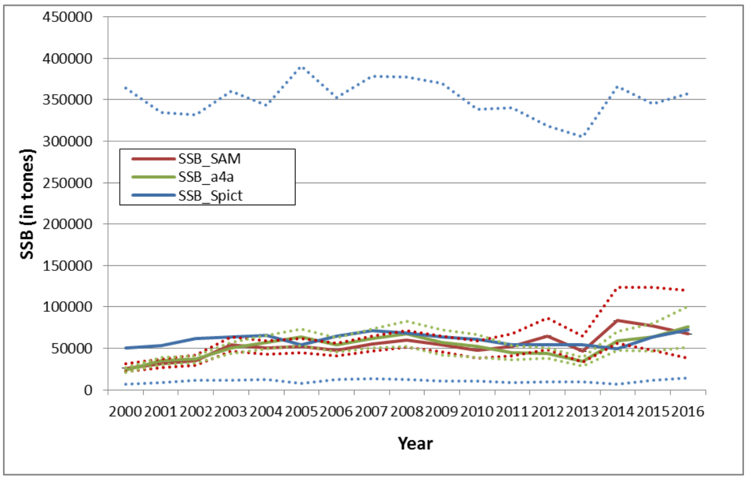
Figure 6.10.2.26 European anchovy in GSA 22. Sensitivity analysis for SPiCT output. Top: Based on different values of the prior FFmsy in 2006 and Bottom: Based on different CV values of the prior FFmsy in 2006.

Conclusions to SPiCT model

The model estimates B_2016/Bmsy=1.83 and F_2016/Fmsy=0.532. However, the estimated confidence intervals were large concerning both the Biomass and F estimates. The failure of the model to convergence without priors, the sensitivity of model output to the values of the priors along with the poor performance of the retrospective analysis in terms of F lead the STECF EW-17 09 to decide that model results was not able to determine current stock status or biomass.

Conclusions to assessment model

The three assessment model results are compared in Figure 6.10.2.27. The surplus production model shows very wide intervals which reflect the great uncertainty in stock status resulting from this approach. The results for SAM and a4a are substantively similar with both SSB and F_{bar} lying within the confidence intervals for both models, the two models give different historic perspectives of SSB, this probably comes from the very different data treatment where a4a estimates missing information within the model and SAM is given externally interpolated data. A4a is therefore the preferred modeling environment, but the coincidence of the two methods greatly increases confidence in the estimates of stock status. In conclusion the a4a model is used to give stock status. However, due to the considerable uncertainty in the model due to missing data the model is not considered suitable for catch advice.



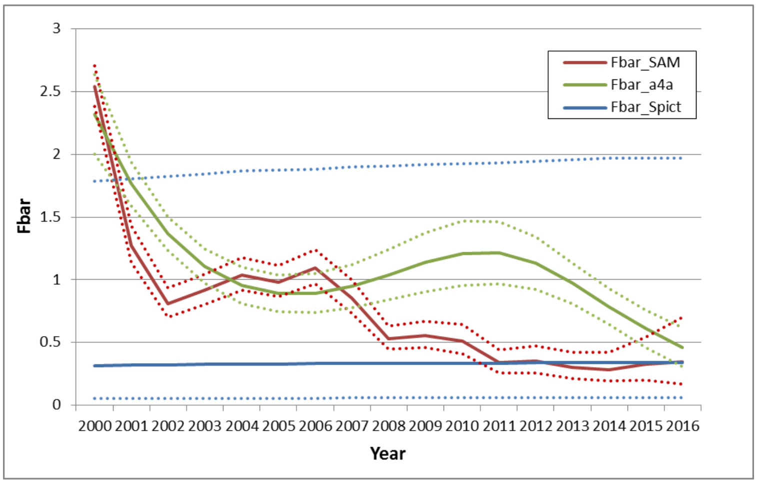


Figure 6.10.2.27 European anchovy in GSA 22. Comparative assessment main outputs with confidence intervals.

6.10.3 Reference Points

No specific MSY reference points evaluations were carried out by EWG 17-09. The Empirical Reference point corresponding at Exploitation rate 0.4 (Patterson 1992) as suggested by the STECF SG-MED 09-02 is used as a proxy for MSY and has been used to define stock status. The F equivalent to E=0.4 is estimated as 0.464 from the M and fishery selection at age in the a4a assessment.

6.10.4 Short term Forecast and Catch Options

Given the uncertainty associated with the model no short term forecast and catch options were carried out for anchovy stock in GSA 22 within STECF EWG 17-09.

6.10.5 Data Deficiencies

Particular deficiencies were found in the DCF data provided. Specifically, no DCF catch / catch-at-length / catch-at-age data were provided for 2007, 2009, 2010, 2011, 2012. No catch-at-age data were provided for 2016. Catch-at-age data were provided only for the last quarter for 2013 and 2015. No acoustic surveys took place in 2007, 2009-2012, 2015. The output of the acoustic survey in 2013 was used only in the SPICT as the survey took place in September instead of June –July.

DCF in 2014 reported landings almost half of the officially reported by Greece in GFCM.

6.11 STOCK ASSESSMENT ON SARDINE IN GSAs 22 & 23

Stock Identity and Biology

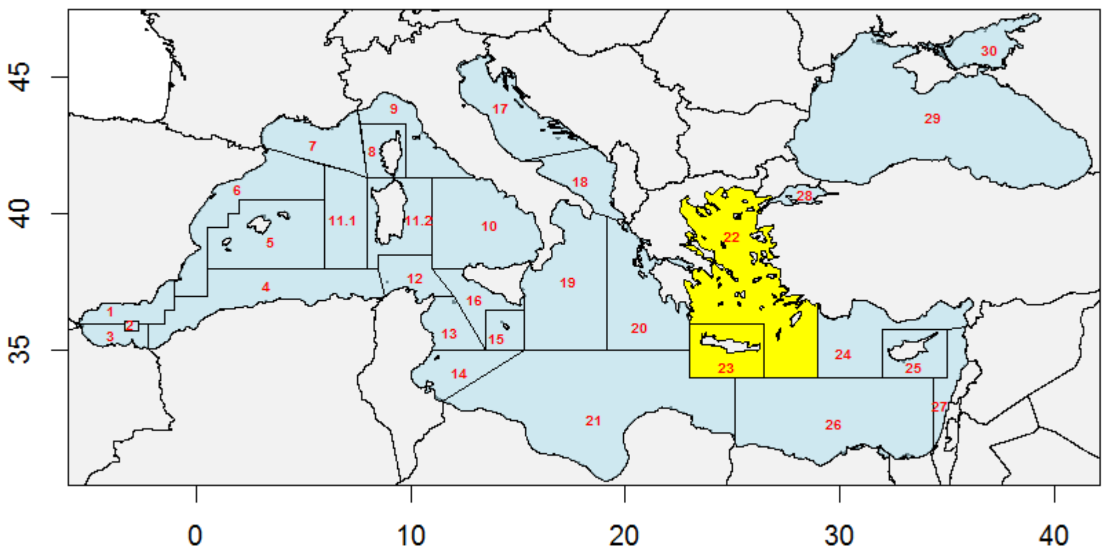


Figure 6.11.1 Geographical location of GSAs 22 & 23

6.11.1 Data

6.11.1.1 Catch (landings and discards)

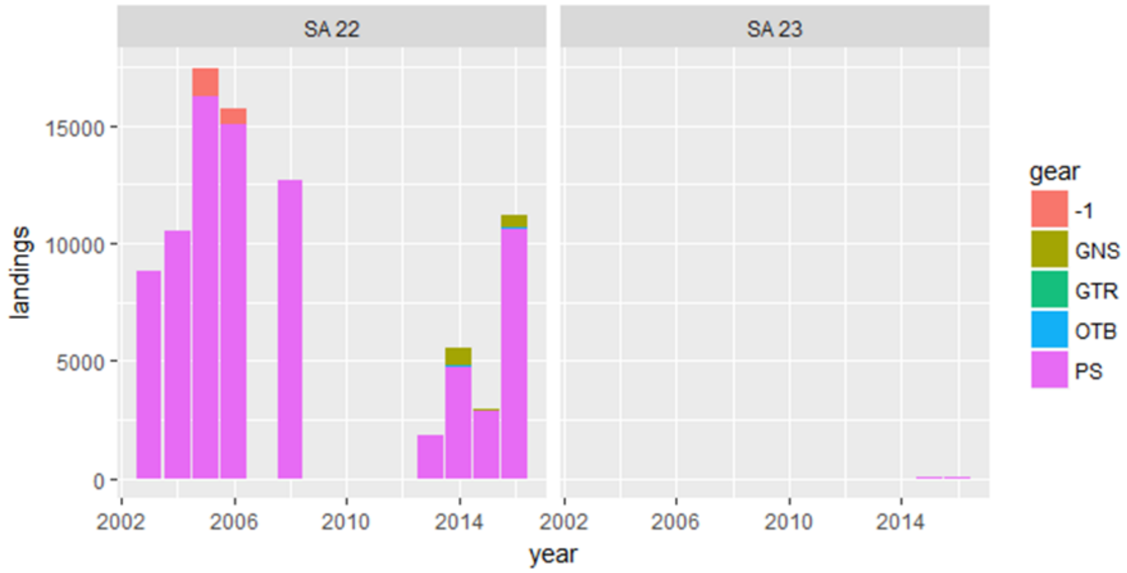


Figure 6.11.1.1.1 Sardine in GSAs 22 & 23. Sardine DCF landings by the Greek fleet in GSA 22 (left) and GSA 23 (right) from different gears. Years 2007 and 2009-2012 are missing, while data from 2013 and 2015 came only from the fourth quarter.

Table 6.11.1.1.1 Sardine in GSAs 22 & 23. Sardine DCF landings in tonnes by the Greek fleet in GSA 22 and GSA 23 from different gears. Years 2007 and 2009-2012 are missing, while data from 2013 and 2015 (*) came only from the fourth quarter.

Year	PS_Landings (t)	GNS_Landings (t)	GTR_Landings (t)	OTB_Landings (t)	Other/ unspecified (t)
2003	8781	-	-	37	
2004	10492	-	-	46	
2005	16211	-	-	28	1168
2006	15045	-	-	26	646
2007	-	-	-	-	
2008	12700	-	-	-	
2009	-	-	-	-	
2010	-	-	-	-	
2011	-	-	-	-	

2012	-	-	-	-	
2013	1798	-	-	-	
2014	4720	759	-	71	
2015	2868	21	9	5	
2016	10605	483	1	80	

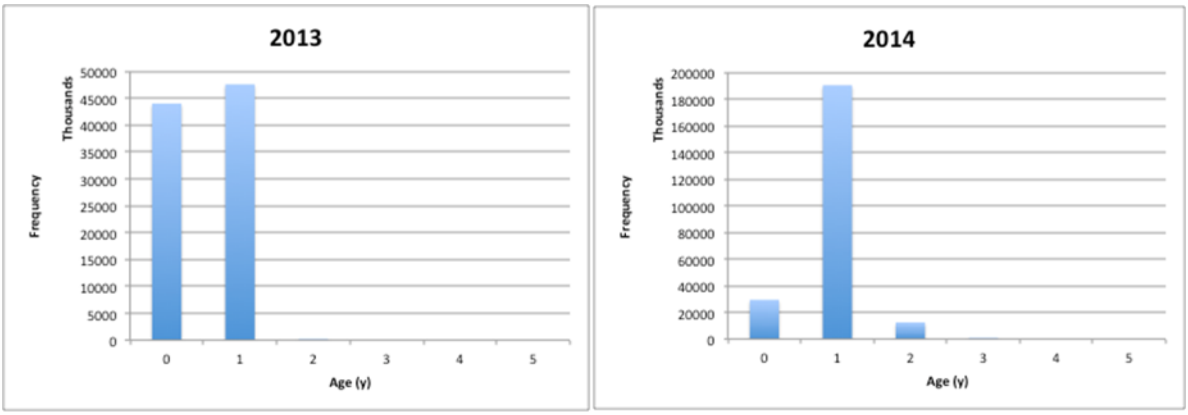


Figure 6.11.1.1.2 Sardine in GSAs 22 & 23. Sardine landings at age by the Greek fleet in GSA 22 from different gears. Years 2007, 2009-2012 and 2015-2016 are missing, while data from 2013 came only from the fourth quarter.

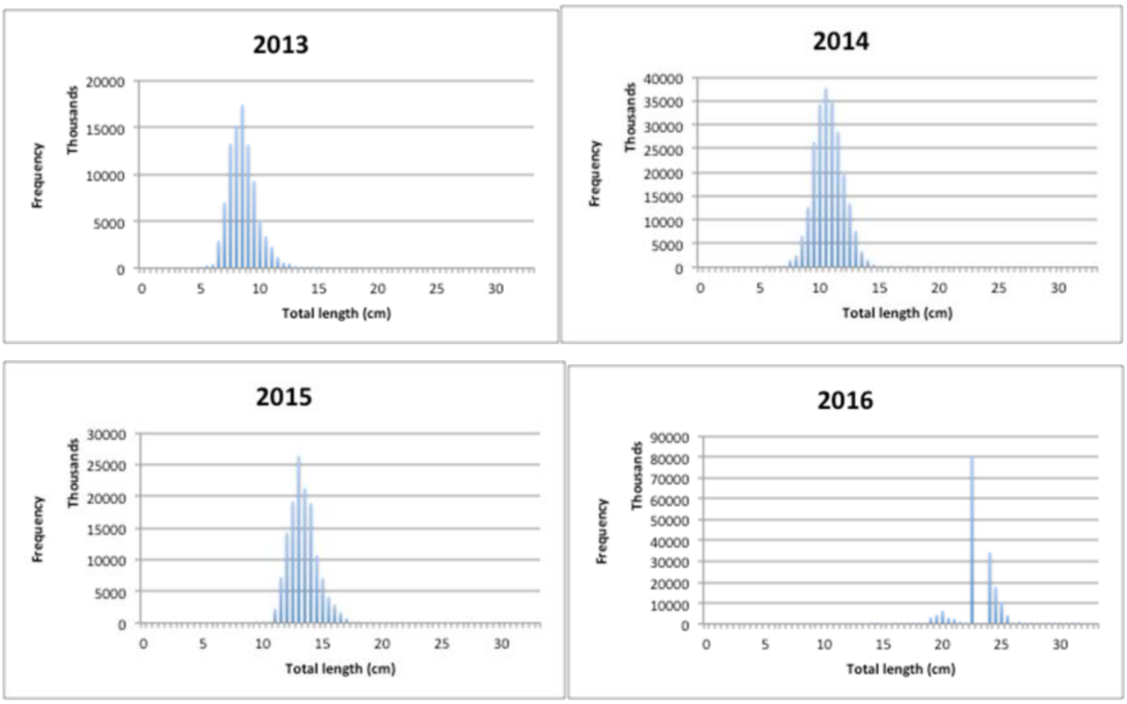


Figure 6.11.1.1.3 Sardine in GSAs 22 & 23. Sardine length frequency distribution of landings by the Greek fleet in GSA 22 from PS. Years 2007 and 2009-2012 are missing, while data from 2013 and 2015 came only from the fourth quarter.

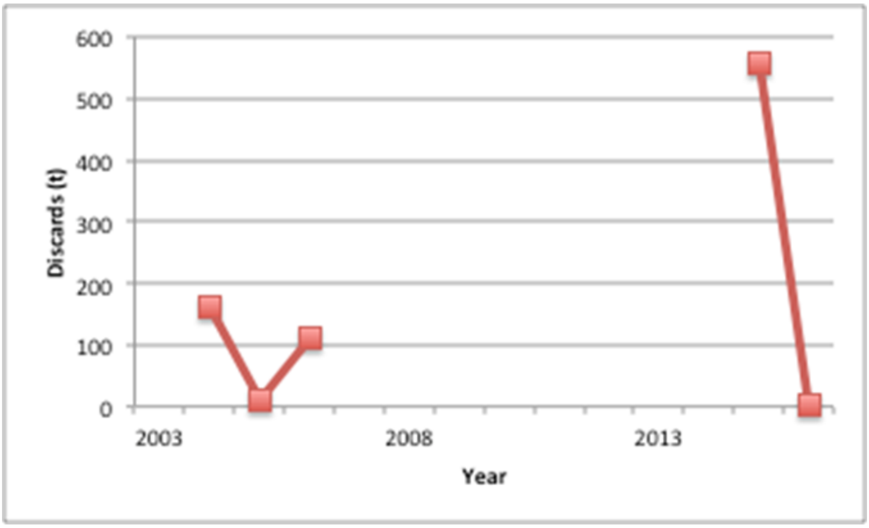


Figure 6.11.1.1.4. Sardine in GSAs 22 & 23. Sardine discards by the Greek fleet in GSA 22.

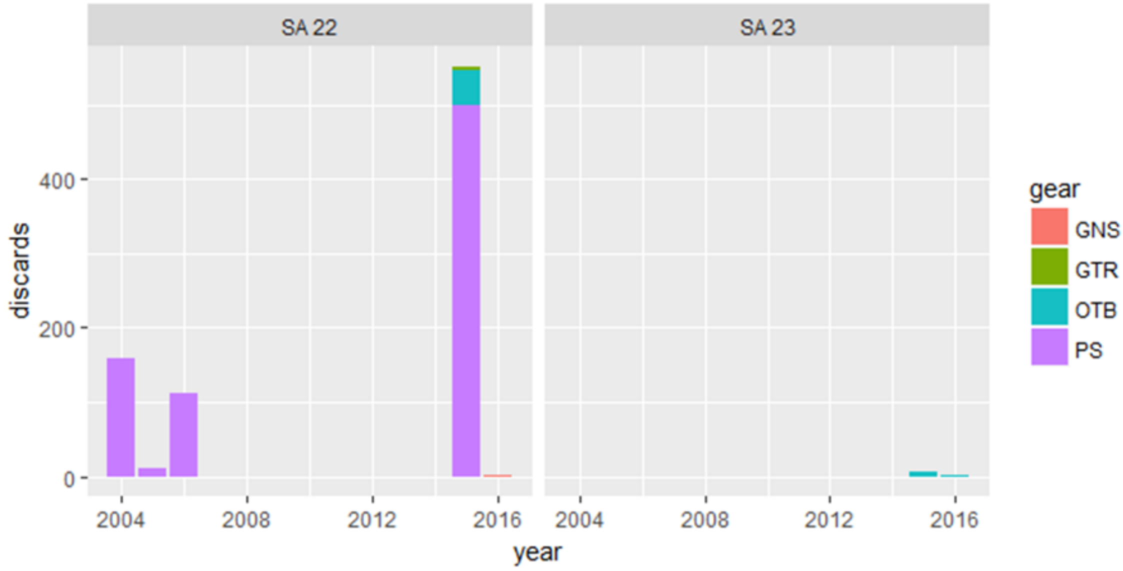


Figure 6.11.1.1.5 Sardine in GSAs 22 & 23. Sardine discards by the Greek fleet in GSA 22.

Table 6.11.1.1.2. Sardine in GSA 22 & 23. Sardine discards in tonnes by fishing gear in GSA 22 as reported by the DCF.

Year	PS_Discards (t)	OTB_Discards (t)	GTR_Discards (t)
2003	-	-	-
2004	160	-	-
2005	10	-	-
2006	112	-	-

2007	-	-	-
2008	-	-	-
2009	-	-	-
2010	-	-	-
2011	-	-	-
2012	-	-	-
2013	-	-	-
2014	-	-	-
2015	500	55	3
2016	<1	3	-

6.11.1.2 Effort

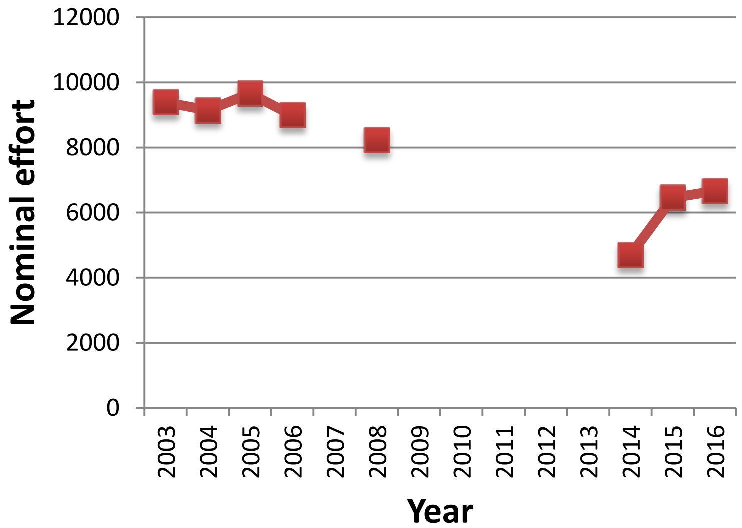


Figure 6.11.1.2.1 Sardine in GSAs 22 & 23. Nominal effort (days at sea) of purse seines in GSA 22 as reported by DCF.

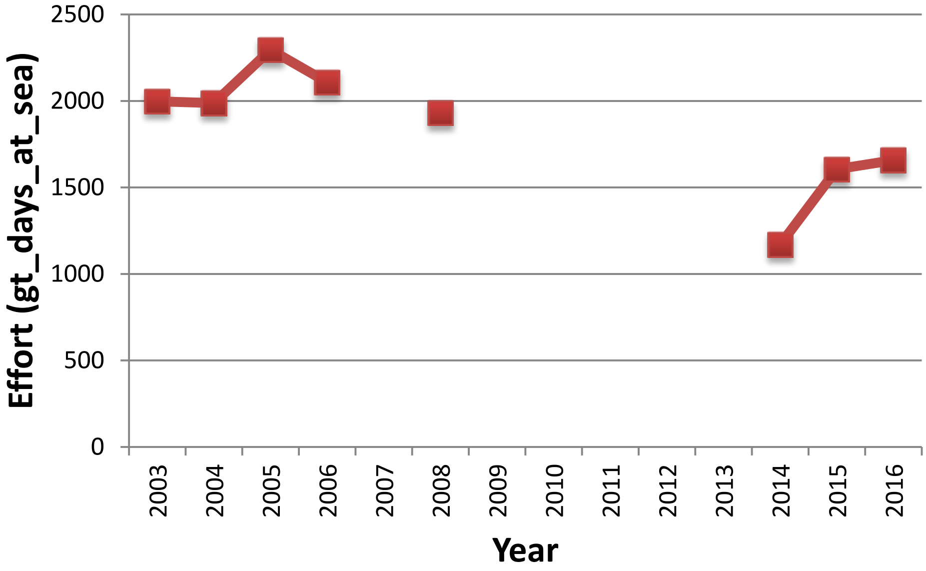


Figure 6.11.1.2.2 Sardine in GSAs 22 & 23. Effort (gt * days at sea) of purse seines in GSA 22 as reported by DCF.

6.11.1.3 SURVEY DATA

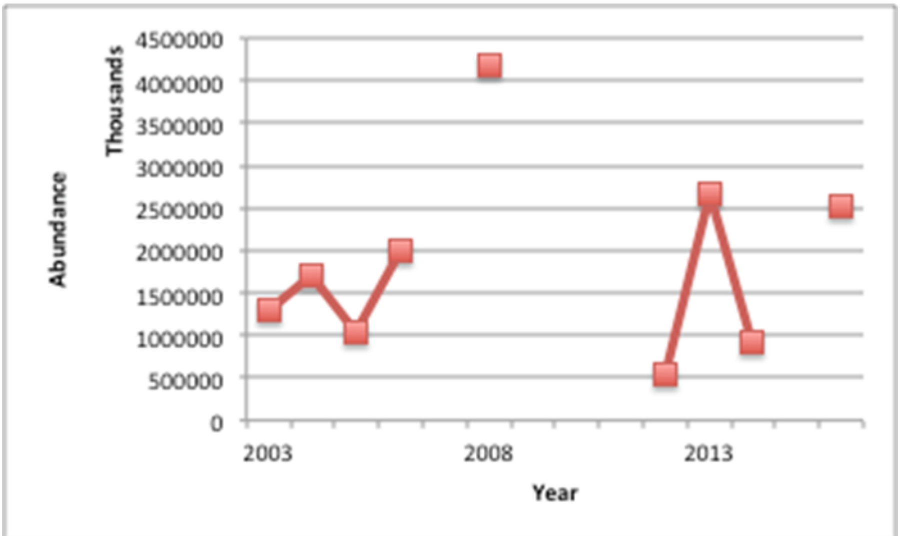


Figure 6.11.1.3.1 Sardine in GSAs 22 & 23. Acoustic survey abundance index of sardine in GSA 22 as reported by DCF. No survey was carried out in 2007, 2009-2011 and 2015. The survey was carried out in June/July except from 2012 when it was carried out in December and 2013 when it was carried out in September.

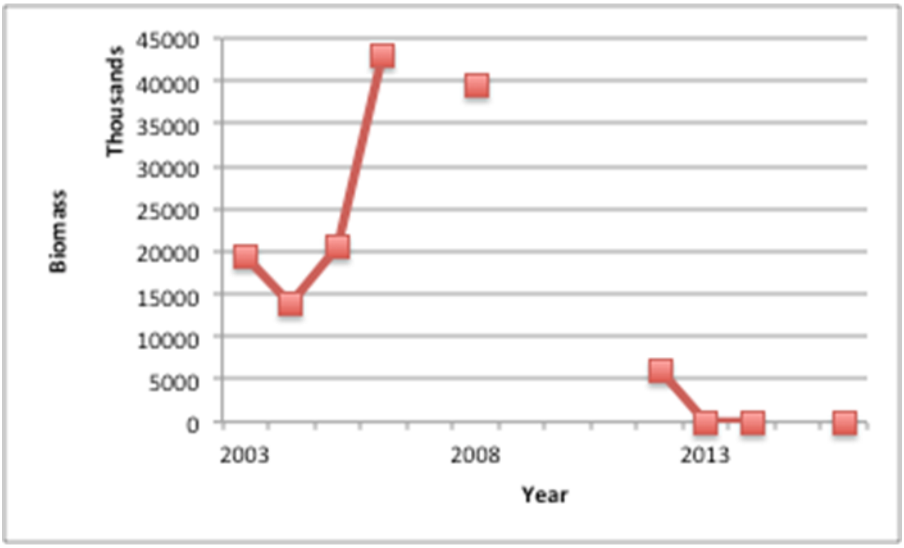


Figure 6.11.1.3.2 Sardine in GSAs 22 & 23. Acoustic survey biomass index of sardine in GSA 22 as reported by DCF. No survey was carried out in 2007, 2009-2011 and 2015. The survey was carried out in June/July except from 2012 when it was carried out in December and 2013 when it was carried out in September.

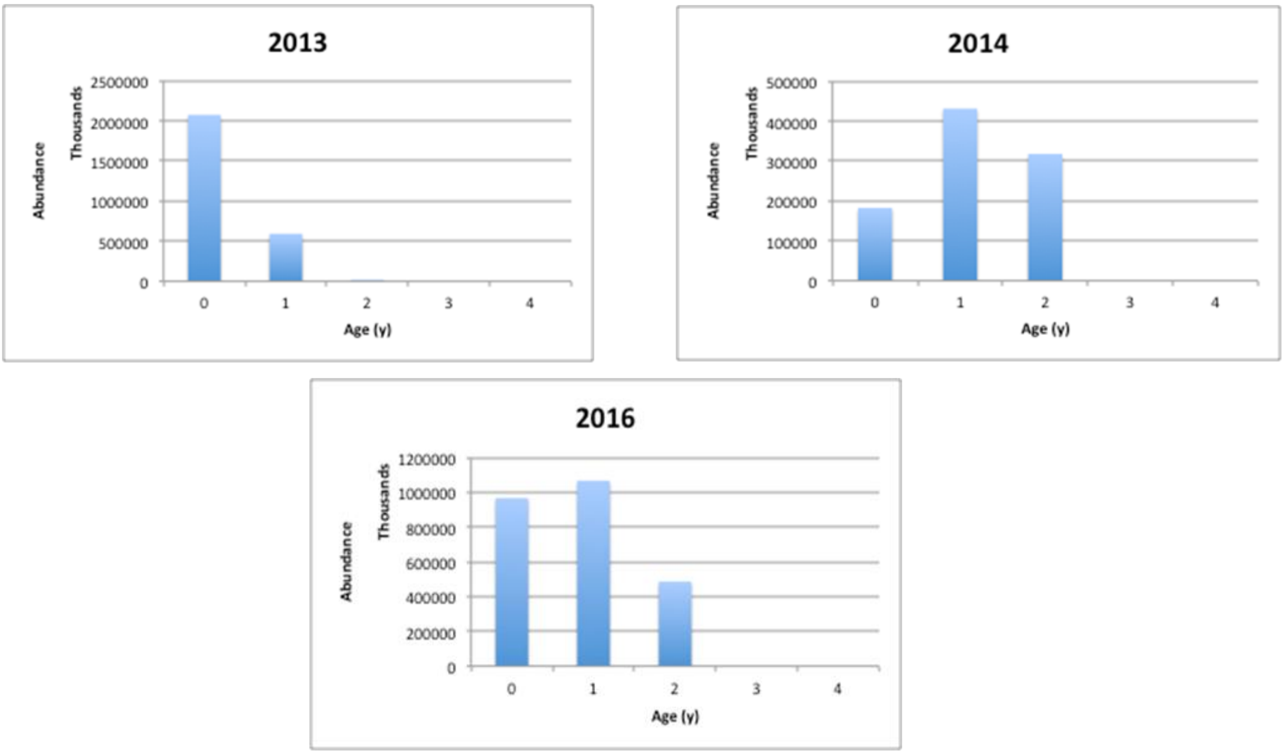


Figure 6.11.1.3.3 Sardine in GSAs 22 & 23. Age frequency distribution of the acoustic survey abundance index of sardine in GSA 22 as reported by DCF. No survey was carried out in 2007, 2009-2011 and 2015. The survey was carried out in June/July except from 2012 when it was carried out in December and 2013 when it was carried out in September.

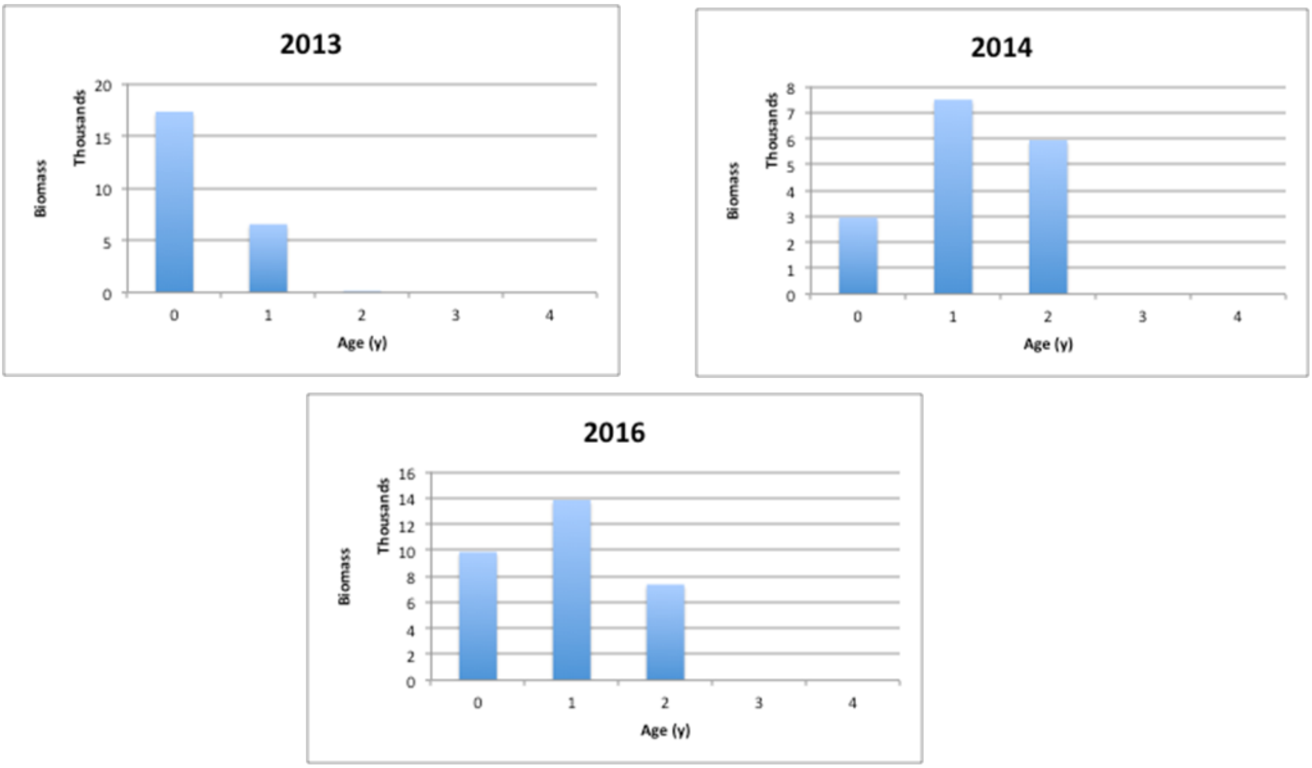


Figure 6.11.1.3.4 Sardine in GSAs 22 & 23. Age frequency distribution of the acoustic biomass index of sardine in GSA 22 as reported by DCF. No survey was carried out in 2007, 2009-2011 and 2015. The survey was carried out in June/July except from 2012 when it was carried out in December and 2013 when it was carried out in September.

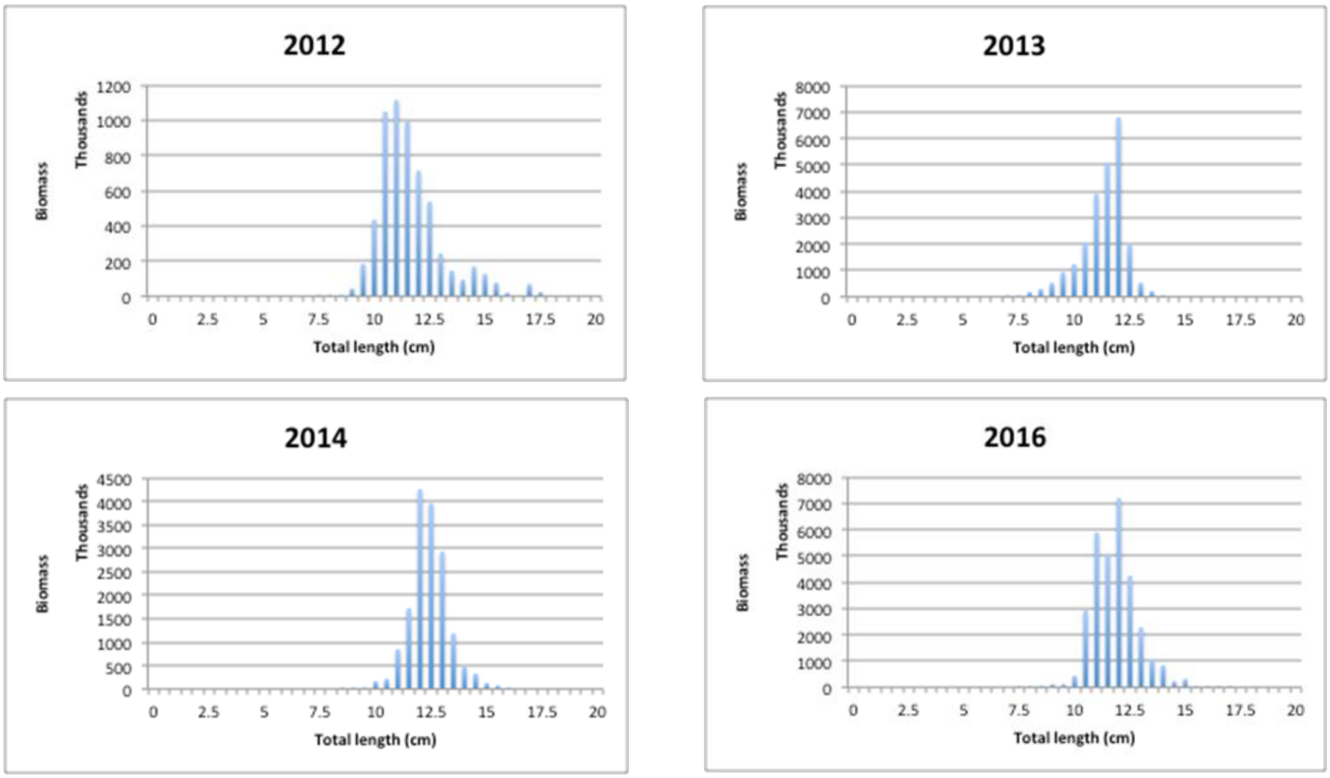


Figure 6.11.1.3.5 Sardine in GSAs 22 & 23. Length frequency distribution of the acoustic survey biomass index of sardine in GSA 22 as reported by DCF. No

survey was carried out in 2007, 2009-2011 and 2015. The survey was carried out in June/July except from 2012 when it was carried out in December and 2013 when it was carried out in September.

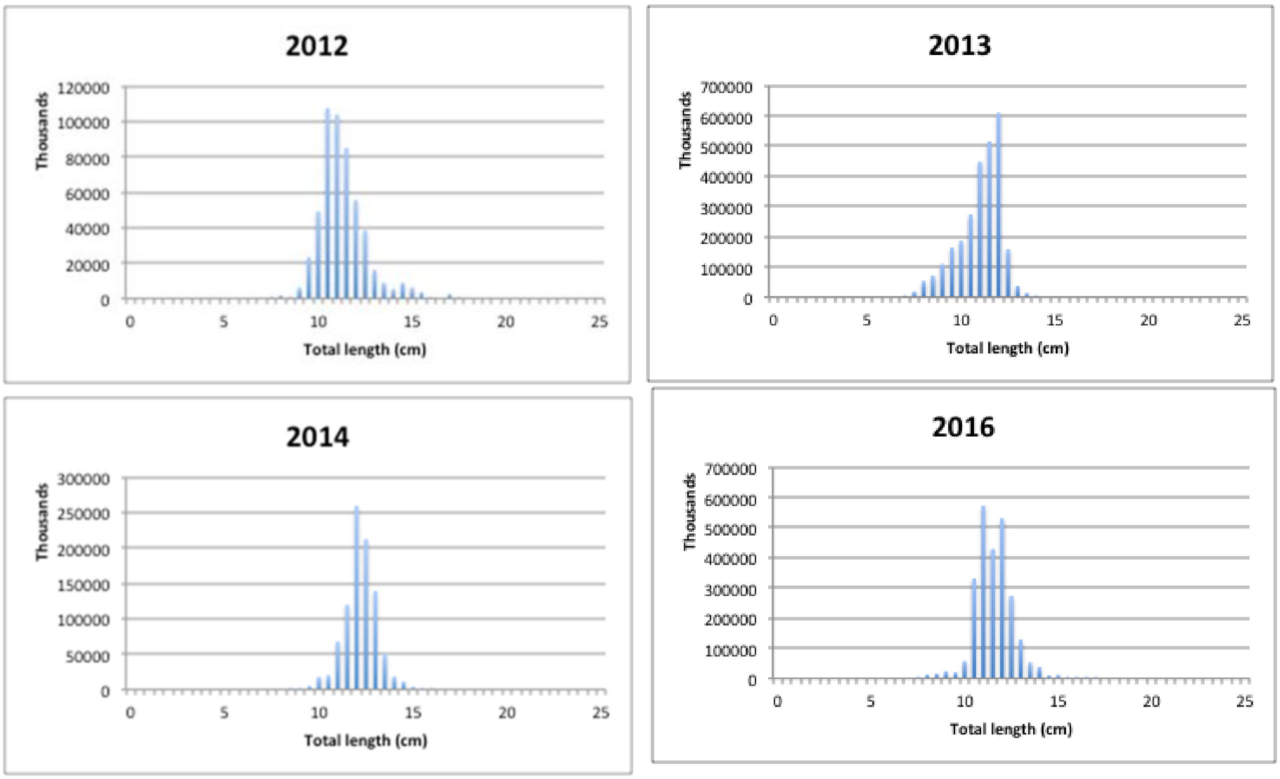


Figure 6.11.1.3.6 Sardine in GSAs 22 & 23. Length frequency distribution of the acoustic survey abundance index of sardine in GSA 22 as reported by DCF. No survey was carried out in 2007, 2009-2011 and 2015. The survey was carried out in June/July except from 2012 when it was carried out in December and 2013 when it was carried out in September.

6.11.2 Stock assessment

Age based methods: a4a and SAM

Two statistical catch-at-age analysis methods were used for this stock. Such methods utilize catch-at-age data to derive estimates of historical population size and fishing mortality. However, unlike VPA, model parameters estimated using catch-at-age analysis are done so by working forward in time and analyses do not require the assumption that removals from the fishery are known without error. Data typically used are: catch, abundance index, statistical sample of age composition of catch and abundance index. Specifically, for sardine stock in GSA 22 we used a) the Assessment for All Initiative (a4a) (Jardim et al., 2015) and b) the State-space Assessment Model (SAM) (Nielsen et al., 2014) in FLR environment. Assessment was performed with version 1.0.2 of FLSAM and 1.1.2 of FLa4a, together with version 2.6.4 of the FLR library (FLCore).

A single tuning fleet was used in both methods based on the biomass at age estimates from summer acoustic surveys conducted in the Greek part of GSA 22 (2003 to 2016 with gaps in 2007, 2009-2013 and 2015) as reported in the DCF.

The analysis was carried out for the ages 0 to 3+ class for the SAM and ages 0 to 4 for the a4a. Concerning the Fbar, the age range used was 1-3 age groups for both methods.

Input data

Sardine (*Sardina pilchardus*) is one of the most important target species for the purse seine fishery in GSA 22. Sardine is being exploited mainly by the purse seine fishery. Pelagic trawls are banned and bottom trawls are allowed to fish small pelagics in percentages less than 5% of their total catch. Commonly sardine is caught from shallow waters about 30 m to 100 m depth.

Growth

Natural mortality (M) was estimated using Gislason (2010) and is shown in Table 6.10.1.1. The input parameters used were Linf = 19.5 cm, k = 0.39, t0 =-0.48. The values of M vector were the used in the last approved assessment for sardine in GSA 22 and compiled in the STECF EWG-11-20 (2012).

Table 6.11.2.1. Sardine in GSAs 22 & 23. Natural mortality estimates per age for sardine in GSA 22.

Age	Age0	Age1	Age2	Age3	Age4
M	1.5	0.96	0.69	0.61	0.57

Maturity

The following maturity at age ogive was used for assessments in GSA 22 as estimated from biological sampling based on length at first maturity estimated approximately at 115 mm (Machias et al., 2001; Machias et al., 2007) in Aegean Sea. The sardine spawning period in GSA 22 extends from November to April with maximum in December-January and a second peak in March.

Table 6.11.2.2 Sardine in GSAs 22 & 23. Proportion of mature fish by age.

Age 0	Age 1	Age 2	Age 3	Age 4
0.5	1	1	1	1

Catch Data

The time series of total PS landings for the Greek part of GSA 22 as estimated in the STECF EWG 16-05 (2016) was used for the period 2000-2014 (Figure

6.11.3.3.1). For 2013 and 2015 the DCF reported landings referred only to the last trimester thus the HELSTAT officially reported landings to FAO GFCM were used. The DCF reported landings were used for 2016. Based on the DCF reported discards as well as on Tsagarakis et al. (2014) discards were considered very low and were added as a 2% percentage in the landings reported data. Thus for the assessment catch was considered equal to the reported landings and no further amounts were added for discards. The total catch data used for assessment are reported in Table 6.11.2.3.

PS catch at age data for the period 2000-2008 were those reported and used in the last approved assessment for sardine in GSA 22 and compiled in the STECF SGMED-09-03 (2009). No DCF was carried out in 2007, 2009-2012. DCF covered only the last quarter in 2013 and 2015. Thus in the a4a method, NA (non available) was used for the catch at age data in the years that no DCF was carried out. As, the SAM model does not allow gaps in the catch at age information, for the years that no DCF data was collected the catch at age was estimated based on the length frequency available in the years before and after the non reported period (e.g. LF for 2009 and 2010 similar to 2008, LF for 2012 similar to the one in 2013 and 2014). Age structure of the catch data used for assessment is the DCF reported as well as the Hellenic Centre for Marine Research age readings (Figure 6.11.2.1).

Table 6.11.2.3 Sardine in GSAs 22 & 23. Observed catch data in tonnes used as input for the a4a and SAM assessment.

Year	Catches
2000	18083
2001	19163
2002	11461
2003	8405
2004	8736
2005	14685
2006	13152
2007	9167
2008	9831
2009	12207
2010	7865
2011	6848
2012	6847
2013	7118
2014	7714
2015	8451
2016	10831

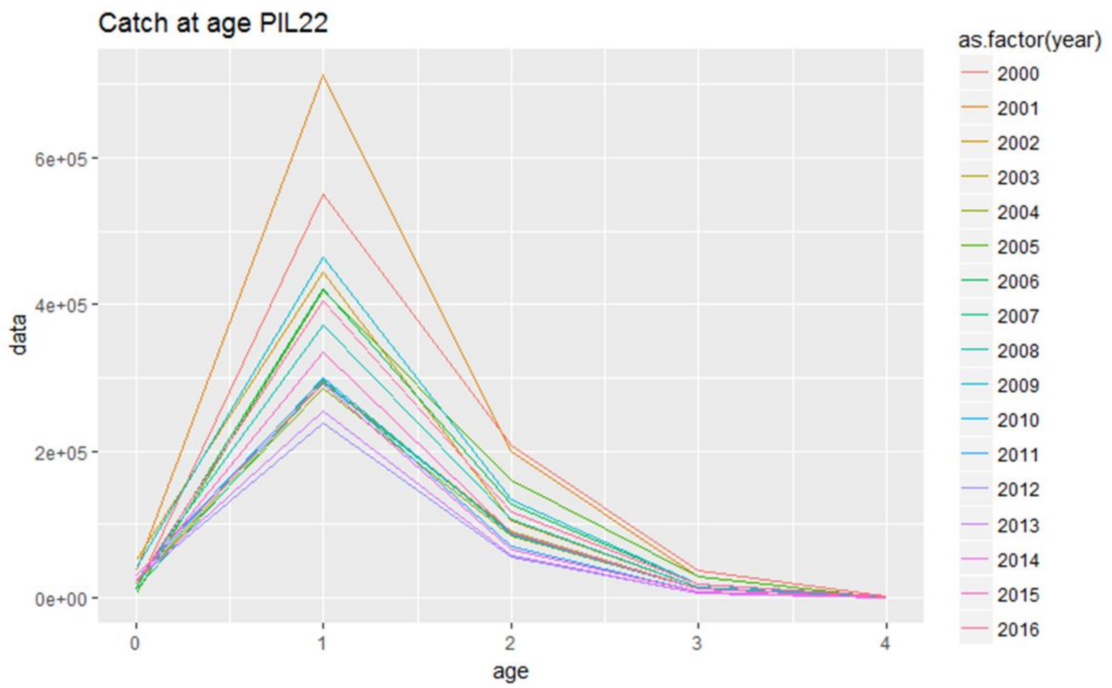


Figure 6.11.2.1 Sardine in GSAs 22 & 23. Age structure of the catch data used in the a4a and SAM assessments. Note that for the a4a NAs were used for years 2007, 2009-2012..

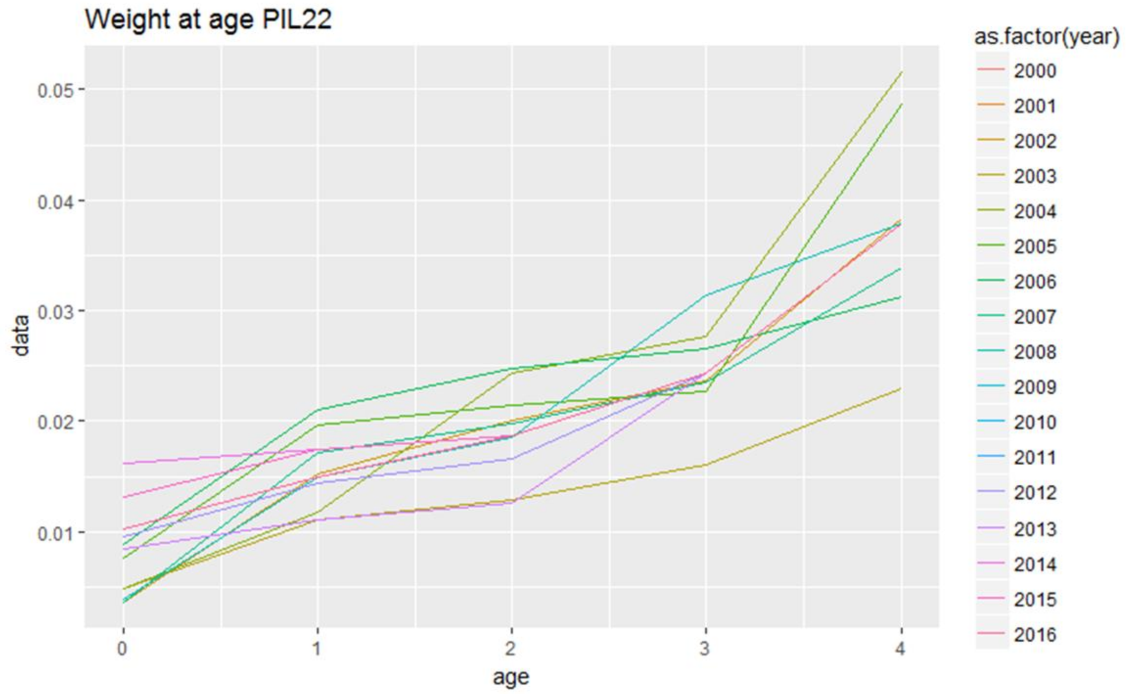


Figure 6.11.2.2 Sardine in GSAs 22 & 23. Weight at age in the stock.

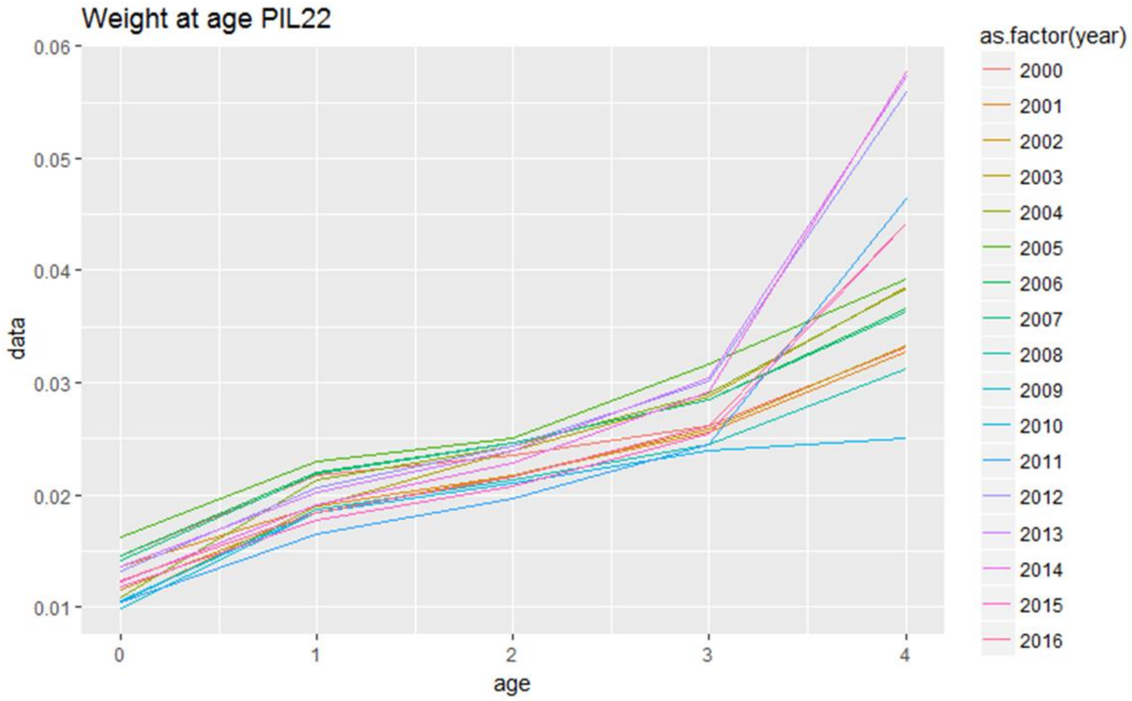


Figure 6.11.2.3 Sardine in GSAs 22 & 23. Weight at age in the catch.

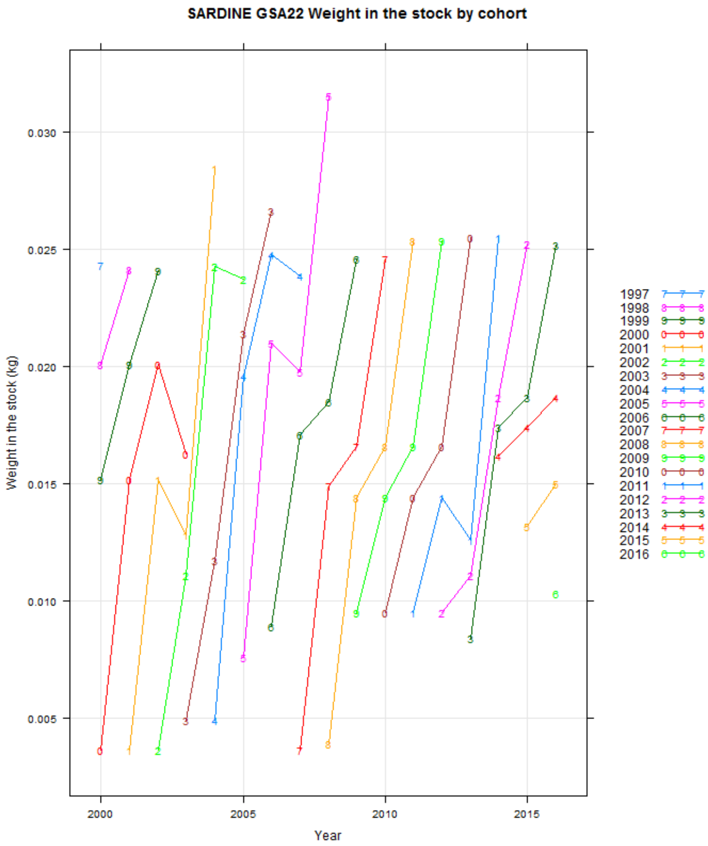


Figure 6.11.2.4 Sardine in GSAs 22 & 23. Weight at age in the stock by cohort.

Discards

Discards data were reported to STECF EWG 17-09 through the DCF. Age structure of the discards is missing for all the years and gears. Discards although considered negligible they were taken into account for the assessment as a 2% percentage to reported landings. The fishery is multispecies and fishermen tend to avoid schools of undersized anchovies/sardines due to sorting difficulties (blocking of the mess) and low price, practically by using nets of bigger mesh size, targeting mostly mackerels or horse mackerels.

Survey Indices of abundance and biomass by year and size/age

Acoustic surveys

We used reported data to STECF EWG 17-09 through the DCF concerning the evaluations of the acoustic surveys for 2003 to 2016 of total biomass, abundance, length and age composition for sardine in GSA 22.

Acoustic surveys methodology

Acoustic echoes were registered continuously along 70 pre-defined transects in the study area in June 2003, 2004, 2005, 2006 and 2008, 2014 with a Biosonics Split Beam 38 kHz DT-X echosounder. The survey in 2016 was carried out with a Simrad Split Beam EK80 at 38 kHz. No acoustic survey took place in 2007, 2009-2011. Survey in 2012 was held in December covering a very small part of the monitored area and the survey in 2013 was held in September. The acoustic survey in GSA 22 is part of the Mediterranean Acoustic Survey (MEDIAS) since 2008 and follows the MEDIAS protocol. Echo trace classification was applied based on a) echogram visual scrutinisation and direct allocation of school marks that characterise anchovy as well as b) allocation on account of representative fishing stations that were held along transects (Simmonds and MacLennan, 2005).

Trends in abundance by age

Abundance indexes were reported to STECF EWG 17-09 through DCF. European Sardine time series of abundance and biomass indices from acoustic surveys in GSA 22 are shown and described in the following figure.

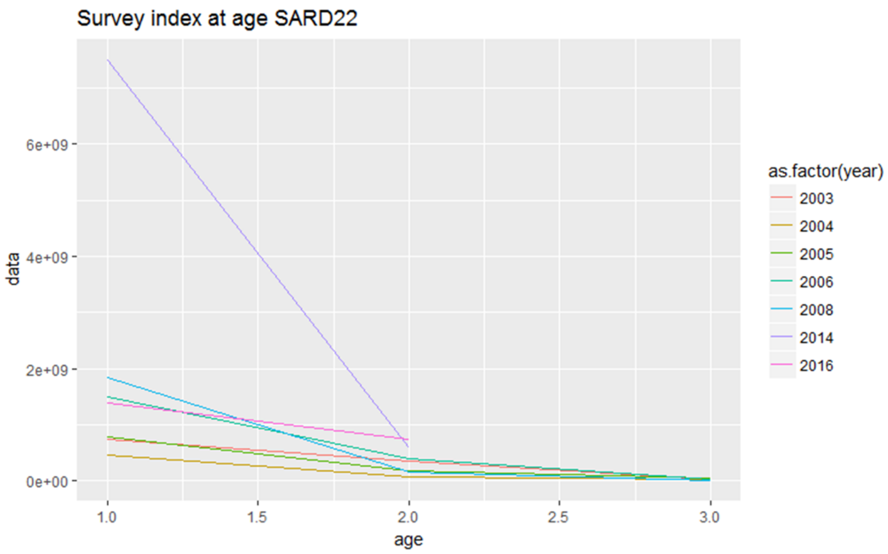


Figure 6.11.2.5 Sardine in GSAs 22 & 23. Acoustic survey abundance index of sardine in GSA 22 by age, as reported by the DCF and used for assessment. No survey was carried out in 2007, 2009-2011 and 2015. The survey was carried out in June/July except from 2012 when it was carried out in December and 2013 when it was carried out in September.

Assessment results

METHOD A4A

Different a4a models were performed (combination of different f, q). The best model (according to a combination of AIC, BIC and residuals) included:

f~ s(replace(age, age>2,2),k=3)+s(year, k = 4)+s(year, k = 5, by = as.numeric(age==0))

q~factor(age)

sr ~geomean(CV=0.5)

Results are shown in Figures 6.11.2.6-6.11.2.13

Based on the a4a assessment, the sardine SSB fluctuated over the time period examined (2000-2016) from 11949 tons (in 2003) to 40084 tons in 2015. A drop in SSB was observed in the years 2009 to 2013 followed by an increase up to 2016. This is generally in accordance with the SAM results that estimate SSB at 18924 tons in 2016. The assessment shows an increasing trend in the number of recruits since 2011. The recruitment (age 0) reached a maximum of 8.15 million individuals in 2015 and a minimum value of 2.95 million individuals in 2011. The recruitment in 2016 is estimated to be 6.18 million individuals. Fbar (1-3) shows a decreasing trend since 2011 reaching the value of 0.53 in 2016.

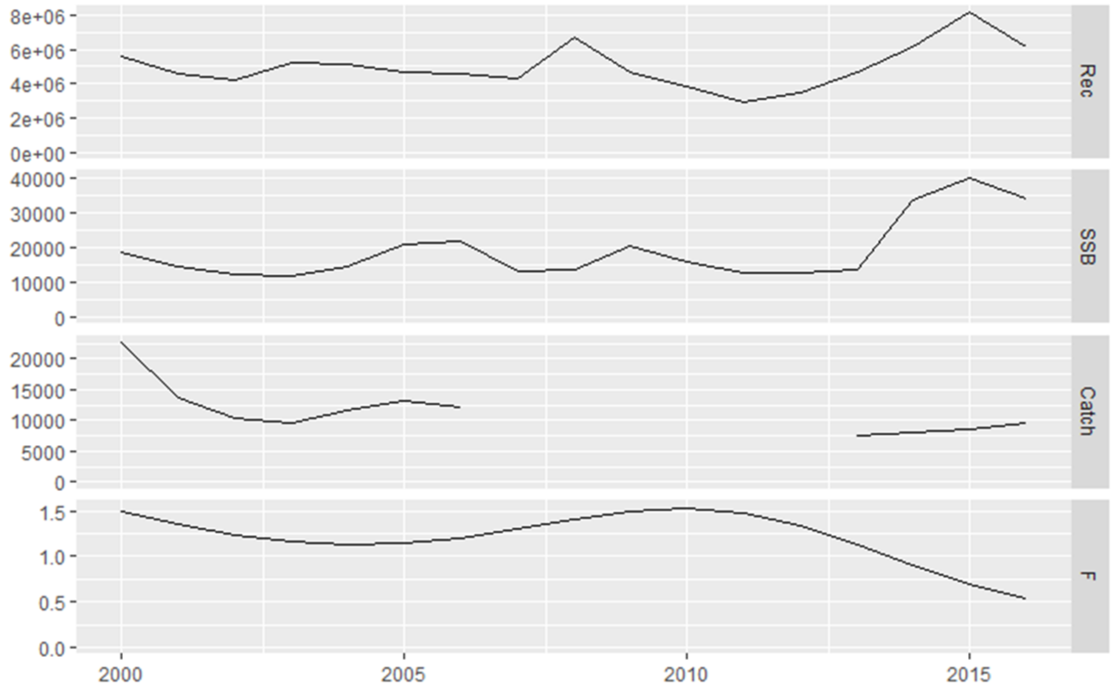


Figure 6.11.2.6 Sardine in GSAs 22 & 23. Stock summary for sardine in GSA 22, recruits, SSB (Stock Spawning Biomass), catch (model output for catch and landings) and harvest (fishing mortality for ages 1 to 3).

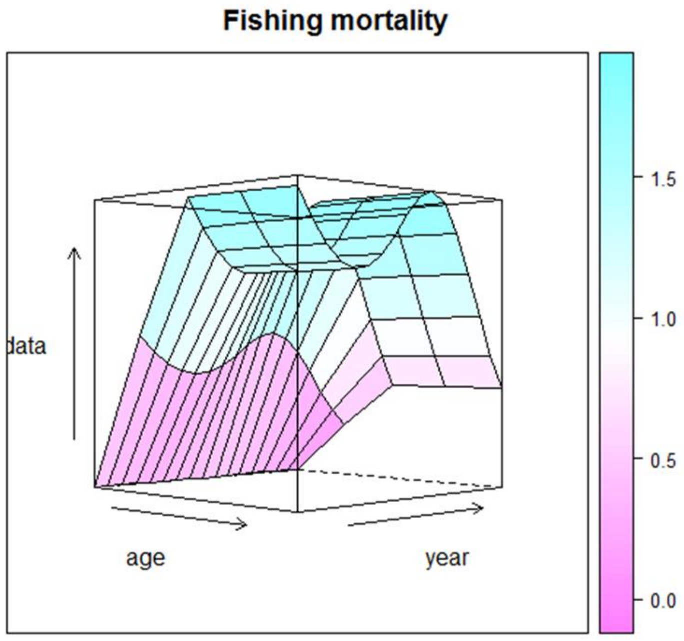


Figure 6.11.2.7 Sardine in GSAs 22 & 23 3D contour plot of estimated fishing mortality at age and year

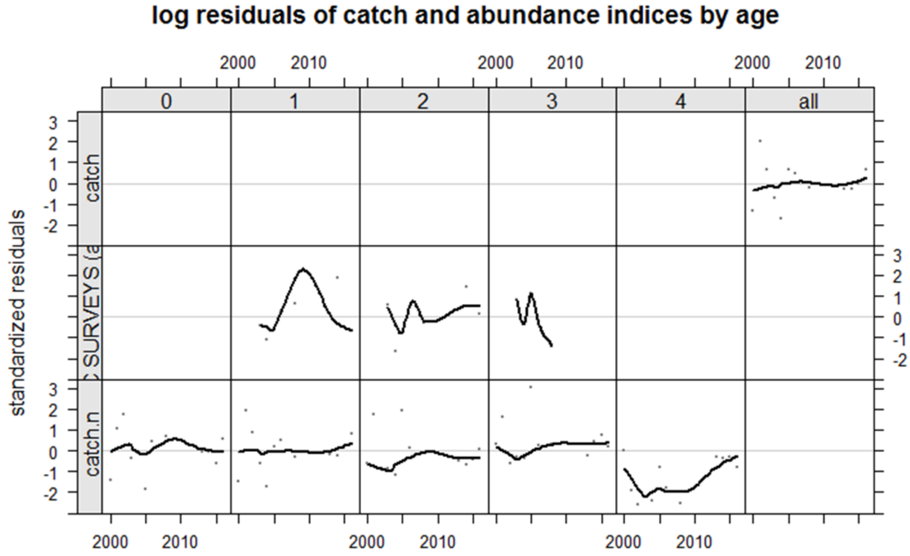


Figure 6.11.2.8 Sardine in GSAs 22 & 23. Standardized residuals for abundance indices (acoustic surveys) and for catch numbers (catch.n). Each panel is coded by age class, dots represent standardized residuals and lines a simple smoother.

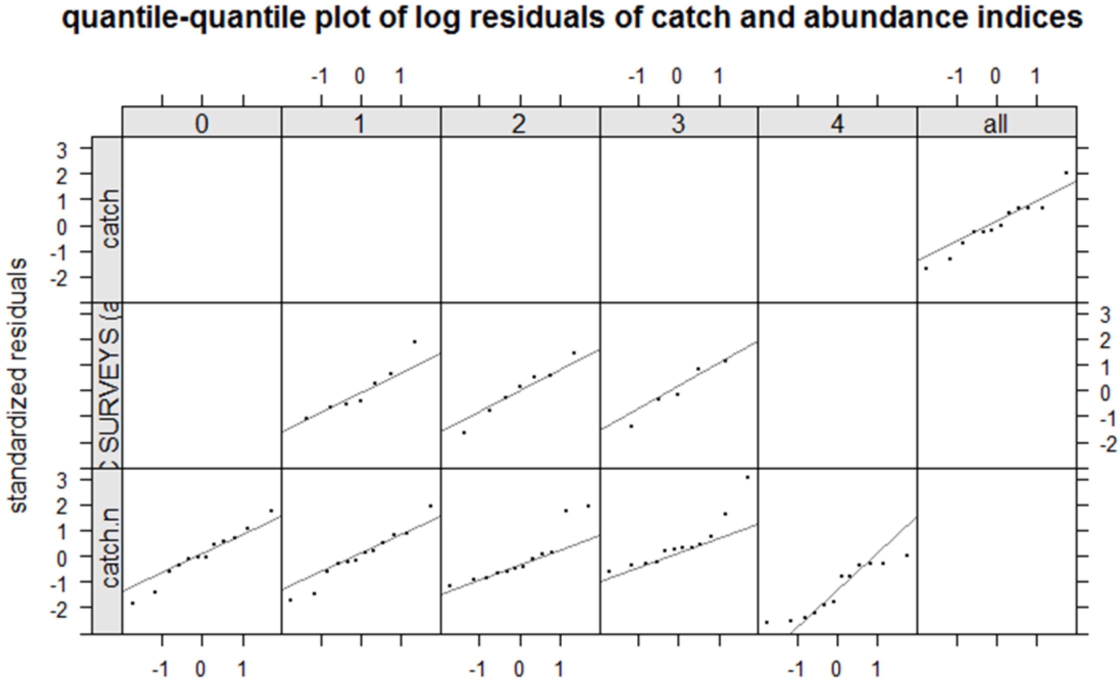


Figure 6.11.2.9 Sardine in GSAs 22 & 23. Quantile-quantile plot of standardized residuals for abundance indices (acoustic surveys) and for catch numbers (catch.n). Each panel is coded by age class, dots represent standardized residuals and lines the normal distribution quantiles.

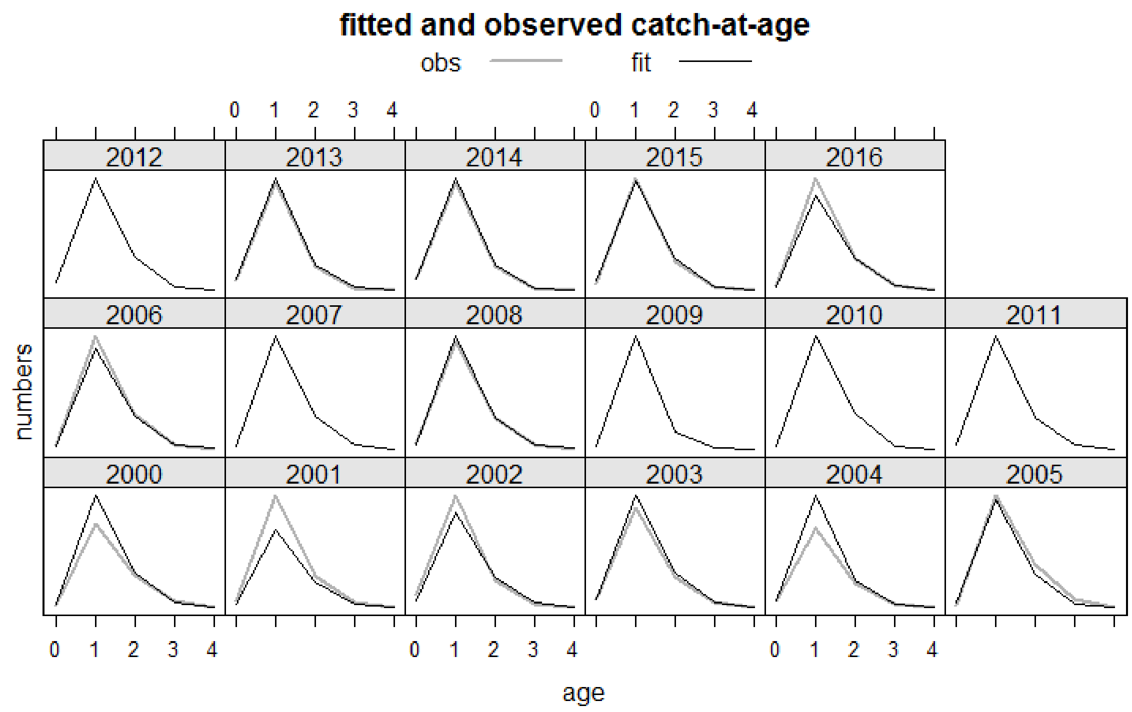


Figure 6.11.2.10 Sardine in GSAs 22 & 23. Fitted and observed catch at age

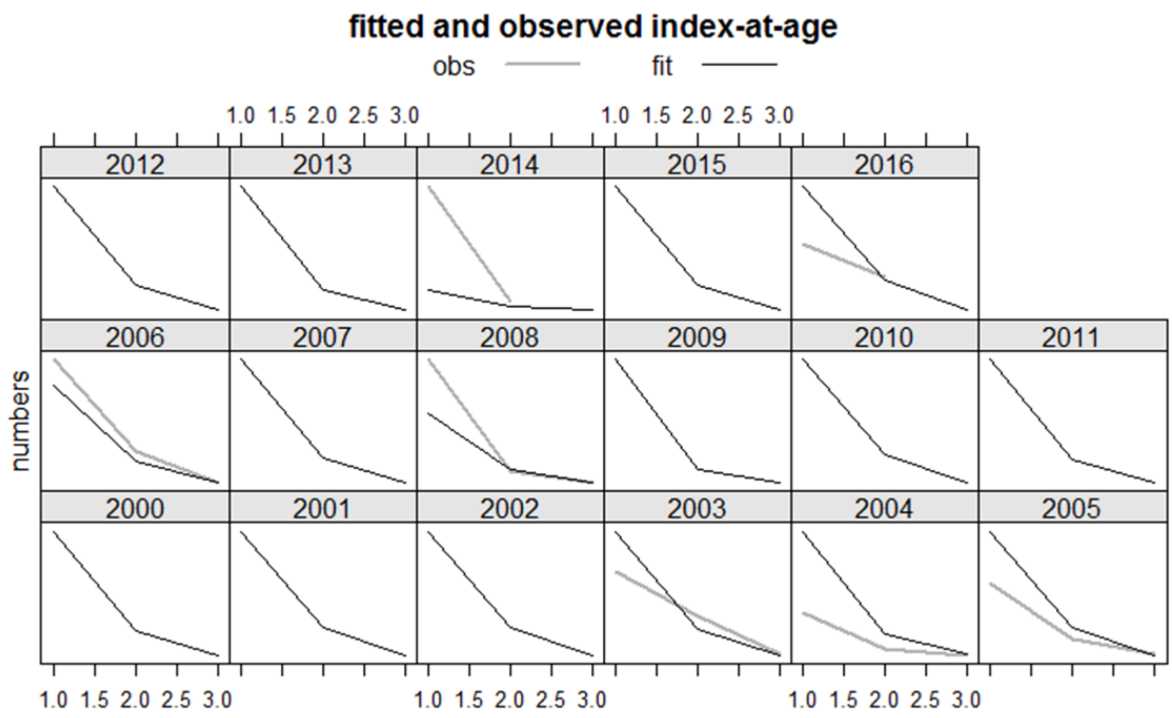


Figure 6.11.2.11 Sardine in GSAs 22 & 23. Fitted and observed index at age

Retrospective

The retrospective analysis was applied up to 3 years back. Models results were quite stable (Figure 6.11.2.12).

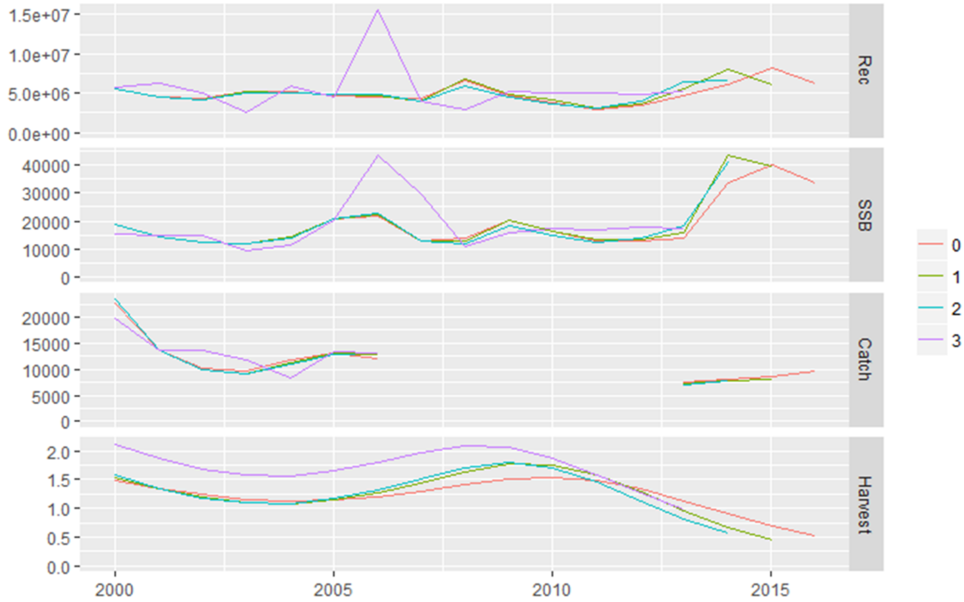


Figure 6.11.2.12 Sardine in GSAs 22 & 23. Retrospective analysis output

Simulations

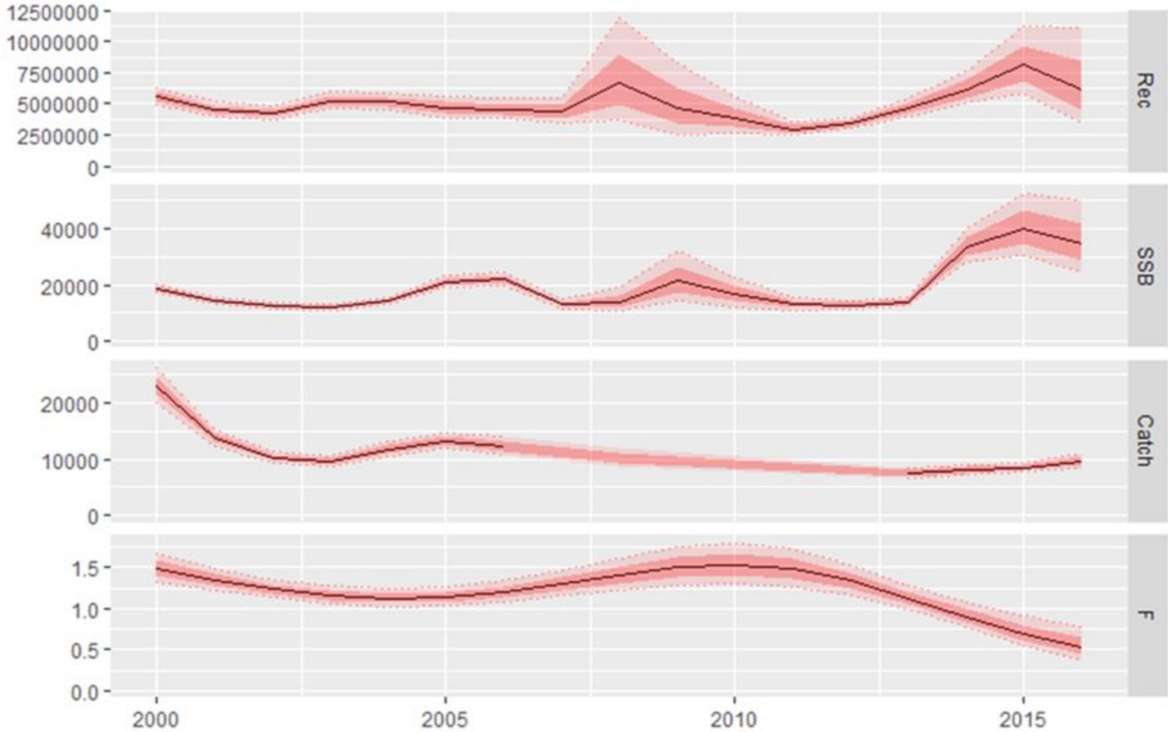


Figure 6.11.2.13 Sardine in GSAs 22 & 23. Stock summary of the simulated and fitted data

The EWG 17-09 concluded that the output of this model was suitable to provide an indication of the current status of the stock. However due to the lack of surveys and catch-at-age data for a big part of the time series since 2009 the EWG 17-09 agreed not to provide forward projections and catch advice based on this assessment. Overall this modelling approach where missing data are dealt with correctly in the model is preferred to the other models described below.

Method SAM

The summary output of the SAM model for sardine stock in GSA 22 is shown in Figure 6.11.2.14.

Based on the model results sardine stock SSB fluctuated over the time period examined (2000-2016) from 24760 tons (in 2013) to 18924 tons in 2016. A drop in SSB was observed in the years 2009 to 2013. The recruitment (age 0) presented a maximum of 5 in 2000 (million individuals) and a minimum value of 3.5 million individuals in 2011. Since then, recruitment slightly increases until 2016 (4.29 million individuals). Concerning the state of exploitation, the Fbar (1-3) showed a slightly decreasing trend since 2012 reaching a value at 0.99 in 2016.

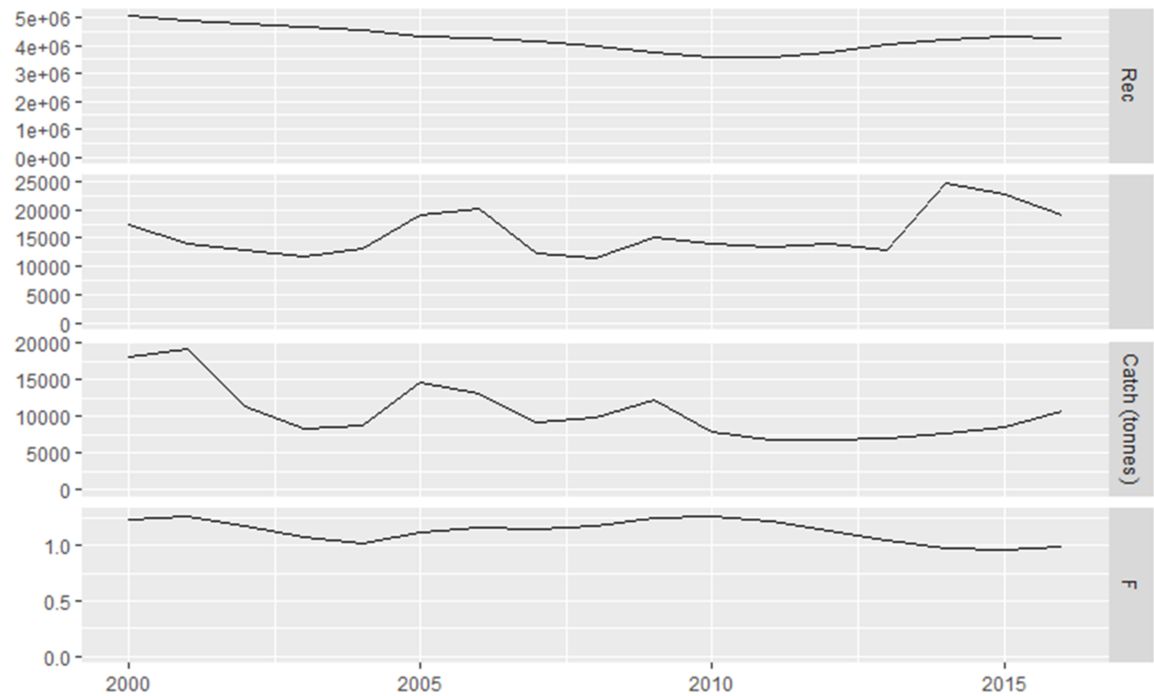


Figure 6.11.2.14 Sardine in GSAs 22 & 23. Stock Biomass (SSB) in tons (on top). F (age 1 to 3) (middle); recruitment (as thousands individuals) (bottom); 95% confidence intervals are shown.

Due to the very short time series of the tuning index (2003-2016) and especially the gaps in the tuning index (2007, 2009-2013, 2015) no retrospective analysis was run.

Selection pattern (F/Fbar) by age class is plotted in Figure 6.11.2.15. The plots show a rather constant pattern in selectivity in all the pentads in the time series of data.

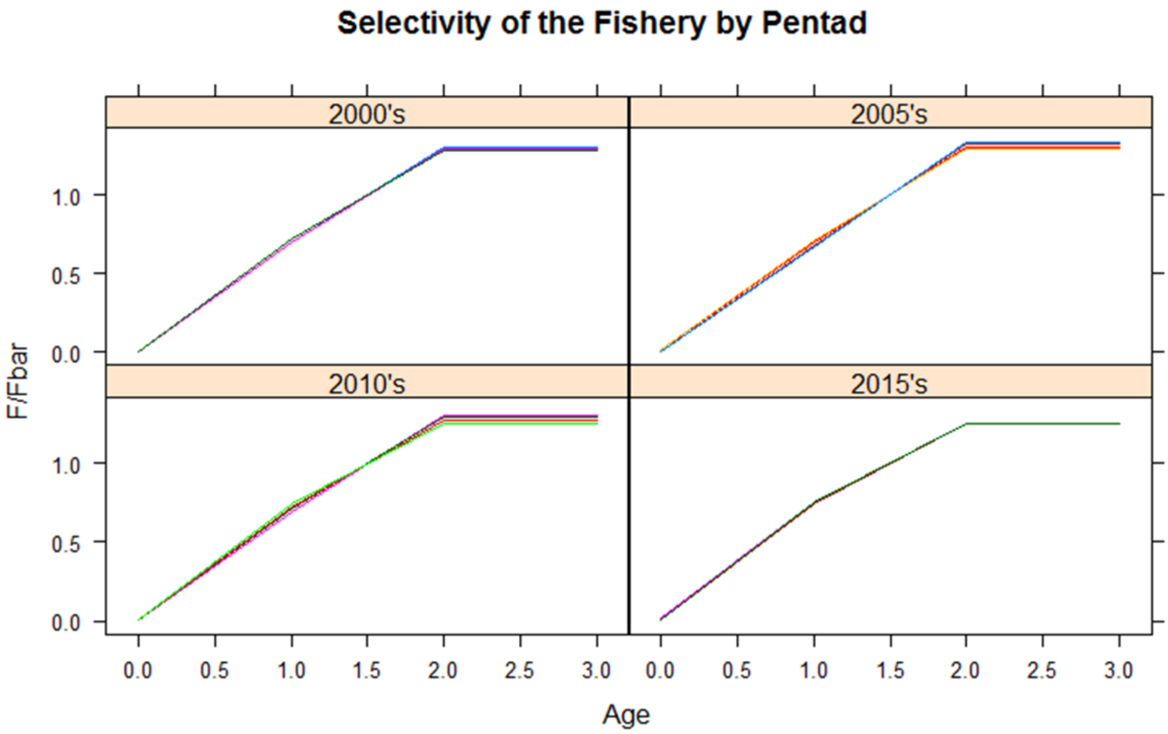


Figure 6.11.2.15 Sardine in GSAs 22 & 23. Selectivity at age by pentads as estimated by the SAM model.

In general, catch residuals did not show any apparent trend. As concerns survey data, both age 1 and 2 presented high residuals in 2014 and 2016. (Figure 6.11.2.16 and 6.11.2.17).

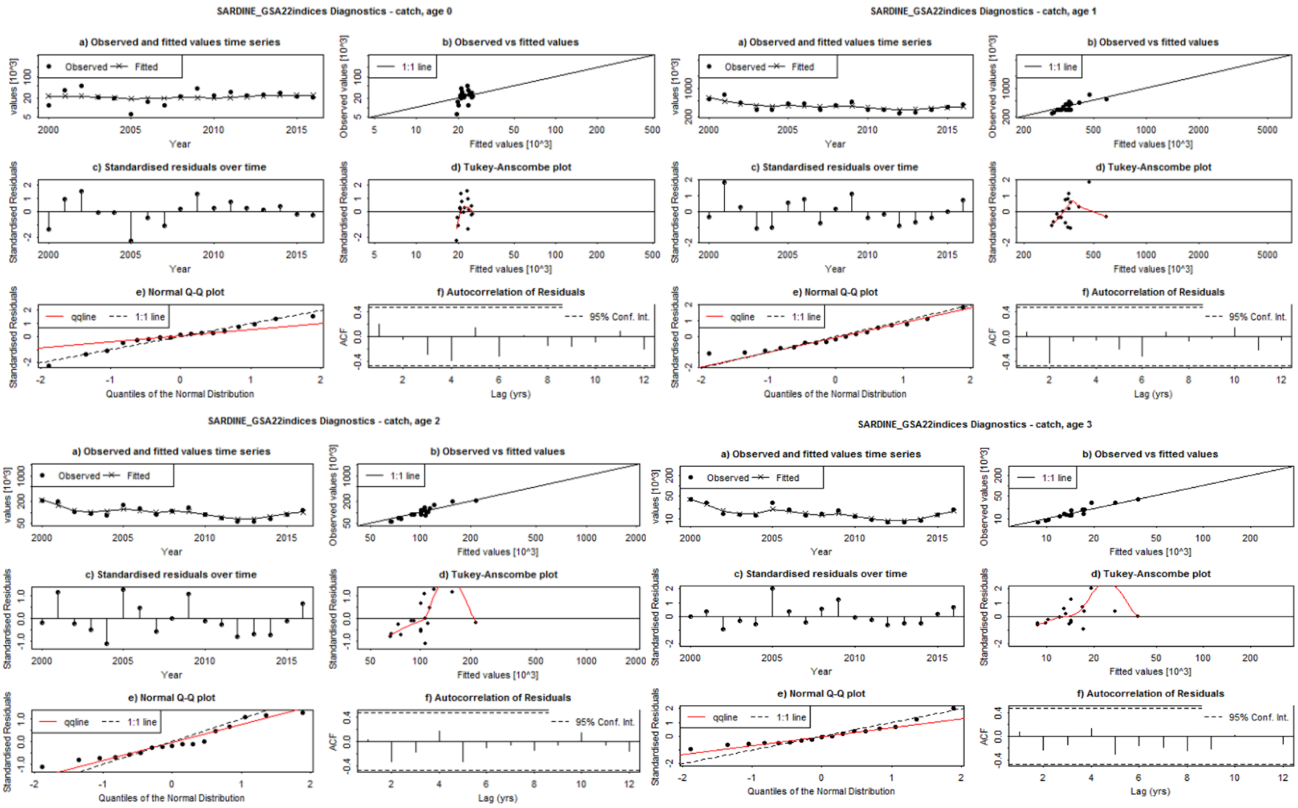


Figure 6.11.2.16 Sardine in GSAs 22 & 23. Diagnostic in the catch at age structure residuals for ages 0, 1, 2, 3.

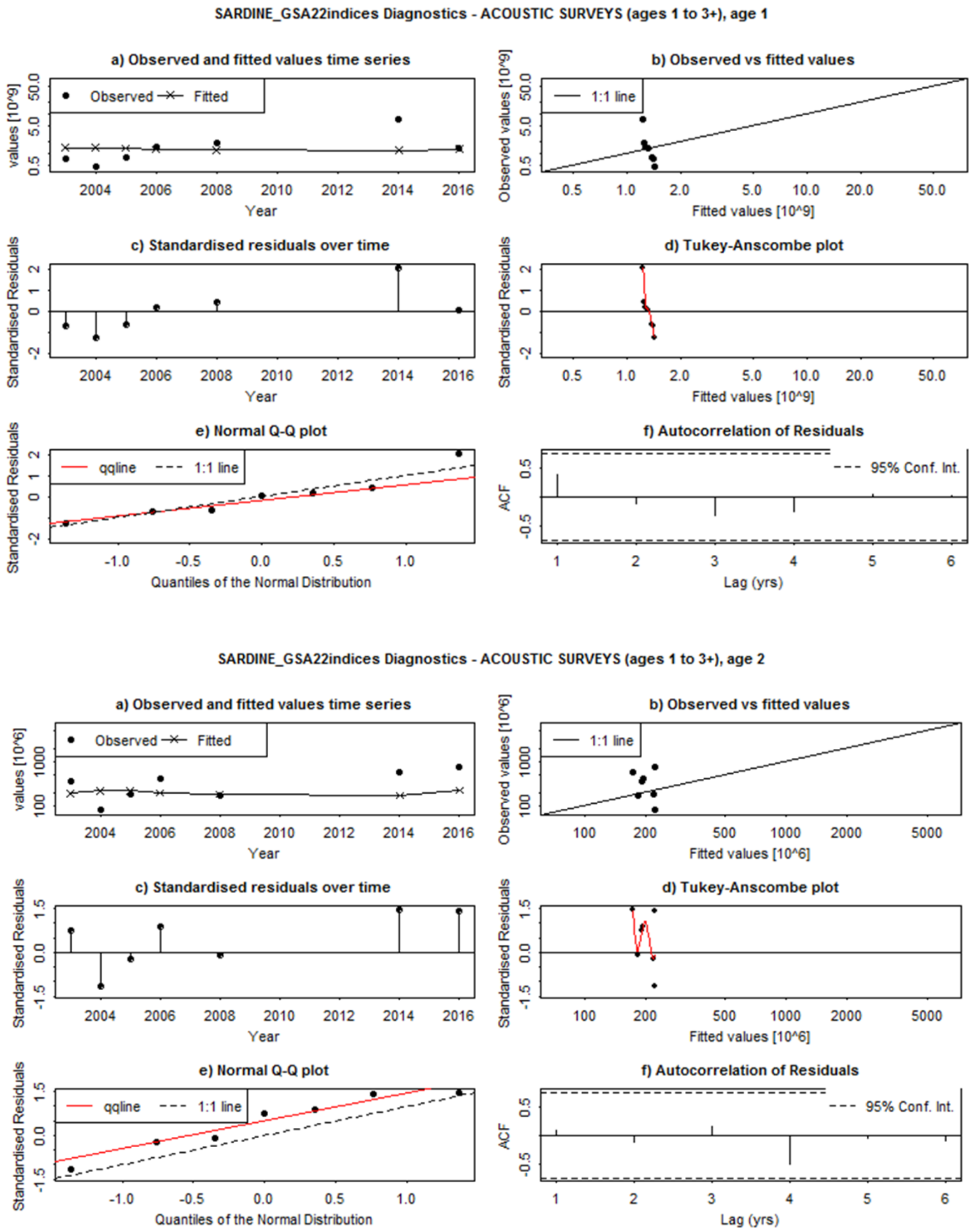


Figure 6.11.2.17 Sardine in GSAs 22 & 23. Diagnostic in the survey index structure residuals for ages 1 and 2.

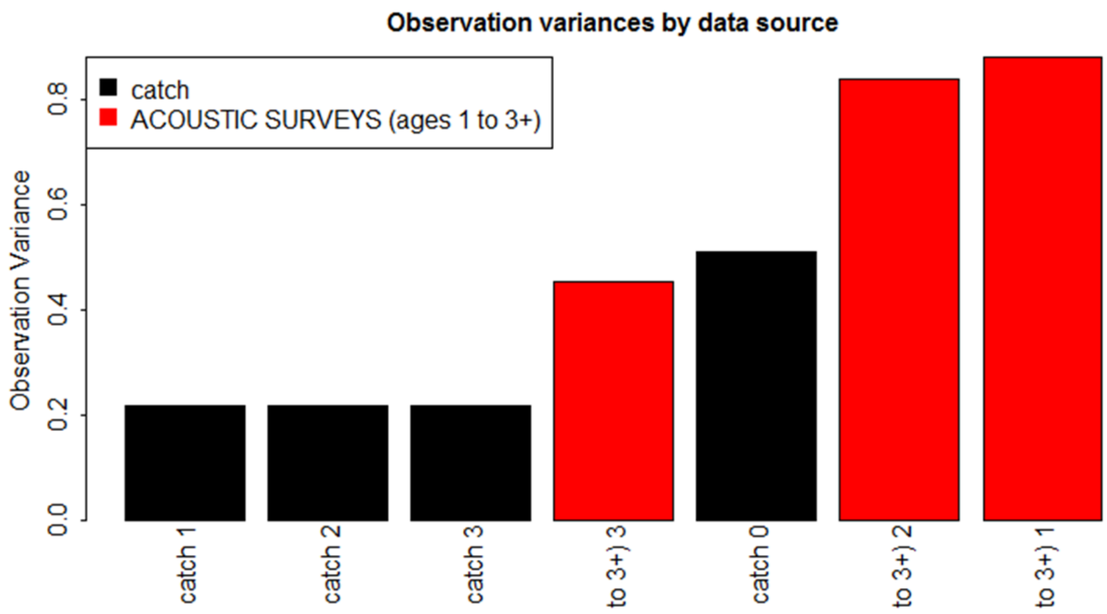


Figure 6.11.2.18 Sardine in GSAs 22 & 23. Plot of the observation variances by input data.

Observation variances by input data (Figure 6.11.2.18) showed that model tends to fit most closely to the catch data. The variability in the survey data is also low. The EWG 17-09 concluded that also the output of this model was suitable to provide an indication of the current status of the stock but the lack of surveys and catch-at-age data for a big part of the time series since 2009 and the need to apply assumptions for the age structure of the catch the EWG 17-09 considered that the preferred model is a4a given above.

Surplus Production Method: SPICT

The Surplus Production in Continuous time (SPiCT) assessment method is fully described in Pedersen and Berg (2017). SPiCT is available as an R (R Core Team 2015) package in the github online repository: https://github.com/mawp/spict.

SPiCT requires a time series of catches and one (or more) time series of tuning index (CPUE or biomass). The expected output includes management reference points F/Fmsy and B/Bmsy that quantify the exploitation rate and stock status. A forecasting period and a fishing management scenario can be tested by changing the multiplication factor that is applied to the current fishing mortality and projecting to the future. Main advantages of SPiCT are:

1. All estimated reference points (MSY, Fmsy, Bmsy) are reported with uncertainties.
2. The model can be used for short-term forecasting and management strategy evaluation.
3. The model is fully stochastic in that observation error is included in catch and index observations, and process error is included in fishing and stock dynamics.
4. The model is formulated in continuous-time and can therefore incorporate arbitrarily sampled data.

Input data

Catches

The official reported landings from the entire Aegean Sea (GSA 22) were used as reported in the FishStat J from the GFCM Database. The catch data from 1980 to 2015 (latest available year) was used. Data prior to 1985 were excluded because they were considered unreliable because of the very low landings from Turkey.

Biomass

The biomass from acoustics surveys that were conducted in the Greek part of the Aegean Sea was used as tuning index. Acoustics data were available by DCF from 2003 onwards (with gaps in 2007, 2009-2012 and 2015). Acoustic estimates in 1995 and 1996 from the Greek part of North Aegean Sea were based on a past research project (Tsimenides et al, 1996; Machias et al., 1997) provided by Marianna Giannoulaki.

Table 6.11.2.4. Sardine in GSAs 22 & 23. Official landings (tons) for sardine in GSA 22 (GFCM database, Greece and Turkey together).

Year	Greek landings (t)	Turkish landings (t)
1980	12062	7959
1981	11591	6999
1982	11581	5846
1983	9524	6376
1984	6967	8154
1985	11064	10486
1986	10133	9327
1987	9466	9234
1988	8772	9456
1989	9355	20112
1990	10154	9216
1991	13616	15610
1992	18536	20024
1993	19143	23439
1994	18784	15045
1995	18022	22150
1996	17713	12332
1997	19189	9055
1998	16190	13774
1999	14292	3351
2000	15065	9205
2001	13258	6467
2002	15116	5008
2003	7241	7068
2004	8182	7588
2005	10032	12489
2006	10322	12750
2007	8686	13088
2008	9645	9777
2009	9183	14107
2010	5900	10838
2011	5159	10015
2012	4435	9974
2013	5978	9415
2014	7648	10483

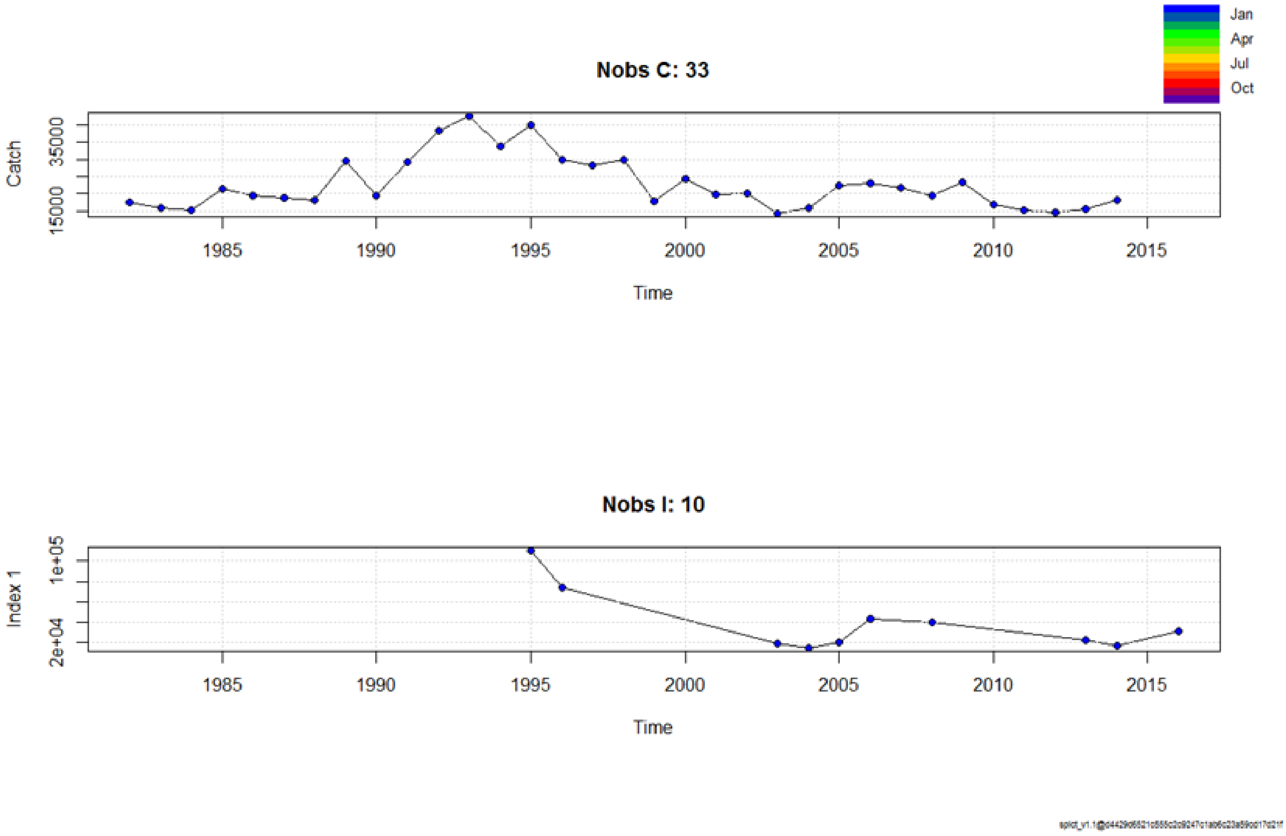


Figure 6.11.2.19 Sardine in GSAs 22 & 23. Input data for sardine in GSA 22.

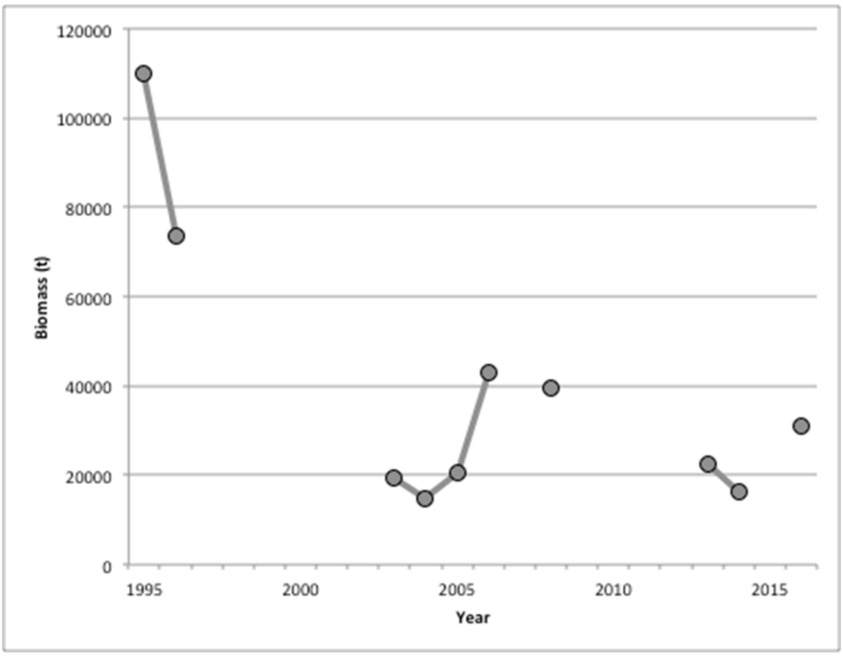


Figure 6.11.2.20 Sardine in GSAs 22 & 23. Acoustic index as biomass (tons) for sardine in GSA 22.

Assessment results

Stock summary

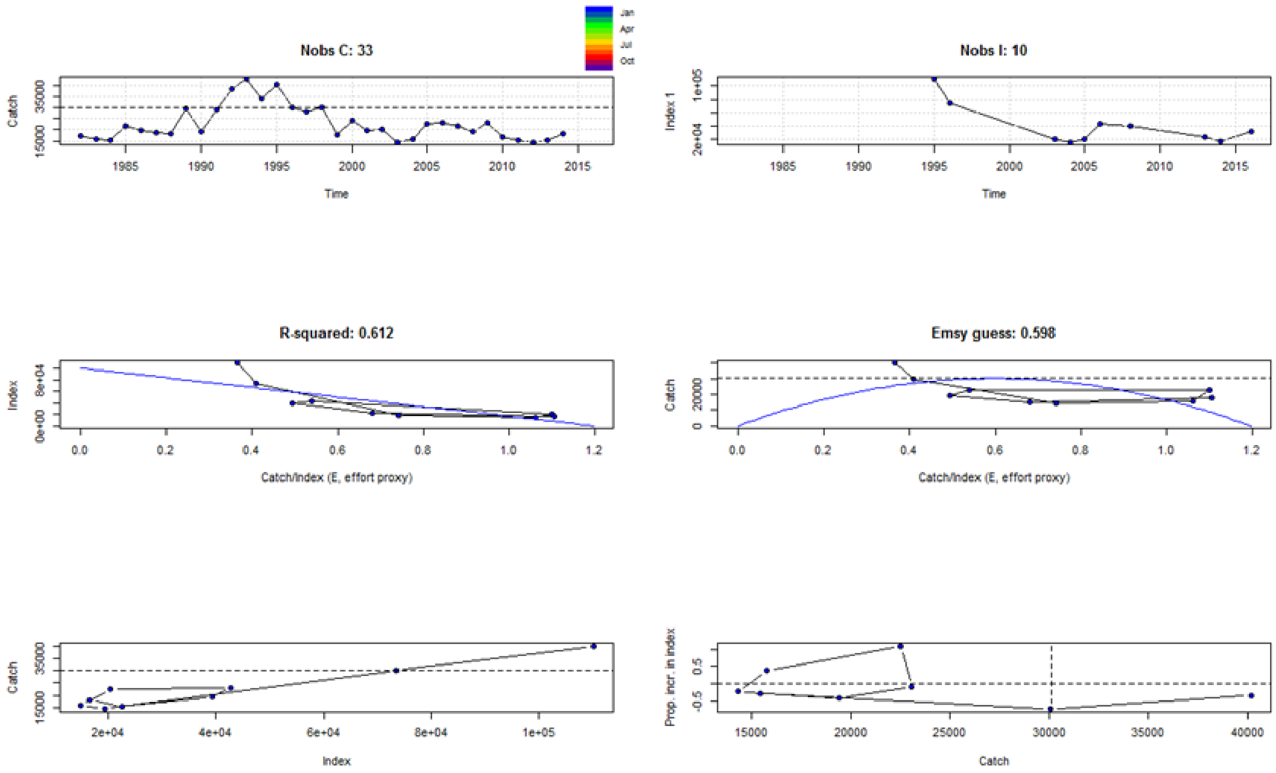


Figure 6.11.2.21 Sardine in GSAs 22 & 23. Summary of the final SPiCT model fit and output. Absolute and relative Biomass and Fishing mortality, state of the stock in F/B space and relative to estimated production.

The output of the model (Model estimates, reference points and summaries) are reported below.

```
[1] "Convergence: 0  MSG: relative convergence (4)"
 [2] "Objective function at optimum: 17.2572975"
 [3] "Euler time step (years):  1/16 or 0.0625"
 [4] "Nobs C: 33,  Nobs I1: 10"
 [5] "Catch/biomass unit: tones "
 [6] ""
 [7] "Priors"
 [8] "     logn  ~  dnorm[log(2), 2^2]"
 [9] " logalpha  ~  dnorm[log(1), 2^2]"
[10] "  logbeta  ~  dnorm[log(1), 2^2]"
[11] ""
[12] "Fixed parameters"
[13] "   fixed.value  "
[14] " n           2  "
[15] ""
[16] "Model parameter estimates w 95% CI "
[17] "           estimate        cilow        ciupp    log.est  "
[18] " alpha  1.809337e+00 7.038596e-01 4.651069e+00  0.5929604  "
[19] " beta   2.660321e+00 2.342739e-01 3.020956e+01  0.9784470  "
[20] " r      4.922035e-01 5.306840e-02 4.565135e+00 -0.7088631  "
[21] " rc     4.922035e-01 5.306840e-02 4.565135e+00 -0.7088631  "
[22] " rold   4.922035e-01 5.306840e-02 4.565135e+00 -0.7088631  "
[23] " m      2.605310e+04 1.576419e+04 4.305734e+04 10.1678922  "
[24] " K      2.117263e+05 2.928071e+04 1.530974e+06 12.2630496  "
[25] " q      4.638538e-01 1.620400e-02 1.327825e+01 -0.7681859  "
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[28] " sdi    3.459922e-01 1.824741e-01 6.560414e-01 -1.0613391  "
[29] " sdc    1.287497e-01 8.404810e-02 1.972261e-01 -2.0498852  "
[30] " "
[31] "Deterministic reference points (Drp)"
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[33] " Bmsyd 1.058631e+05 1.464036e+04 7.654871e+05 11.56990  "
[34] " Fmsyd 2.461017e-01 2.653420e-02 2.282567e+00 -1.40201  "
[35] " MSYd  2.605310e+04 1.576419e+04 4.305734e+04 10.16789  "
[36] "Stochastic reference points (Srp)"
[37] "          estimate        cilow        ciupp   log.est rel.diff.Drp  "
[38] " Bmsys 1.007497e+05 1.481747e+04 6.850357e+05 11.520394  -0.05075413  "
[39] " Fmsys 2.371399e-01 2.365610e-02 2.377198e+00 -1.439105  -0.03779138  "
```

```
[40] " MSYs  2.384594e+04 1.271354e+04 4.472626e+04 10.079369  -0.09255922  "
[41] ""
[42] "States w 95% CI (inp$msytype: s)"
[43] "                  estimate       cilow       ciupp    log.est  "
[44] " B_2016.00       5.880351e+04 1707.9395194 2.024575e+06 10.9819568  "
[45] " F_2016.00       3.245621e-01    0.0105306 1.000331e+01 -1.1252782  "
[46] " B_2016.00/Bmsy 5.836595e-01    0.0773426 4.404539e+00 -0.5384375  "
[47] " F_2016.00/Fmsy 1.368653e+00    0.3635089 5.153134e+00  0.3138268  "
[48] ""
[49] "Predictions w 95% CI (inp$msytype: s)"
[50] "                 prediction       cilow       ciupp    log.est  "
[51] " B_2016.00       5.880351e+04 1.707940e+03 2.024575e+06 10.9819568  "
[52] " F_2016.00       3.245621e-01 1.053060e-02 1.000331e+01 -1.1252782  "
[53] " B_2016.00/Bmsy 5.836595e-01 7.734260e-02 4.404539e+00 -0.5384375  "
[54] " F_2016.00/Fmsy 1.368653e+00 3.635089e-01 5.153134e+00  0.3138268  "
[55] " Catch_2016.00  1.919464e+04 1.182044e+04 3.116925e+04  9.8623865  "
[56] " E(B_inf)       5.051207e+04           NA           NA 10.8299675
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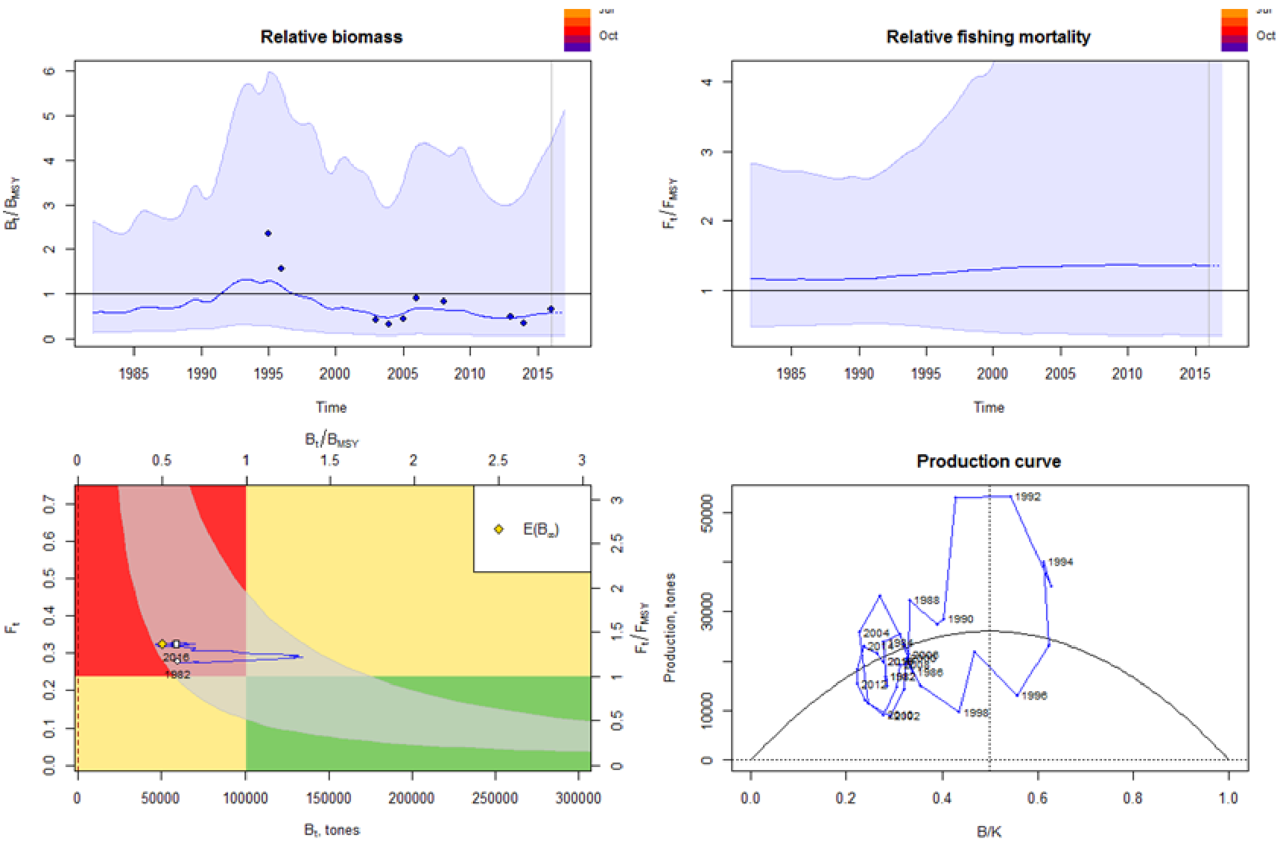

Figure 6.11.2.22 Sardine in GSAs 22 & 23. Relative biomass and fishing mortality, F/B plot and production curve as given by the SPiCT model for sardine in GSA 22.

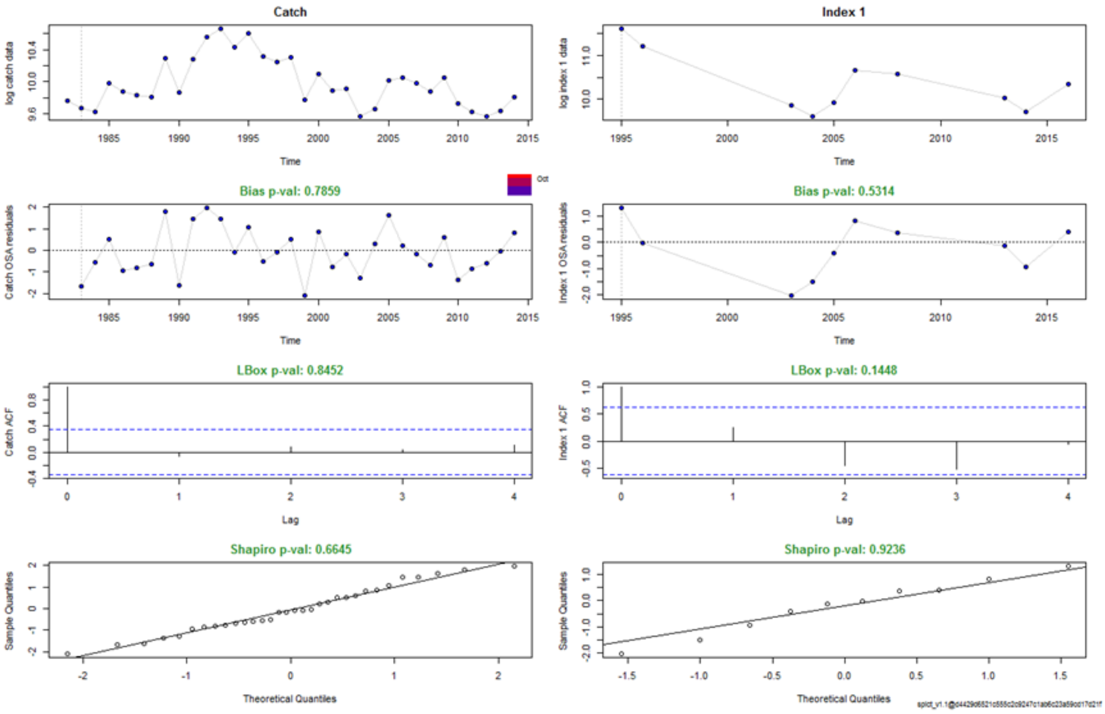

Figure 6.11.2.23 Sardine in GSAs 22 & 23. Diagnostics from SPiCT model for sardine in GSA 22.

Retrospective analysis

A retrospective analysis was run with 4 retro years. The retrospective patterns are consistent across in terms of B/Bmsy but results in poorer performance when F/Fmsy is concerned.

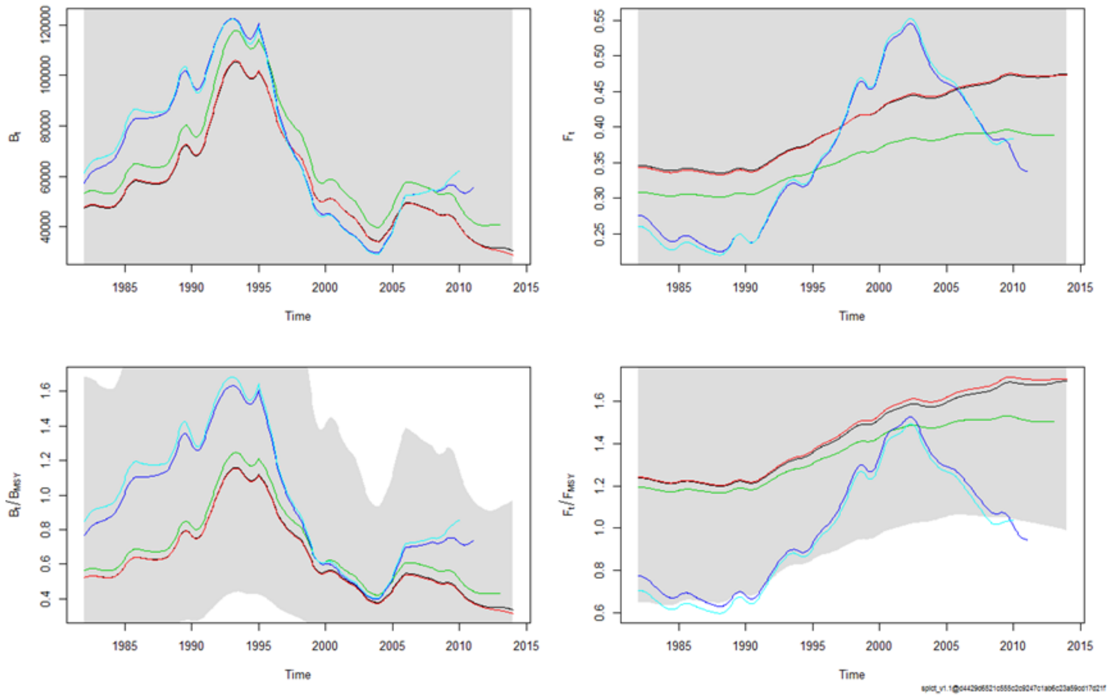

Figure 6.11.2.24 Sardine in GSAs 22 & 23. Retrospective analysis for the SPiCT model for sardine in GSA 22.

The SPiCT model estimates B_2016/Bmsy=0.583 and F_2016/Fmsy=1.368. However, the estimated confidence intervals were too large concerning both the Biomass and F estimates, along with and the poor performance of the retrospective analysis in terms of F lead the EWG 17-09 to decide that model results was indication that the stock is overexploited and the fishing effort should be reduced but this assessment will not be used for specific advice.

Conclusions to the stock assessment

The three assessment model results can be compared (Fig 6.11.2.25) The SPiCT model has very wide confidence intervals and very poor retrospective results implying it is uninformative and not suitable for obtainining stock status. The two age based models a4a and SAM give substantively similar general stock trajectories, but with significant differences in the final years, the confidence intervals for 2015 do not overlap. The data treatment for missing data is more appropriate for a4a and the retrospective performance suggests model stability. SAM has a greater tendency to smooth results which makes the slower response to changes in F unsurprising. This is not the case for the a4a. The divergence between SAM and a4a in the last years is of concern. Overall given the retrospective performance of the a4a model is considered to best represent the current state of the stock. In conclusion the a4a model is used to give stock status. However, due to the considerable uncertainty in the model due to missing data the model is not considered suitable for catch advice.

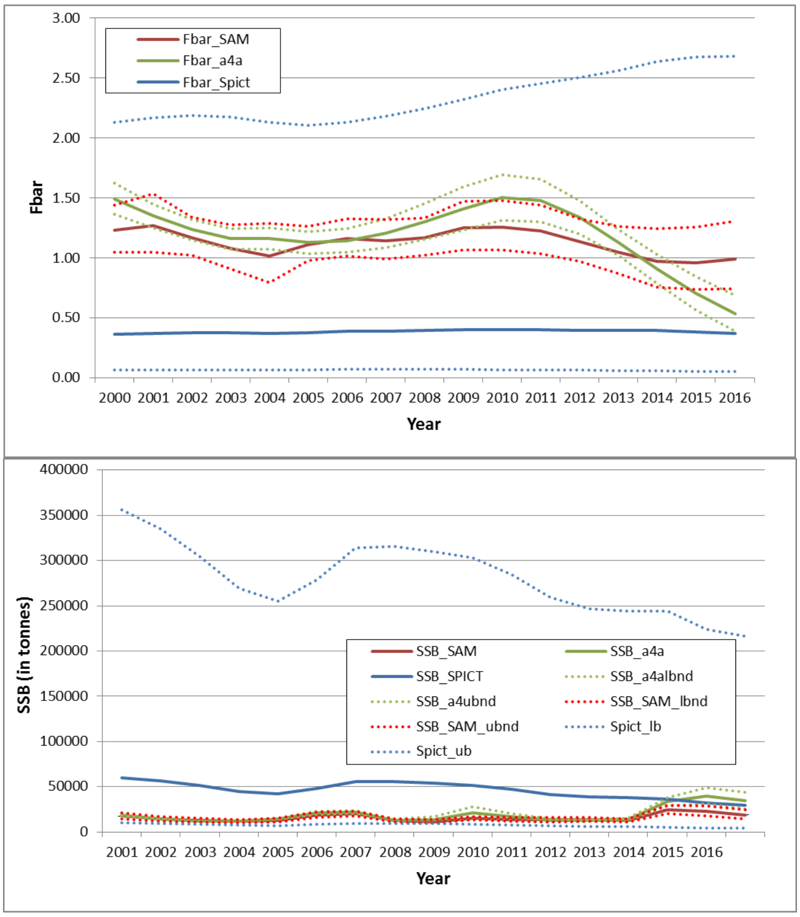

Figure 6.11.2.25 Sardine in GSA 22 & 23. Comparative assessment main outputs with confidence intervals.

6.11.3 Reference Points

Given the short time series in the age based assessments and the poor quality of the SPiCT analysis no specific MSY analysis was carried out and MSY reference points were not estimated in EWG 1709. The Empirical Reference point corresponding at Exploitation rate 0.4 (Patterson 1992) as suggested by the STECF SG-MED 09-03 was used provide an MSY proxy to examine stock status. The F equivalent to E=0.4 is estimated as 0.534 based on M and fishery selection at age from the a4a assessment.

6.11.4 Short term Forecast and Catch Options

No short term forecast and catch options were carried out for sardine stock in GSA 22 within STECF EWG 17-09.

6.11.5 Data Deficiencies

Particular deficiencies were found in the DCF data provided. Specifically, no DCF catch / catch-at-length / catch-at-age data were provided for 2007, 2009, 2010, 2011, 2012. No catch-at-age data were provided for 2016. Catch-at-age data were provided only for the last quarter for 2013 and 2015. No acoustic surveys took place in 2007, 2009-2012, 2015. The output of the acoustic survey in 2013 was used only in the SPICT as the survey took place in September instead of June –July.

DCF in 2014 reported landings almost half of the officially reported by Greece in GFCM.

7 DATA QUALITY AND DEFICIENCIES BY STOCK

ToR 8. *To summarize and concisely describe all data quality deficiencies, including possible limitations with the surveys of relevance for stock assessments and fisheries. Such review and description are to be based on the data format of the official DCF data call for the Mediterranean Sea launched on the March 2017. Identify further research studies and data collection which would be required for improved fish stock assessments. This review shall be presented in a manner that is compatible with the online platform developed by the JRC for data issues.*

7.1.1 ANCHOVY IN GSA 5

7.1.2 ANCHOVY IN GSA 6

Growth parameters of anchovy in GSA 6 should be revised (t_0 values are very negative). The procedure for transforming landings lengths into ages is not known. The availability of this procedure might help in the interpretation of the lengths and ages structures within a given area and among areas. ALK should be available from the acoustic surveys.

7.1.3 ANCHOVY IN GSA 7

The use of two different codes for the same area, GSA 7 and SA 7 should be avoided. This issue can lead to an incomplete selection of data from the Gulf of Lions.

No data on age structure in 2004.

OTM fishing effort, the main fishing gear targeting small pelagic in the area, is reported for 2014-2016.

As indicated in previous reports, the growth parameters should be revised (t_0 values are very negative). The procedure for transforming landings lengths into ages is not known. The availability of this procedure might help in the interpretation of the lengths and ages structures within a given area and among areas. ALK should be available from the acoustic surveys

7.2.1 SARDINE IN GSA 5

The information of sardine in GSA 5 is very limited, which can be explained by the low amount of landings and the also limited fishing activity of purse seine in the area.

7.2.2 SARDINE IN GSA 6

Growth parameters of sardine in GSA 6 should be revised (t_0 values are very negative). The procedure for transforming landings lengths into ages is not known. The availability of this procedure might help in the interpretation of the lengths and ages structures within a given area and among areas. ALK should be available from the acoustic surveys.

7.2.3 SARDINE IN GSA 7

The use of two different codes for the same area, GSA 7 and SA 7 should be avoided. This issue can lead to an incomplete selection of data from the Gulf of Lions.

OTM fishing effort, the main fishing gear targeting small pelagics in the area, is reported for 2014-2016.

As indicated in previous reports, the growth parameters should be revised (t_0 values are very negative). The procedure for transforming landings lengths into ages is not known. The availability of this procedure might help in the interpretation of the lengths and ages structures within a given area and among areas. ALK should be available from the acoustic surveys.

GSA 7- PIL landings 2016 – check unit used in 2016
GSA 7- PIL no length data in 2011
GSA 7- PIL no age data in 2004, 2005, 2011
GSA 7- check reported OTB discards in 2014 (376 t) should be checked.
GSA 7- PIL numbers in the size structure in 2013 should be checked.

7.3 ATLANTIC HORSE MACKEREL IN GSAs 1,5,6 & 7

There were a numbers of data deficiencies and errors in the data submitted through DCF. Detailed information can be found in section 6.3.

The most critical issues appear to be the missing French landings and/or catch data, only data for 2016 was reported by France and that appears to be incorrect

7.4 ANCHOVY IN GSAs 9,10 & 11

The landings time series was not available for the GSA 11, as well as the biological parameters. However, growth parameters, maturity at length and at age of the contiguous areas 9 and 10 were applied, considering that according to the official transversal data the landing of this species in GSA 11 is negligible. Data on biomass and abundance coming from the MEDIAS survey were not available for GSA 11. For the GSAs 9 and 10 the time series started in 2009, showing gaps in 2010 and 2012. For the GSA 9 also 2013 was not available. The lack of acoustic information before 2009 as well as the gaps in some recent years could have probably influenced the analysis.

7.5 SARDINE IN GSAs 9,10 & 11

The data on biomass and abundance coming from the MEDIAS survey were not available for GSA 11. For the GSAs 9 and 10 the time series started in 2009, showing gaps in 2010 and 2012. For the GSA 9 also 2013 was not available. The lack of acoustic information before 2009 as well as the gaps in some recent years could have probably influenced the analysis.

7.6 ATLANTIC HORSE MACKEREL IN GSAs 9, 10 & 11

The quality of species separation in fisheries (between T. trachurus and T. mediterraneus) has been questioned, but no problems are evident in the available data, as a separation between the two species is clearly assumed within the DCF and data are provided separately for both species. The quality of landings data is therefore assumed to be sufficient for the most important gear targeting horse mackerel. If issues do exist, it is possible that they produce a different impact in the landings and discard data, possibly more impacting in the latter. We did not attempt to assess the T. mediterraneus stock.

It is important to note that although small horse mackerel catches tend to occur with a number of different gear, significant volumes of landings and discards are concentrated in a more restricted group of gears, namely bottom trawling, purse-seining and gillnetting.

Days at sea may not always truly reflect effort in terms of fishing capacity. For the horse mackerel fishery, the most important gear are trawls (OTB), purse-seines and set gill nets (GNS) which are sufficiently different in terms of effort deployment that days at sea may not reflect effort similarly for all.

It would therefore be desirable that specific measures of effort are reported for each fishery, such that better measures of LPUE are available.

From the last DCF official data call (2016) biological data are not of the same quality in terms of continuity and gears covers for all GSAs. Total discards and discards at length information are missing for 2009, 2014 and 2015 in GSA 10 and for 2010 and 2014 in GSA11, while reported for all other years in time frame (2009-2016). Total landings are reported from 2003 for GSA9, from 2006 for GSA10 and from 2009 for GSA11, while structures at length from 2007 for GSA9, 2009 for GSA10 and 2010 for GSA11 with differences on gears among years. In some years the difference among reported total catches and catches derived from the biological sampling of landing and discards can be explained taking in to account that this species is not an economically important and generally is poorly landed in the region.

It would be useful to have a group of people that could strive to check data availability and quality prior to assessments. A check and eventually an update on catch data and more appropriate sample procedures of landings would improve the assessment.

7.7 EUROPEAN ANCHOVY IN GSAs 17 & 18

Compared to previous assessments carried out by STCF EWGs (STECF EWG 16-03) and GFCM WGSASP 2016, the SAM assessment of anchovy in GSAs 17-18 run at STECF EWG 17-09 shows similar trend in terms of SSB, fishing mortality, and recruitment.

This assessment was performed using the updated data set from the last GFCM stock assessment (GFCM, 2017). However, some modifications were carried out:

1) Albania sent new catch for years from 2008 to 2016, thus landings and catch at age data for these years were updated with the new estimates;
2) Abundance indexes at age for acoustic survey West and East were updated applying new age length keys, that are different from ALKs used for ageing recent commercial catches and age slicing of historical length data. These discrepancies can result in uncertainties and affect accuracy of catch-at-age matrix (see figures below);
3) Despite the fact that all MEDIAS data from Croatia were available, the data series from 2013 to 2016 were considered as an index of abundance at age is still very short. However, an index of biomass from the previous national PELMON survey including years from 2003 to 2012, was included as separate tuning index.

To underline the differences due to the use of different ALK, the figures below represent the 50% transition between ages classes (0-1, 1-2, 2-3, 3-4) for the West echo survey GSAs 17-18 and GSA 18west (Figure 7.7.1), for the East echo survey GSA 18east (Figure 7.7.2) and the Italian commercial data (Figure 7.7.3). For the echo surveys, the transition between age class 0 and age class 1 is at 12 cm, between 1-2 at 14.4 cm, between 2 and 3 at 16 cm and between 3 and 4 at 16.5 cm. Whereas for the Italian commercial data the transition between age class 0 and age class 1 is at around 11 cm, between 1-2 at around 13 cm, between 2 and 3 at around 14.5 cm and between 3 and 4 at around 16 cm.

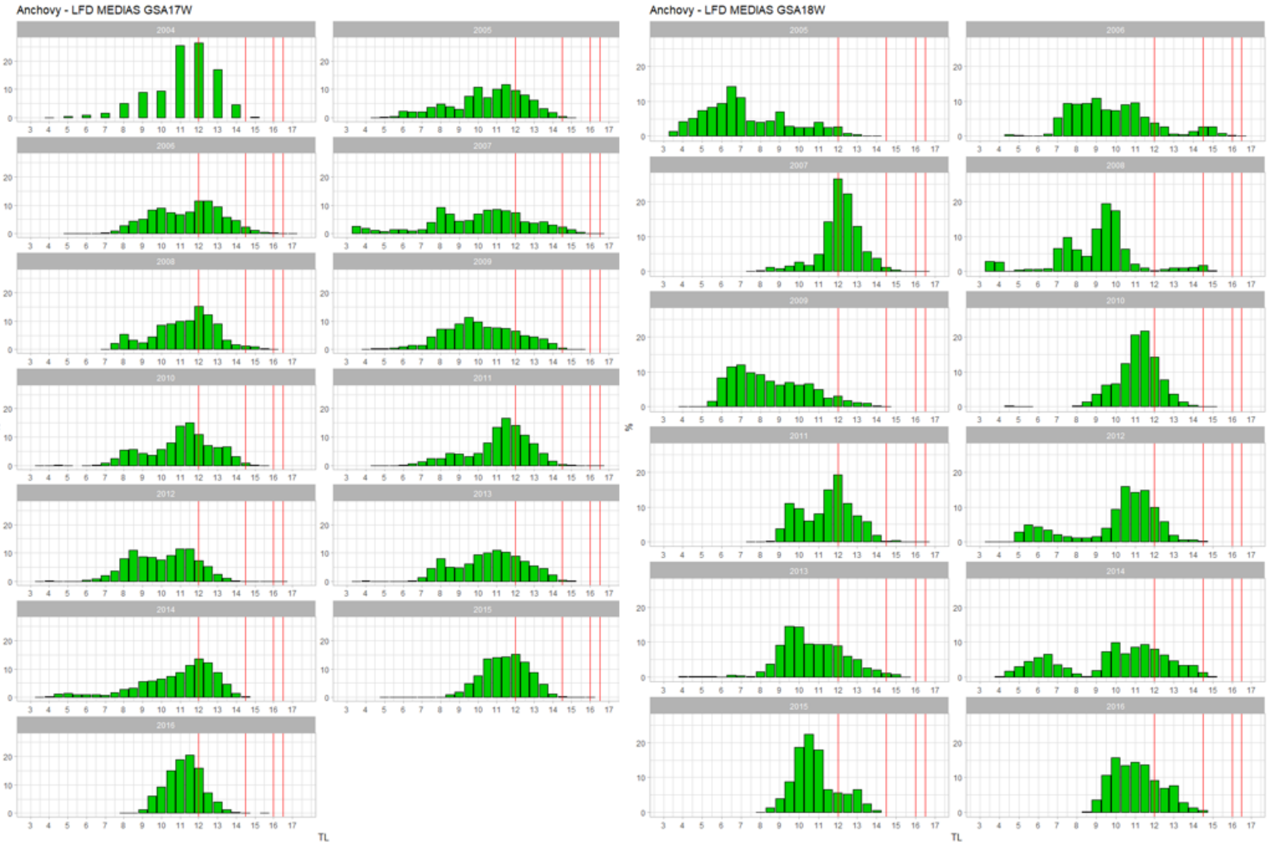

Figure *7.7*.1 50% transition lengths between age classes for GSA 17 West and GSA 18west

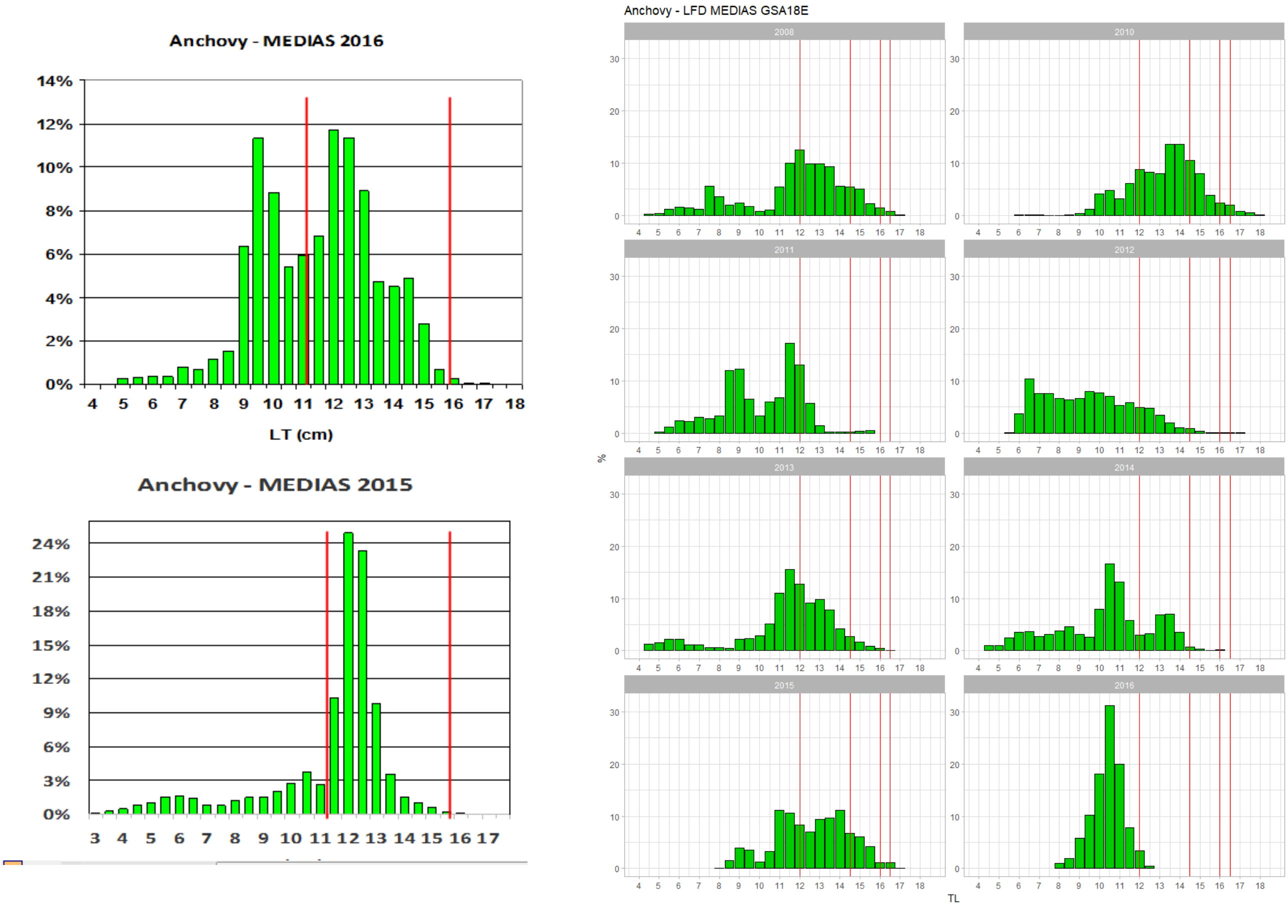

Figure *7.7*.2 50% transition lengths between age classes for GSA 17 East (A) and GSA18 East (B).

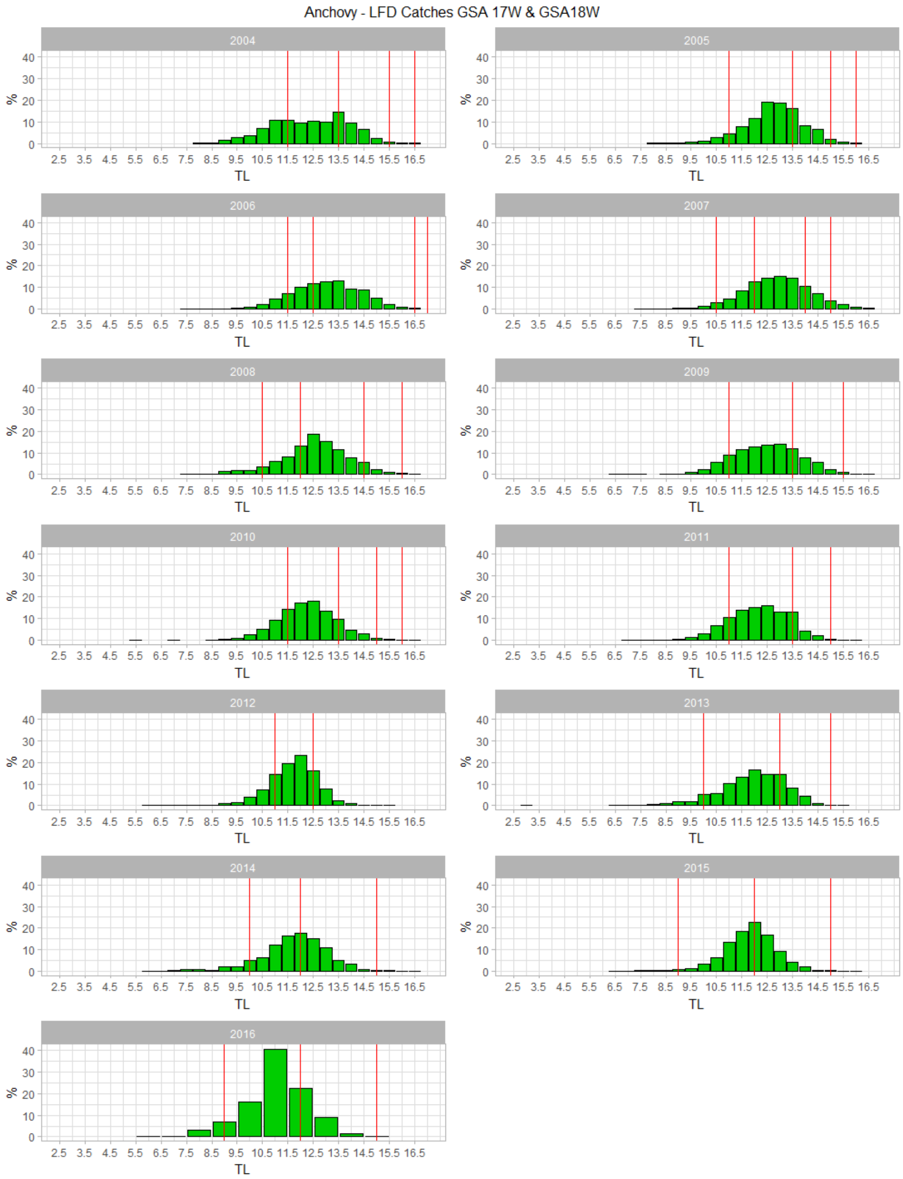

Figure *7.7*.3 50% transition lengths between age classes for the Italian commercial data (GSA 17 and 18).

Two runs were performed: one considering all the available data (1975 – 2016) and the other one considering only the most recent years (2000 – 2016). These runs showed very similar results, suggesting the use of the long time series of data in order to give a clearer picture of the dynamics of this stock.

7.8 SARDINE IN GSAs 17 & 18

Despite the fact that all MEDIAS data from Croatia were available, this time series of the Echo East is still very short, i.e. from 2013 to 2016 only; in addition, an index of biomass for acoustic surveys including years from 2003 to 2012. was included as separate tuning index.

7.9 ATLANTIC HORSE MACKEREL IN GSAs 17,18, 19 & 20

The STECF EWG 17-17 was not possible to apply any assessment methodology to assess the status of horse mackerel in the joint areas of GSA 17-18-19-20 for the following reasons.

Large gaps and inconsistencies were detected in the Greek, Italian and Croatian catch data.

Landings

There were gaps in the landings data for GSA 17, for the years 2008 – 2010. An attempt to fill the missing data from the landings data submitted through the Fleet-Economic Performance data call, failed due to the inconsistencies between these two datasets. In particular the values in the economic landings data were two-fold than the ones in the landings coming from the Mediterranean Data Call submissions, due to unreported data for midwater trawl. Furthermore, there were misreported landings in the economic data for the years 2014 and 2016. For GSA 20 the only years that appeared in the Mediterranean Data Call submissions were 2013, 2014 and 2016 with the amount of landings being at least 10 times less than what was reported in the other GSA areas. Also values submitted for year 2013, referred only to the 4th quarter of the year. As a result, working on the maximum value among the three years, does not allow for making any reasonable assumption on the data.

Discards

The same gaps observed in the landings data were also apparent in the discards data, making any attempt for reconstructing missing years an impossible task. An additional problem in identifying trends in discards data was the fact that *Trachurus trachurus* and *Trachurus mediterraneus*, are often being misidentified and mixed up in the reported discards due to similarities between species, especially in smaller specimens.

Effort

Effort data seemed the only consistent data, excluding GSA 20 where numerous gaps were observed between the years 2007 and 2012.

Survey

Due to absence of Greek MEDITS experimental survey data prior to 2014 the EWG decided to send an urgent request to the member state national correspondent to upload all MEDITS data. The request was served within 4 days. After merging all GSA data, it was discovered that the full dataset (GSA 17-18-19-20) suffered of great inconsistencies and is of low quality for conducting a proper assessment. MEDITS survey is conducted in GSA 17, 18, 19 since 1994 but no corresponding information on landings exists prior to 2002. As for the GSA20 the existence of the same gaps reported in landings/discards data left us with no other alternative than considering the data as misreported and inconsistent.

7.10 ANCHOVY IN GSAs 22 & 23

Particular deficiencies were found in the DCF data provided. Specifically, no DCF catch / catch-at-length / catch-at-age data were provided for 2007, 2009, 2010, 2011, 2012. No catch-at-age data were provided for 2016. Catch-at-age data were provided only for the trimester for 2013 and 2015. No acoustic surveys took place in 2007, 2009-2012, 2015. The output of the acoustic survey in 2013 was used only in the SPICT as the survey took place in September instead of June – July.

DCF in 2014 reported landings almost half of the officially reported by country state in GFCM.

7.11 SARDINE IN GSAs 22 & 23

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DCF in 2014 reported landings almost half of the officially reported by country state in GFCM.

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10 List of Annexes

Electronic annexes are published on the meeting's web site on: https://stecf.jrc.ec.europa.eu/ewg1709

List of electronic annexes documents:

EWG-17-09 – Annex 1 - Length based Indicators

11 List of Background Documents

Background documents are published on the meeting's web site on:
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List of background documents:

EWG-17-09 – Declarations of invited and JRC experts (see also section XX of this report – List of participants)

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LB-AX-17-015-EN-N

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doi:10.2760/897559

ISBN 978-92-79-67487-7