Working Document presented to the ICES WKPELA 2018 Benchmark Assessment Workshop. ICES HQ. Copenhagen, 12-16 February 2018.

Ane.27.9a stock (Anchovy in ICES Division 9a). Western component (Anchovy in ICES Subdivision 9a North, Central North and Central South): Fishery and Surveys data. Data availability and trends. Alternatives for Assessment and advice.

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1) STOCK STRUCTURE

A separate WD is being delivered within the benchmark process on the stock structure of the anchovy in Division 9a. Evidences included in that WD led to the decision of considering the anchovy populations inhabiting the southern and western Iberian regions as separate stock units for management purposes. The western component or western stock here described inhabits ICES Sub-areas 9a-N, 9a-CN and 9a-CS (Fig. 1.1).

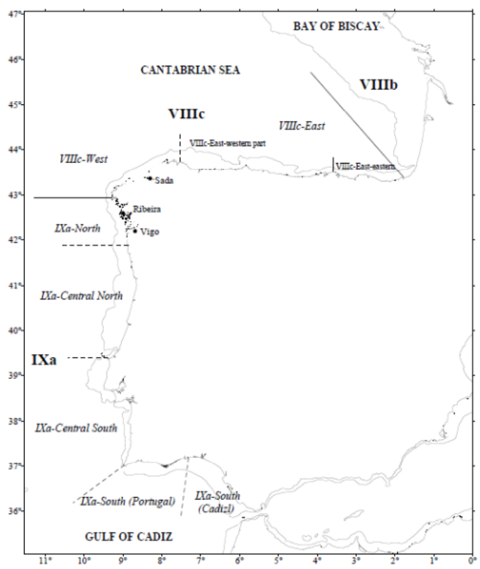

Figure 1.1. ICES Statistical Divisions and Subdivisions in Southern Europe.

2) LANDINGS IN SUBDIVISION 9A NORTH, CENTRAL NORTH AND CENTRAL SOUTH

2.1 - TOTAL LANDINGS, LANDINGS BY COUNTRY AND LANDINGS BY MÉTIER

Anchovy in ICES Sub-areas 9a-N, 9a-CN and 9a-CS (hereafter referred to as 9a.West) is harvested by Portugal and Spain (at present composed by 257 Portuguese vessels and ?? Spanish ones). A small number of purse-seine vessels may fish within the territorial waters of the other country. There are additional 50-70 polyvalent local vessels with license to purse-seine in Portugal. Vessels in northern Spain (northwest and Cantabrian Sea) are generally large (mean LOA 24.6 m and mean engine power 24.6 kW). Portuguese purse seine fleet mainly ranges from 18 to 24m (mean engine power 215 kW). In Portugal, around 60% of purse-seine vessels have their home port in the northwest and 10% in the southwest (remaining 10% in the 9a South area). The purse-seine fleet operating in the sub-area 9a.West mainly targets sardines but in recent years has been targeting other pelagic fish species, due to restrictions to sardine fisheries, such as chub and horse mackerel and occasionally during some years also anchovy (Silva et al. 2015).

For Portugal, statistics of annual landings date back to 1943 (Fig. 2.1.1, Pestana, 1996; ICES, 1997) while Spanish annual landings are available since 1989 (before that time there was mixing of catches from Spanish and Moroccan fishing grounds). Large populations in Galicia and Portugal have historically supported large harvests until the early 1960s when these populations declined (Junquera, 1986; Pestana, 1989). Total landings in sub-areas 9a-CN and 9a-CS, for which there is data since 1943, ranged between 0 (for 1964 and 1972) and landings above 5000 tons, which occurred in 2016, 1995 and 1943 (being 6918, 7056 and 7476 tons, respectively). Landings since 1989, when all the western component area is covered, ranged between 24 tons in 1993 and 12385 tons in 1995. The mean percentage of landings per sub-area from 1989 to 2016 was 70.8% for the 9a-CN, 16.3% for the 9a-N and 12.9% for the 9a-CS, corresponding to mean landings of 1065.8, 309.3 and 61.7 tonnes, respectively.

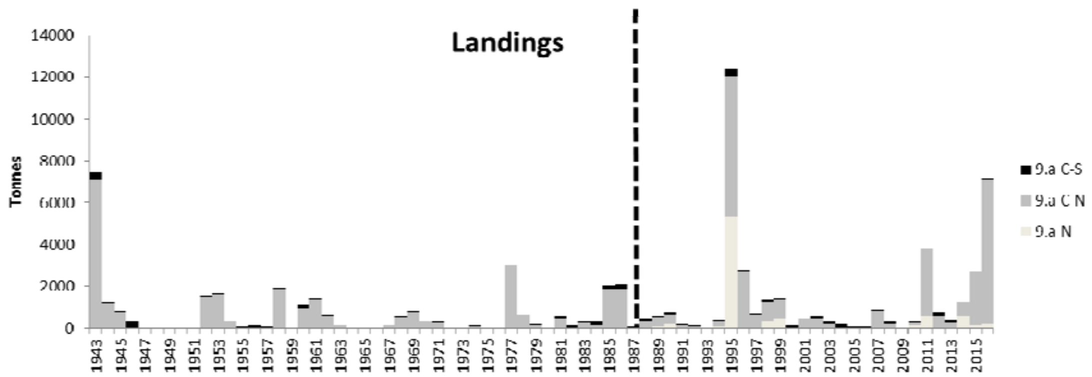

Figure 2.1.1 – Landings by sub-division for the western component of Division 9a. Note that before 1989 (dotted line) no data for Spanish fishery are available (9.aN).

Portugal and Spain routinely provide landings statistics by métier to ICES on an annual and quarterly basis. The *métiers* harvesting anchovy in subdivisions in 9a West are the following:

Portuguese fishery: 1) Purse-seine (PS_SPF_0_0_0), 2) Other bottom trawl directed to demersal fish (OTB_DEF_>=55_0_0), 3) Artisanal (mixed gears) using artisanal PS (also called in their national statistics as "polyvalent" vessels) (MIS_MIS_0_0_0_HC).

Spanish fishery: 1) Purse-seine (PS_SPF_0_0_0), 2) Other bottom trawl directed to mixed crustacean and demersal fish species (OTB_MCD_>=55_0_0). Until 2000 anchovy was captured as by-catch. Since then anchovy is discarded, 3) Artisanal (mixed gears) (MIS_MIS_0_0_0_HC) (incidental catches).

For the period of 1989 to 2016 the purse-seine fleet was the main responsible for the anchovy fishery, accounting, on average, for >95% of the total anchovy landings in the three western sub-divisions (9aN, 9aCn and 9aCS) (Fig. 2.1.2).

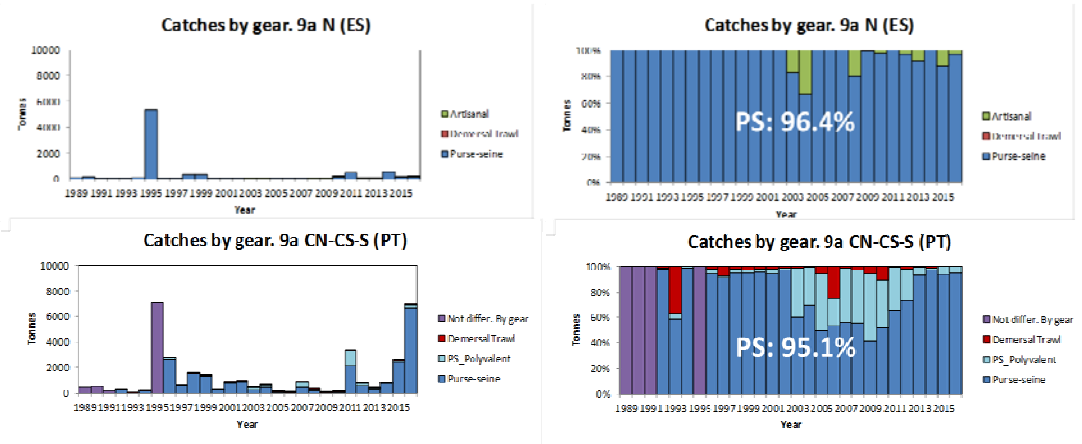

Figure 2.1.2 - Number (left panels) and percentage (right panels) of catches per gear and sub-division.

2.2 - LANDINGS BY QUARTER

The distribution of landings per quarter in the 9aWest sub-area from 1989 to 2016 varied spatially and temporally (Fig. 2.2.1). In sub-division 9.a-N, most landings occur in the 3rdQ (mean 39.9%), followed by the 4thQ (29.1%), 1stQ (19.8%) and 2ndQ (11.2%). In sub-division 9.a-CN the highest percentage of landings occurred in the 4th quarter (mean 40.1% of landings) followed by the 3rdQ (22.5%), 1stQ (21.7%) and 2ndQ (15.7%). This pattern has changed in the last decade, when most of the catches concentrate in the 3rdQ (mean 35.7%) followed by the 4thQ (mean 28.0%). In sub-division 9.a-CS most of the catches from 1989 to 2016 occurred in the 1stQ (48.3%), followed by the 2ndQ, 4thQ and 3rdQ (with 24.4, 19.4 and 7.9%, respectively).This pattern did not change significantly in the last decade, although in some years there are also significant landings in the 2ndQ and 4thQ.

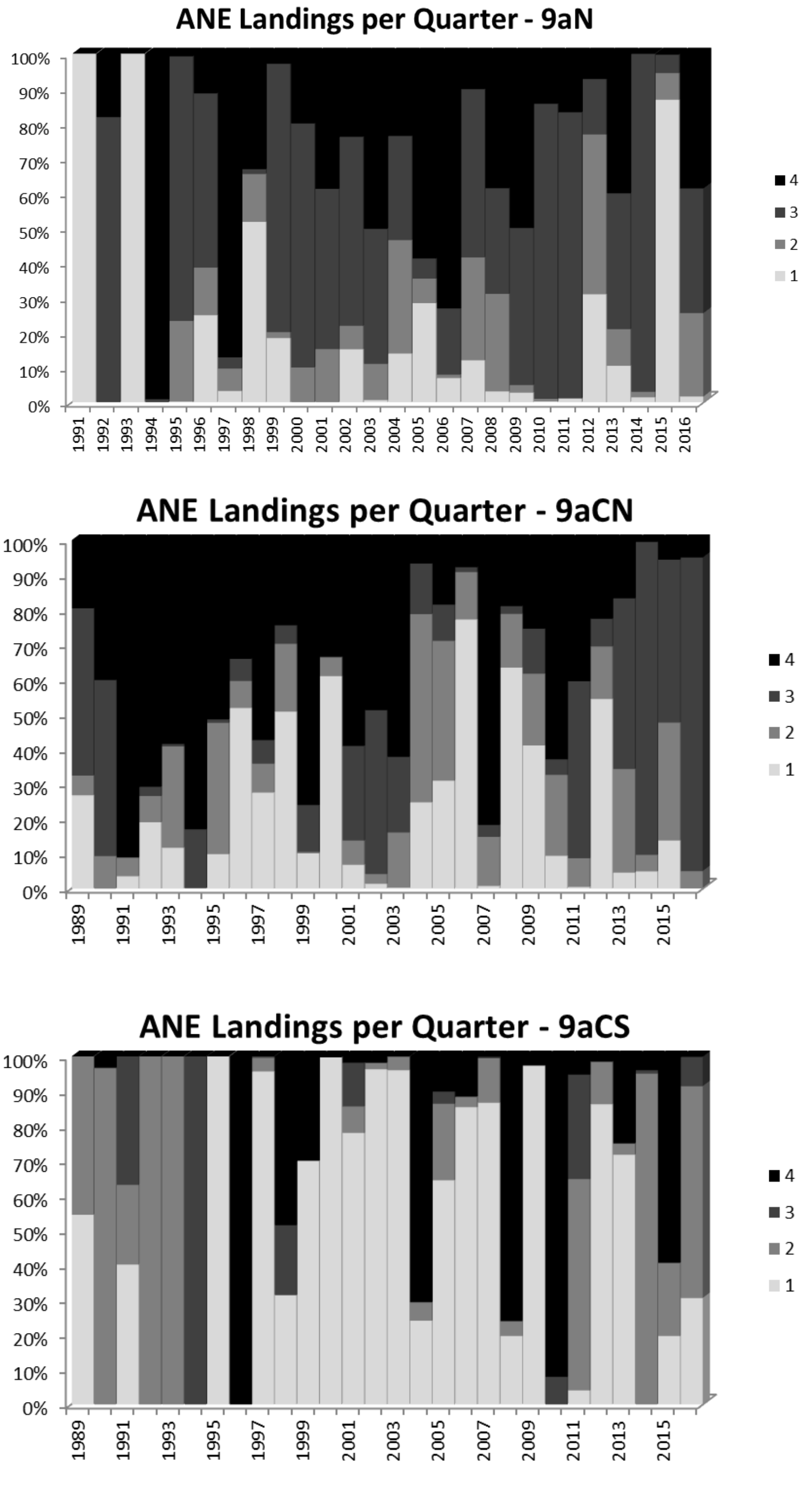

Figure 2.2.1 – Percentage of landings by quarter for the sub-divisions 9a-N, 9a-CN and 9a-CS.

2.3 - DISCARDS:

Although the actual magnitude of discarding practices for the past anchovy fishery in the Division 9a is unknown, the respective DCF national sampling programs have revealed for the recent fishery (since the early 2000s) that, in general terms, anchovy discards may be considered as negligible or even null. Anchovy discards in the Portuguese fishery are considered null, therefore for the Portuguese fishery landings = catches. Discards in the Spanish fishery are estimated since 2014, when the sampling coverage was sufficient to provide reliable estimates: in 9a North discards are almost zero (discards ratios have oscillated for the period 2014-2016 between 0 (0%) – 0.001 (<0.1%).

2.4 - SIZE COMPOSITION OF LANDINGS

Length–frequency distribution (LFD) of catches and catch-at-age data from the western component of Division 9a are not available on a regular basis (Table 1), given that historically, commercial landings were low and sporadic (Fig. 2.1.1). The increase of anchovy abundance in the last decade has led to an increase in the exploitation of the species by the fleets operating in those areas and more data of quarterly LFDs has been provided for the Spanish and Portuguese fishery in Subdivisions 9.aN and 9aCN, respectively. Given the low abundance of anchovy in sub-division 9aCS even in recent years, the availability of anchovy length data for that area is extremely low.

Table 1 – Availability of length and age composition of catches for sub-division/year/quarter are represented in green. For sub-divisions 9aCN and 9aCS numbers represent the number of samples and, between brackets, the number of individuals sampled.

area	quarter	1998	1999	2009	2011	2012	2013	2014	2015	2016
9aN	1									
	2									
	3									
	4									
9aCN	1		3 (319)		3 (214)	1 (78)			3 (662)	1 (134)
	2					1 (101)	1 (153)		4 (408)	6 (714)
	3		2 (195)		2 (171)			1 (104)	4 (495)	8 (1440)
	4		8 (965)	1 (120)		1 (115)			1 (55)	
9aCS	1						1 (101)			
	4								1 (58)	

Given the scarce representativeness of métiers other than purse-seine (that is responsible, as mentioned before by >95% of anchovy caught in western Iberia), the purse-seine LFD are used to raise the quarterly data of the total catches (catches from all fleets pooled).

Anchovy length in Spanish landings in the sub-division 9a.N ranged from 9 to 20 cm (Fig. 2.4.1). The most frequent and abundant size classes landed ranged between 13.5 and 16.5 cm (each occurred in >75% of all samples). Anchovy size was similar for fish caught during the different quarters of the year in this sub-division. The lowest quarterly mean lengths landed in subdivision 9.N were recorded in 1998 Q4 (11.8 cm) and the highest in 1999 Q3 and Q4 (16.8 cm).

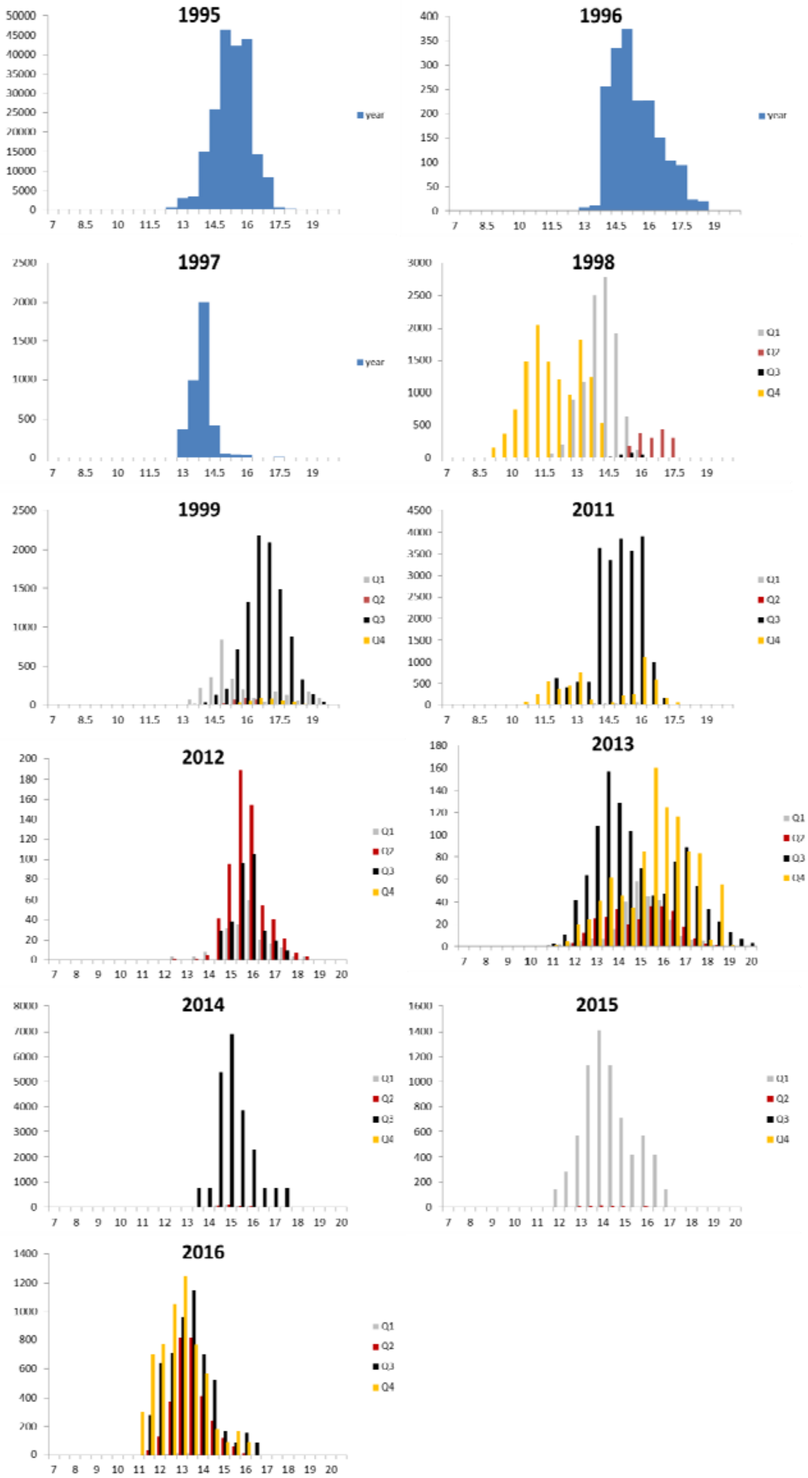

Figure 2.4.1 – Length distribution per year and quarter of anchovy caught in commercial landings in sub-division 9aN.

Anchovy length of Portuguese landings in the sub-division 9aCN ranged from 10 to 20.5 cm (Fig. 2.4.2), similarly to sub-division 9a.N. The most frequent and abundant size classes landed ranged between 14.5 and 17 cm (occurred in >75% of all samples). The lowest quarterly mean lengths landed in subdivision 9.CN were recorded in 2013 Q2, 2015 Q1 and 2016 Q2 (13.6 cm) and the highest in 2016 Q1 (17.1 cm). Anchovy size was similar for fish caught during different quarters of the year in this sub-division, except during the second quarter, when smaller size classes (between 12 and 14.5 cm) were also frequently caught.

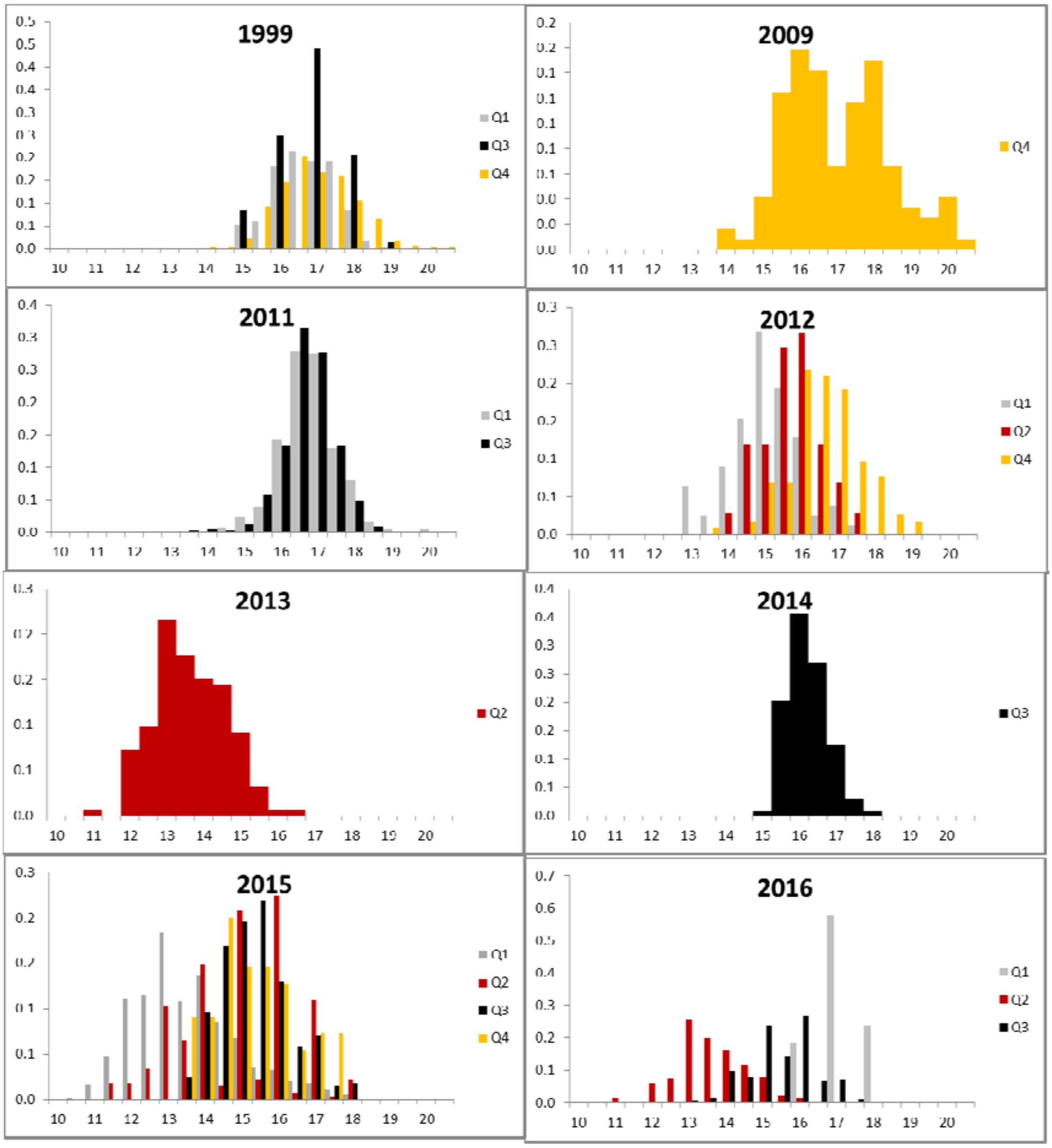

Figure 2.4.2 – Length distribution per year and quarter of anchovy caught in commercial landings in sub-division 9aCN.

Besides the length frequency distribution of anchovy from purse-seine landings, for 2015 and 2016 there is also available data of length distribution of anchovy caught in sub-division 9a.N by other métiers, particularly otter trawl and polyvalent gears in 2015 and trammel net, polyvalent and gill net in 2016. Although there is very few data, the length composition of these other fisheries seems to be similar to those caught during the same year by purse-seine fishery (Fig. 2.4.3).

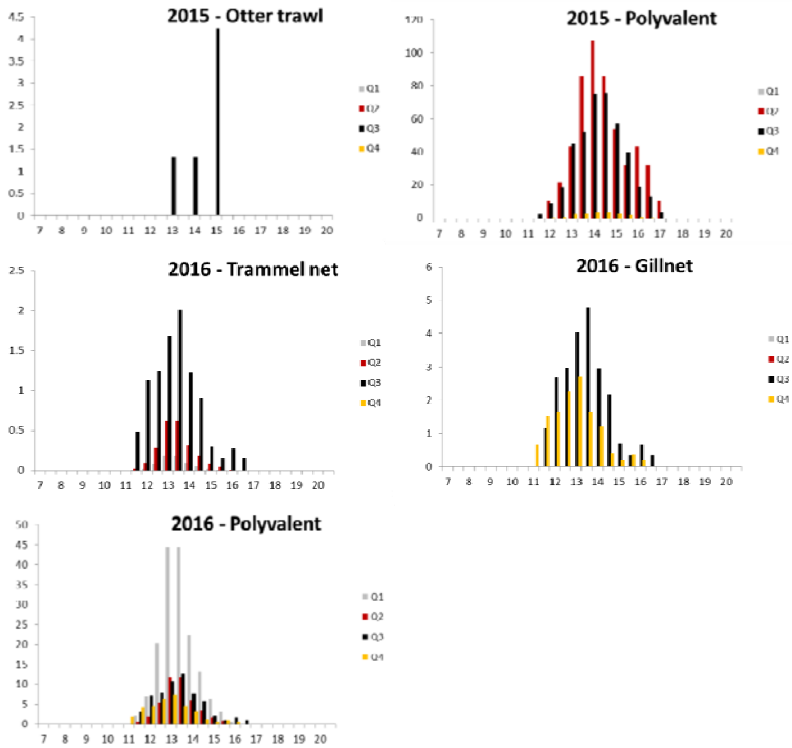

Figure 2.4.3 – Length distribution per year and quarter of anchovy caught in commercial landings in sub-division 9aN caught by *métiers* different from purse-seine fishery.

Length distribution data of other métiers are also available for the 9a.CN area in few recent years when the stock was more abundant in the western coast (Fig. 2.4.4). Despite the scarcity of data, it can be seen that length distribution is similar between fish caught by purse-seine and otter trawl, although the first caught also small fish. Gill nets used in the 2nd Q of2015 captured fish on the lower range of those caught by purse-seine and smaller than those caught by otter trawl.

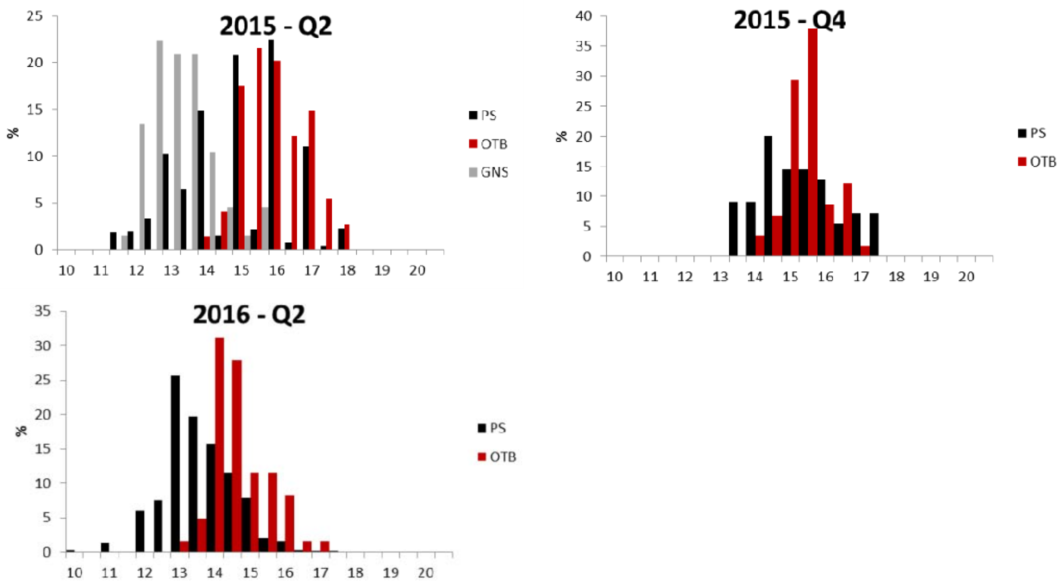

Figure 2.4.4 – Length distribution (percentage per length class) of anchovy caught by different métiers during the same year/quarter in sub-division 9a.CN.

Mean length of anchovy in catches was slightly smaller in sub-division 9aN when compared to sub-division 9aCN (Fig. 2.4.5).

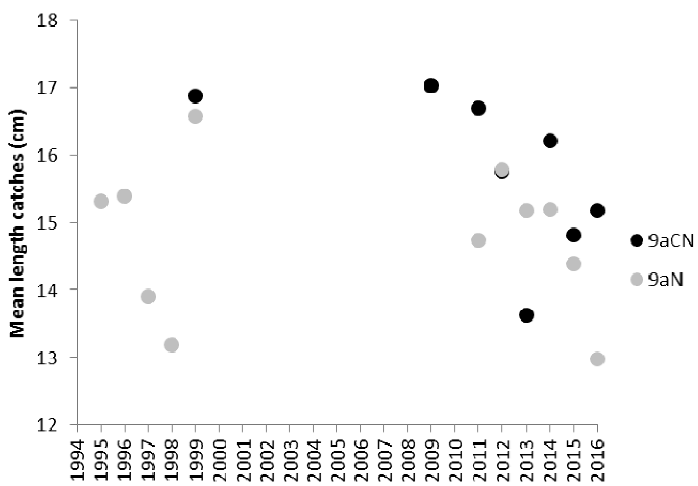

Fig 2.4.5 - Annual mean length of anchovy in sub-divisions 9a.N and 9a.CN.

Regarding the age structure of the population in the catches, only data from the Spanish fishery (9aN) is available; no age structure is available for the Portuguese anchovy catches. Age distribution of anchovy in the catches of sub-division 9a.N (Fig. 2.4.6) is dominated by fish of 1 and 2 years old. Fish with 3 years old are rare in the catches representing <3% for all samples. Recruits (0 years old) were only significantly caught (>10% of catches) in the strong year classes of 2011 and 2016.

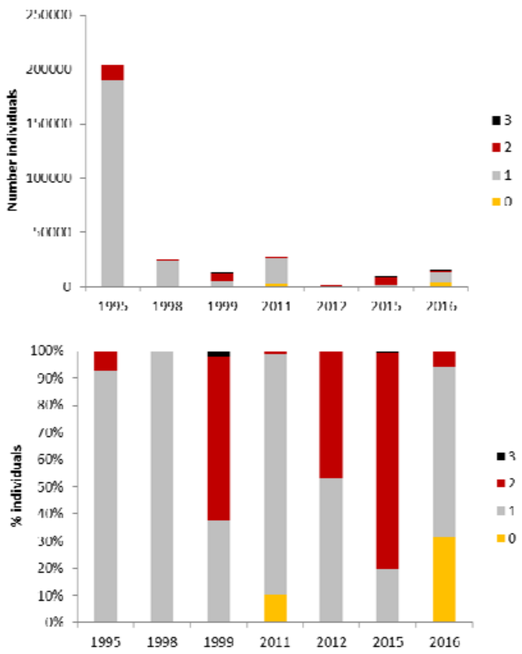

Figure 2.4.6 – Age distribution per year (when available) of anchovy caught in commercial landings in sub-division 9aN, represented in number of individuals (upper panel) and percentage of individuals (lower panel).

2.5 – BIOLOGICAL PARAMETERS FROM LANDINGS

Complete biological sampling, besides length frequency distribution, has been conducted with very few samples and individuals caught by commercial landings in Portugal until 2016 (Table 2). For this reason, it is not possible to estimate growth and maturity ogives from landings. Alternatively, maturity at length and maturity at age were estimated from the data of the PELAGO survey and submitted to the datacall.

A recent and special sampling effort was carried out during 2017 in the main fishing port of sub-division 9a.CN (Matosinhos). This allowed better defining the anchovy spawning cycle off the western Iberia, which is described in section 4.3.3 of the present Working Document.

Table 2 – Available biological sampling from landings in the 9a.CN and 9a.CS sub-divisions.

AREA	YEAR	QUARTER	DATA_AM	Total
IXaCN	2011	3	06-09-2011	58
			08-08-2011	38
			12-07-2011	45
			21-09-2011	47
			25-07-2011	41
	2011	4	13-10-2011	49
			29-11-2011	44
			31-10-2011	54
	2012	1	10-01-2012	54
			31-01-2012	60
	2013	2	28-05-2013	78
	2016	2	06-04-2016	52
			25-05-2016	56
			29-06-2016	48
	2016	3	06-07-2016	40
IXaCS	2011	3	06-09-2011	44
TOTAL				808

3 - FISHERY-INDEPENDENT INFORMATION

3.1 - SURVEYS

A description of the available acoustic surveys providing estimates for anchovy in Division 9.a is given in the Stock Annex. Survey's methodologies deployed by the respective national Institutes (IPMA and IEO) are also thoroughly described in ICES (2008, 2009).

3.1.1 - SPRING ACOUSTIC SURVEYS

PELACUS series

This Spanish spring acoustic survey series is the only one that samples yearly the waters off the Subdivisions 9.a North and Subarea 8.c since 1984 (Table 3). This series is currently funded by DCF. This series provides the size composition (LFD) of the estimated population in numbers and biomass. Age composition is available since 2007.

PELAGO series

The PELAGO survey (spring Portuguese acoustic survey) has been conducted every year by IPMA since 1999 (Table 3), surveying the waters of the Portuguese continental shelf and those of the Spanish Gulf of Cadiz (Subdivisions 9.a Central-North, Central-South, and South), between 20 and 200 m depth. This survey series is currently financed by DCF. There were no PELAGO survey in 2012 due to the RV Noruega was not operative for the survey season. The PELAGO time-series with estimates for anchovy in the western component of Division 9a dates back to 1999, with gaps in 2000, 2004 and 2012. Population estimates are provided without a measure of dispersion. This series provides the size composition (LFD) of the estimated population in numbers and biomass. Age composition is available since 2008. Nevertheless, there is a collection of anchovy otoliths from the older surveys of the PELAGO series (from 1999 to 2007) that are currently being analyzed and will be available within 2018.

3.1.2 - RECRUITMENT SURVEYS

SAR/JUVESAR autumn survey series

The last survey in the SAR series (aimed to cover the sardine early spawning and recruitment season in the Division 9.a, but also covering the anchovy recruitment season) was carried out in 2007 (Table 3). The JUVESAR autumn survey series, is an acoustic surveys restricted to the Subdivision 9.a Central-North, the main sardine recruitment area for sardine in Portuguese waters, started in 2013. However, the scarce presence and abundance of anchovy in the 2013 and 2014 surveys prevented from providing any acoustic estimate for the species.

Table 3 - Acoustic surveys providing direct estimates for anchovy in the western component of Division 9.a.

Method	**Acoustics**				
Survey	**PELACUS**	**PELAGO**		**SAR**	**JUVESAR**
Institute (Country)	**IEO (Spain)**	**IPMA (Portugal)**		**IPMA (Portugal)**	**IPMA (Portugal)**
Subareas	**9.a N**	**9.a CN-9.a S**		**9.a CN-9.a S**	**9.a CN**
Year/Quarter	**Q2**	**Q1**	**Q2**	**Q4**	**Q4**
1998				Nov	
1999		Mar			
2000		Mar		Nov	
2001		Mar		Nov	
2002		Mar			
2003		Feb		Nov	
2004			Jun		
2005			Apr	Nov	
2006			Apr	Nov	
2007			Apr	Nov	
2008	Apr		Apr	Nov	
2009	Apr		Apr		
2010	Apr		Apr		
2011	Apr		Apr		
2012	Apr				
2013	Mar		Apr		Nov
2014	Mar		Apr		Nov
2015	Mar		Apr		Dec

2016	Mar		Apr		Dec
2017	Mar		Apr		Dec

3.1.3 – TIME SERIES OF ACOUSTIC SURVEYS

Estimated abundances of anchovy in the western component of Division 9.a in the acoustic surveys in terms of number of individuals and biomass are presented in Figure 3.1.3.1.

The longest time series of these surveys is the PELACUS spring survey covering Subdivisions 9.a North, extending from 1992 to the present. Anchovy abundance and biomass in this sub-division was very low throughout the time-series, and the acoustic estimates were zero for the majority of the surveyed years. Anchovy was estimated by the PELACUS survey in this area during 1992 and 1995, was not detected until 2008 and then occurred all years in this area from 2008 to 2012 with a mean abundance of 16226 individuals and 395 tons, with a peak in 2011 (with 66233 individuals and 1508 tons). Anchovy was again absent from the 9aN area during the PELACUS survey and then in 2016 and 2017 was again acoustically detected, reaching its historical maximum in 2017 with 122974 individuals and 3525 tons.

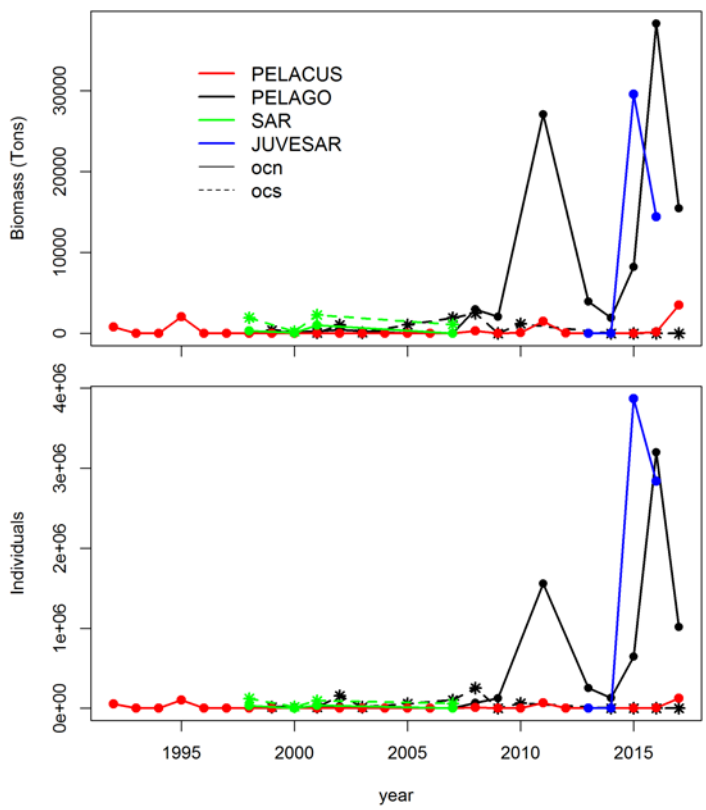

Figure 3.1.3.1 – Trends of anchovy biomass (upper panel) and abundance (lower panel) for the acoustic surveys estimating anchovy abundance in the western component of Division 9a.

The SAR autumn acoustic survey covered sub-divisions 9a.CN and 9a.CS in terms of the western component of Division 9a and provided anchovy acoustic estimates from 1998 to 2008 with several gaps (see Table 3). During this time series anchovy abundance was low but higher then 0 except for 2007 for both 9a.CN and 9a.CS sub-divisions. Highest abundance and biomass of anchovy during this time series occurred in 1998 (122247 individuals and 1951 tons) and 2001 (93670 individuals and 2276 tons). Abundance and biomass of anchovy during the SAR survey series was significantly higher in sub-division 9aCS when compared to sub-division 9aCN, having >68% of the total anchovy abundance and biomass estimated for each SAR survey (Fig. 3.1.3.1).

The more recent autumn acoustic surveys JUVESAR only covers the 9aCN area and takes place since 2013 to present. Acoustic estimates of anchovy of the JUVESAR survey were zero for 2013 and 2014 and very high during 2015 (3869611 individuals and 29556 tons) and 2016 (2836029 individuals and 14397 tons) (Fig. 3.1.3.1).

Finally, the PELAGO spring surveys that, similarly to the SAR survey, coveres sub-divisions 9a.CN and 9a.CS and provides anchovy acoustic estimates since 1999 to present (with a gap in 2012). Anchovy abundance in this PELAGO series in sub-division 9a.CN ranged between 0 (2003, 2005,2007 and 2010) and 3198016 individuals and 38302 tons in 2016. In sub-division 9a.CS, anchovy abundance ranged between 0 (2009, 2014, 2015, 2016 and 2017) and 252246 individuals and 2505 tons in 1998. Given that the highest abundances of anchovy were registered for this survey during the last decade when most of the populations were estimated in sub-division 9a.CN, mean abundance and biomass in this subdivision during the time series is significantly higher than those estimated for the 9a.CS sub-division (542604 and 51823 individuals, and 7228 and 644 tons, respectively) (Fig. 3.1.3.1).

3.1.4 - INTERNAL CONSISTENCY OF SURVEYS

Age estimates of anchovy in the western component of Division 9a are available for the PELACUS and PELAGO survey series since 2008. For this reason, the internal consistency of surveys by cohort tracking can only be done for these two survey series.

Cohort tracking of the PELAGO survey (Fig. 3.1.4.1) shows that, generally, the abundance of anchovy decreases with increasing age, with the exception of some cohorts such as the 2004 and 2009 but there is a high variability of mortality per age between cohorts.

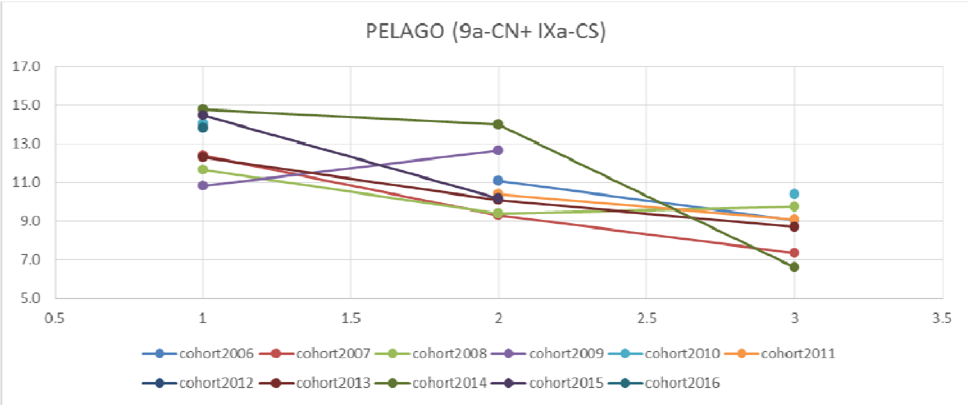

Figure 3.1.4.1 - Cohort tracking of anchovy estimated by the PELAGO surveys in sub-division 9a.CN and 9a.CS. Cohorts (ln(N) per age group) tracked by the survey series.

Cohort tracking of the PELACUS survey (Fig. 3.1.4.2) shows that there is no clear tendency in the abundance per age, with increases as age for some cohorts and decreases for others. This survey is conducted in a small area of the western component (9a.N), with very low abundance when compared to the contiguous 9a.CN sub-division. For this reason, it is difficult to ascertain the internal consistency of the PELACUS survey by cohort tracking estimated by the survey.

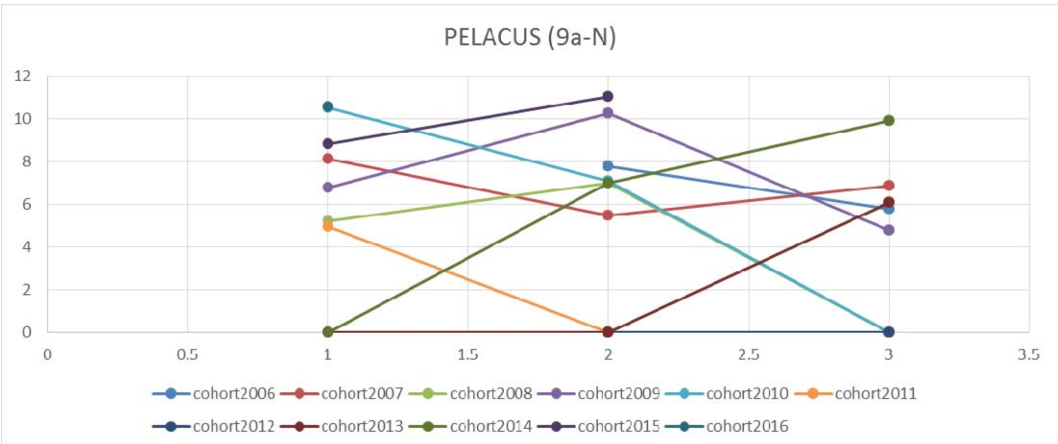

Figure 3.1.4.2 - Cohort tracking of anchovy estimated by the PELACUS surveys in sub-division 9a.N. Cohorts (ln(N) per age group) tracked by the survey series.

3.1.5 - BETWEEN SURVEY CONSISTENCY

The only surveys that coincide in space are the PELAGO and SAR in the 9aCN and 9aCS sub-divisions from 1999 to 2008 and the PELAGO and JUVESAR in the 9aCN sub-division from 2013 until present. Both pairs coincide in the same years, although the first is conducted during spring and the others in the autumn. The pairs PELAGO and PELACUS and SAR and PELACUS are/were conducted during spring in contiguous areas.

In general, the general trends estimated by the acoustic surveys in the western component of Division 9a are fairly consistent (Fig. 3.1.5.1 and 3.1.5.2). Periods of low abundance were detected by the PELAGO, SAR and PELACUS from 1998 to 2007 and a small peak in 2008 and larger during 2011 was estimated by both the PELAGO and PELACUS surveys. During 2016, the highest peak in abundance for the 9a.CN area and for the western stock was only estimated by the PELACUS survey during the following year (2017), when anchovy abundance in the remaining sub-divisions decreased to the 3rd largest abundance registered by these surveys.

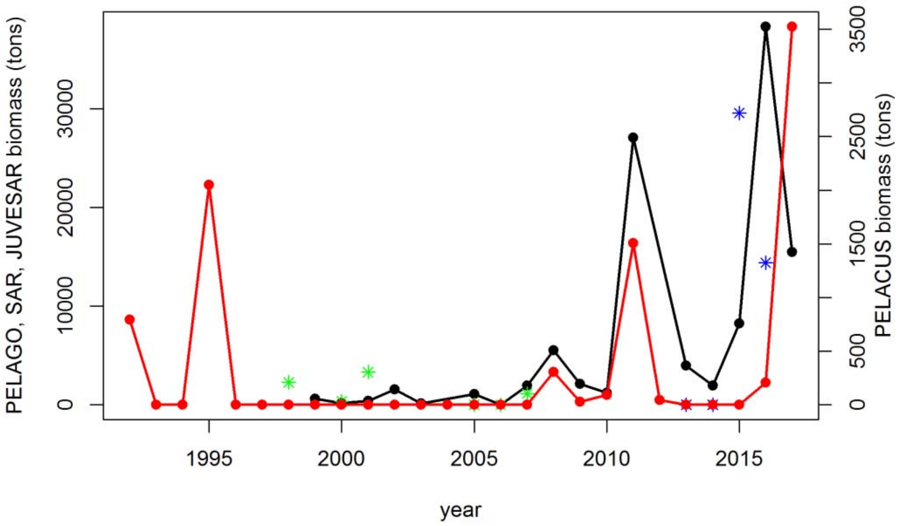

Figure 3.1.5.1 – Comparision of survey trends between PELAGO (black line), PELACUS (red line), SAR (green line) and JUVESAR (blue line). Note that due to the lowest abundance estimated by this survey, PELACUS biomass is represented on a different scale.

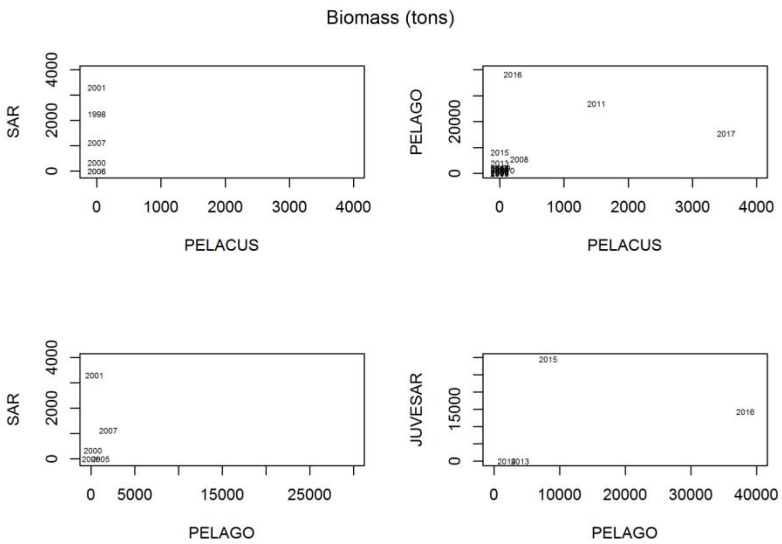

Figure 3.1.5.2 – Relation between the estimates of acoustic surveys conducted in the same year but in contiguous areas (SAR and PELACUS, PELAGO and PELACUS) or in the same area and year but in different seasons (SAR and PELAGO). PELAGO and JUVESAR coincide in the 9a.CN but radials are shorter for the latter.

When the estimates of the spring acoustic surveys are pooled (and also the recruitment survey conducted in the fall for age zero), the results are similar to those estimated by the PELAGO survey, that is conducted in sub-divisions 9a.CN and 9a.CS where generally >95% of the whole stock occurs. Cohorts generally show, as expected, higher abundances at lower ages, with the exception of few cohorts where abundance increases between two age groups. There is a high variability of mortality per age between cohorts (Fig. 3.1.5.3).

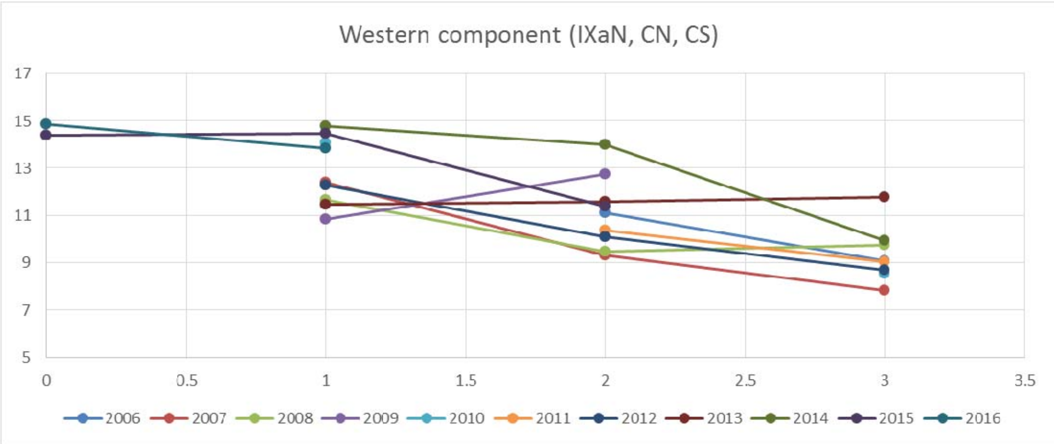

Figure 3.1.5.3 – Cohort tracking of anchovy estimated for the western component of Division 9a (PELAGO and PELACUS surveys). Age 0 represents fish caught in the JUVESAR survey carried out in the last quarter of the year.

Regression analysis between three points has some limitations, particularly for limited data such as that currently available for the western coast. The graphical analysis of cohort tracking does not show a clear signal of strong cohorts being detected at several ages (Fig. 3.1.5.4).

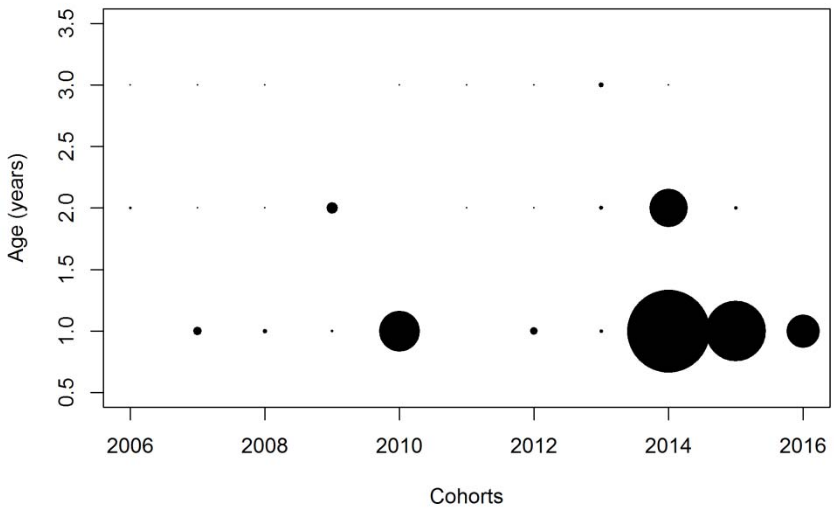

Figure 3.1.5.4 – Abundance of anchovy per age estimated in the spring acoustic surveys (PELAGO and PELACUS) in the western component of Division 9a (9a.N, 9a.CN, 9a.CS).

3.1.6 – ANCHOVY DISTRIBUTION

Anchovy distribution off the Iberia is detailed in the WD on stock Identification presented to the benchmark. Particularly in the western component of Division 9a, the main areas of distribution of anchovy are mainly located in the northwestern coast of Portugal (sub-division 9a.CN, Fig. 3.1.6.1). In some years, anchovy is also abundant off the northern part of sub-division 9a.CS, from Cape Carvoeiro to Cape Espichel. Off the sub-division 9a.N anchovy is less abundant and was less frequent in the beginning of the survey time series, where estimates where frequently zero, being more frequent in recent years. Anchovy abundance in sub-division 9a.N has been ≤0.05% of total abundance in the western component of Division 9a, except for 2017, when it represented 19% of the fish caught in the western Iberia.

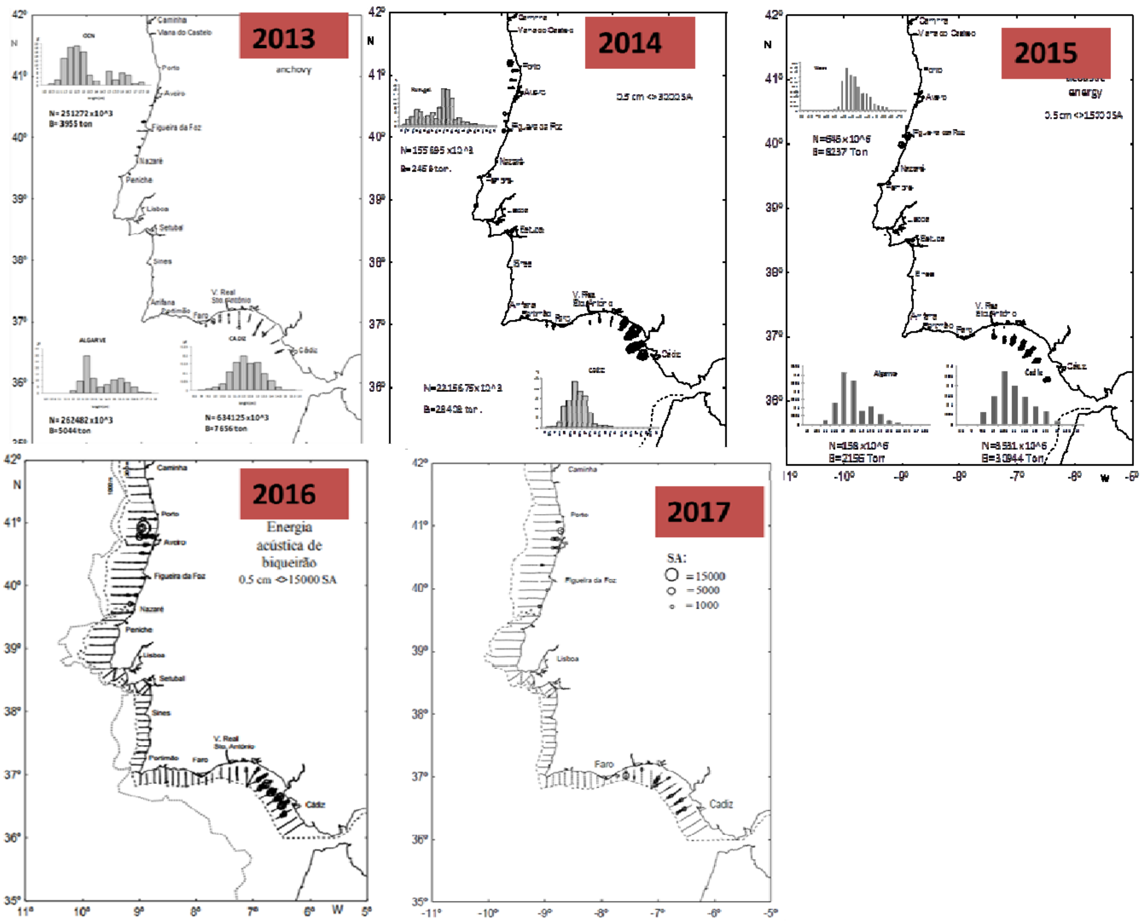

Figure 3.1.6.1 – Anchovy distribution estimated in the PELAGO survey series, in sub-divisions 9aCN and 9a.CS

4 - LIFE-HISTORY PARAMETERS

4.1 – LENGTH COMPOSITION OF SURVEYS

The length frequency distribution of anchovy populations in the 9a.N subdivision estimated by PELACUS during spring varied annually. Minimum size was registered during 2015 (6.5 cm) and maximum during 2010 (21 cm). Modal size class varied between 13.5 cm (1992) and 17.5 cm (2017) (Fig. 4.1.1) but for the majority of the years ranged between 15 and 16.5 cm.

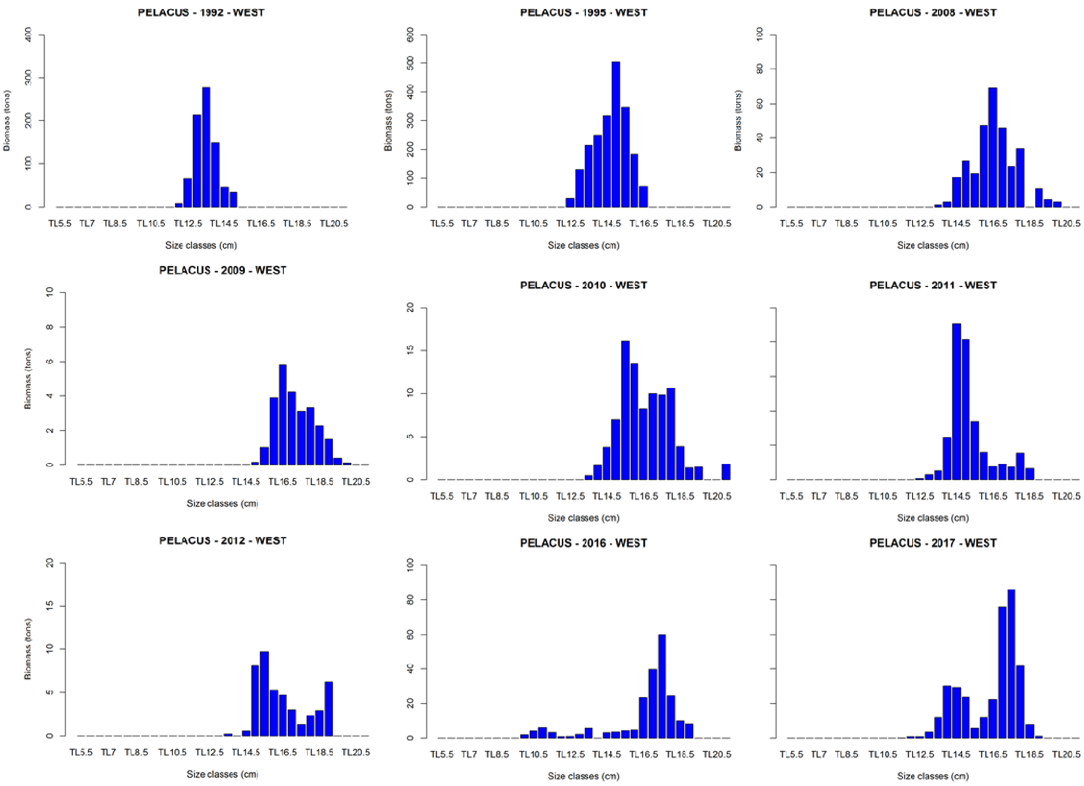

Figure 4.1.1 - Length composition of anchovy in the PELACUS acoustic spring survey series in sub-division 9a.N.

The length frequency distribution of anchovy populations estimated by PELAGO during spring in the 9a.CN and 9a.CS sub-divisions varied spatially and annually (Fig. 4.1.2). Minimum and maximum sizes estimated in the 9a.CN were 6.5 (in 2015) and 19 cm (in 2000, 2002, 2008 and 2009). Minimum and maximum sizes estimated in the 9a.CS were 7.5 (in 2008) and 18.5 cm (in 1999 and 2002). Modal length class ranged between 11 and 17.5 cm and between 10 and 16 cm for the 9a.CN and 9a.CS, respectively. Length frequency distribution was frequently bi-modal in the 9a.CN area, as opposed to the 9a.CS that generally had just one mode.

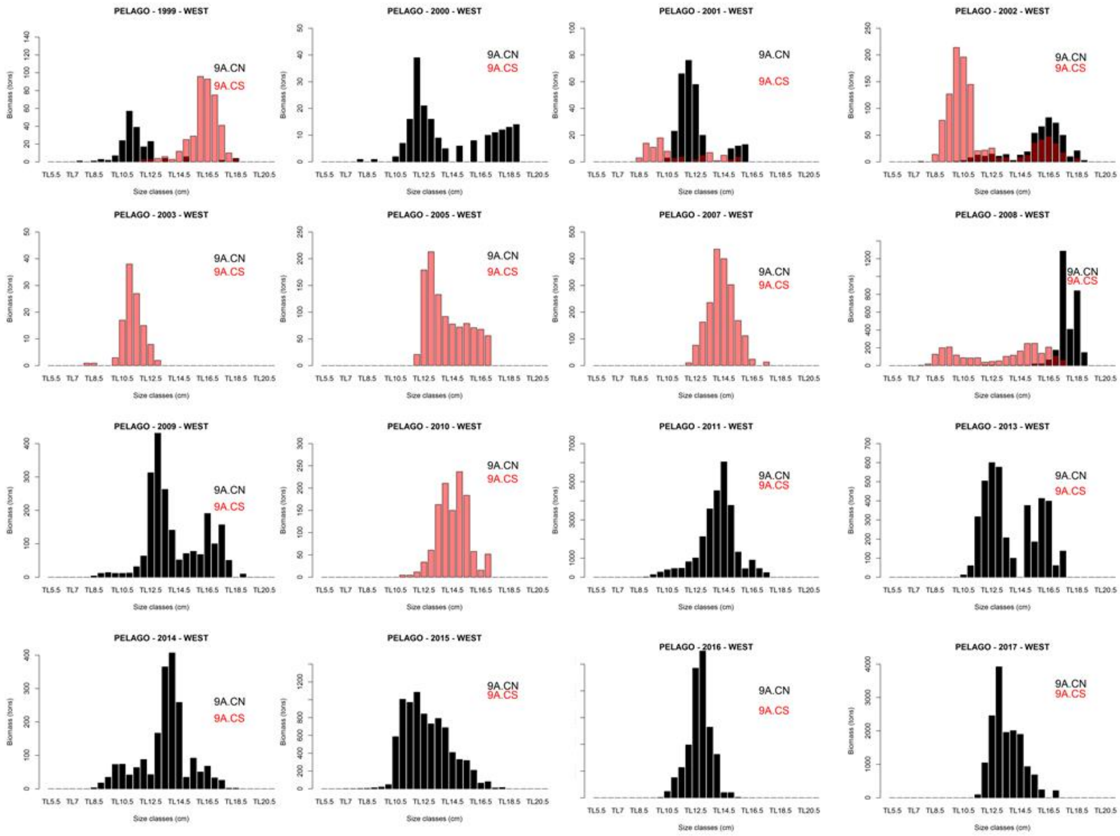

Figure 4.1.2 - Length composition of anchovy in the PELAGO acoustic spring survey series in sub-divisions 9a.CN and 9a.CS.

The length frequency distribution of anchovy populations estimated by SAR during autumn was similar for the 9a.CN and 9a.CS sub-divisions (Fig. 4.1.3). Minimum sizes were 8 cm estimated during 1998 for both areas and maximum sizes were 19 and 18 cm (estimated during 2000 and 2001 for the 9a.CN and 9a.CS, respectively). Modal length class ranged between 12 and 16 cm and between 12.5 and 16.5 cm for the 9a.CN and 9a.CS, respectively.

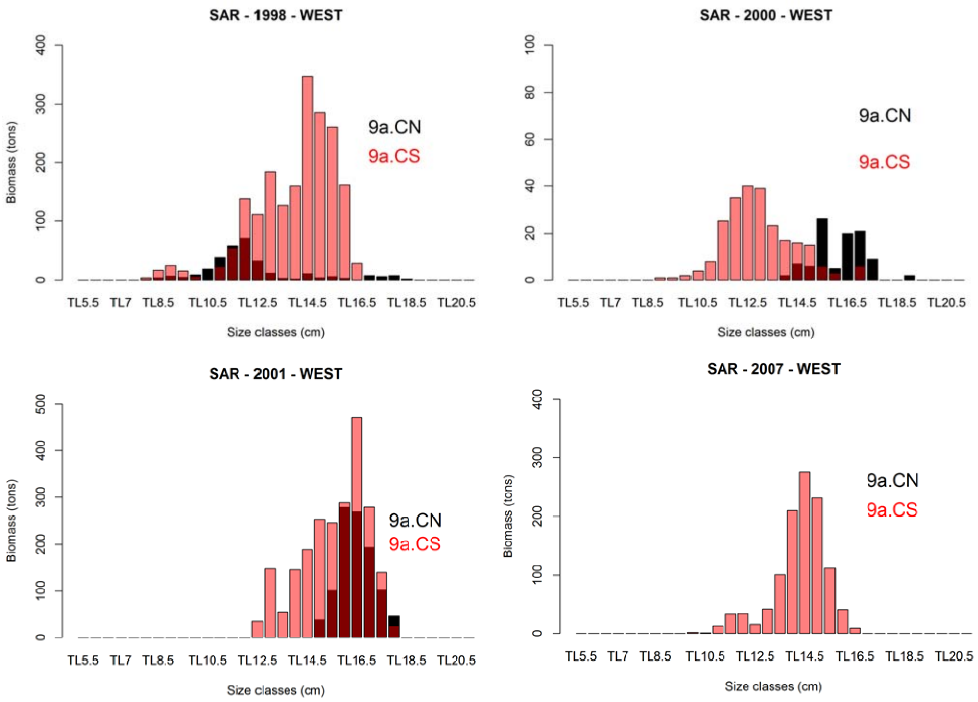

Figure 4.1.3 – Length composition of anchovy in the SAR acoustic autumn survey series in sub-divisions 9a.CN and 9a.CS.

The length frequency distribution of anchovy populations was estimated by the JUVESAR survey during the autumn of 2015 and 2016 (Fig. 4.1.4). While the range of size classes was similar to the other surveys (from 8.5 to 16.5 and from 7.5 to 16 cm for 2015 and 2016, respectively), the modal size classes were significantly lower (10.5 and 10 cm for 2015 and 2016, respectively). Those anchovies were probably the juveniles of the year.

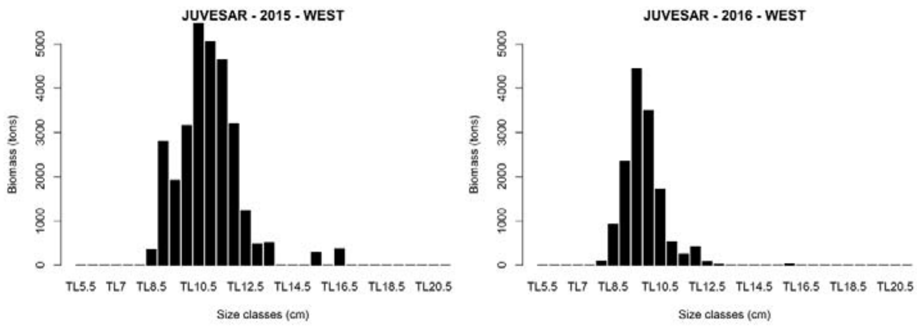

Figure 4.1.4 - Length composition of anchovy in the JUVESAR acoustic autumn survey series in sub-division 9a.CN.

Mean length estimated during spring for the western population (PELAGO + PELACUS surveys) was generally lower in the 9a.CN and 9a.CS when compared to the 9a.N (Fig. 4.1.5), which contrasts with the data from landings (Fig. 2.4.5). Mean weight was significantly higher for sub-division 9a.N when compared to the other areas and decreased in recent years for all sub-divisions (Fig. 2.4.5).

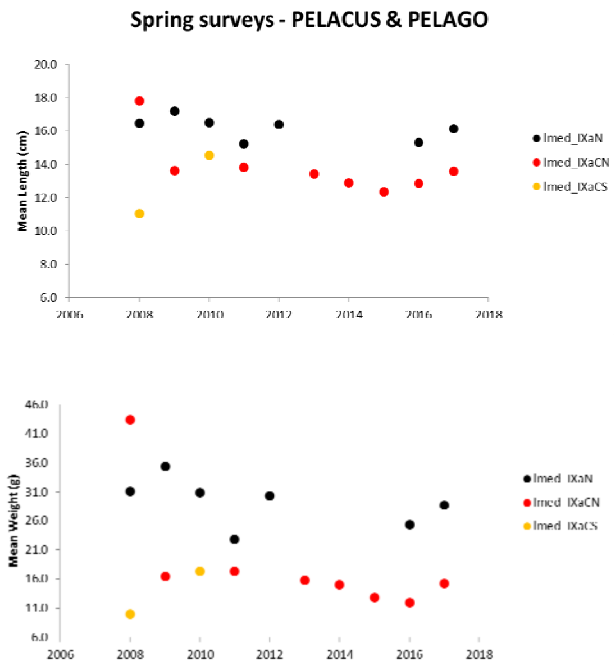

Figure 2.4.5 – Mean length (upper panel) and mean weight (lower panel) of anchovy caught by spring acoustic surveys in each subdivision of the western component of division 9a estimated by PELACUS (9a.N) and PELAGO (9a.CN, 9a.CS).

Mean weight-at-age for the western component derived from the PELAGO and PELACUS surveys was 16.41 g at age 1, 23.79 g at age 2, 27.08 g at age 3, 31.28 g at age 4 (Fig. 2.4.6). In the JUVESAR cruise the mean weight at age 0 was 5.3 g (Fig. 2.4.6).

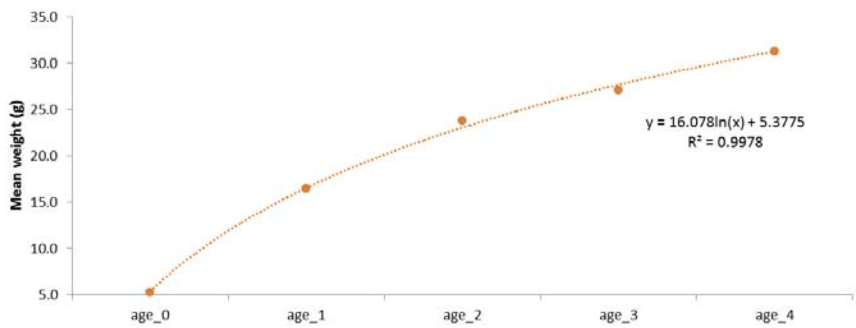

Figure 2.4.6 – Mean weight-at-age for the western component of Division 9a estimated in the PELACUS and PELAGO spring acoustic surveys for ages 1 to 4 and in the autumn recruits JUVESAR survey for age 0.

4.1.2 – COMPARISON OF LENGTH COMPOSITION OF CATCHES AND SURVEYS

As shown before (Table 1), catches by length and at age from the Spanish (9a North) and from the Portuguese fishery (9a Central North and Central South) are available since 1998 but not on a regular basis. The length distribution and age structure available from landings was compared to those from surveys in the same areas and quarters, to explore a potential selectivity of the catches for given sizes or a consistency between the two types of data.

Length distribution of anchovy in the main area off the western Iberia (9a.CN sub-division, Fig. 4.1.2.1) was generally coincident between the PELAGO survey and landings, except during 2015 when the size class mode of the survey was significantly lower than that of landings (11 and 16 cm, respectively), suggesting the fishery targeted larger fish. The same tendency is even clearer when comparing anchovy length distribution between JUVESAR survey and landings, with estimating a high abundance of small fish and landings targeting only the larger ones.

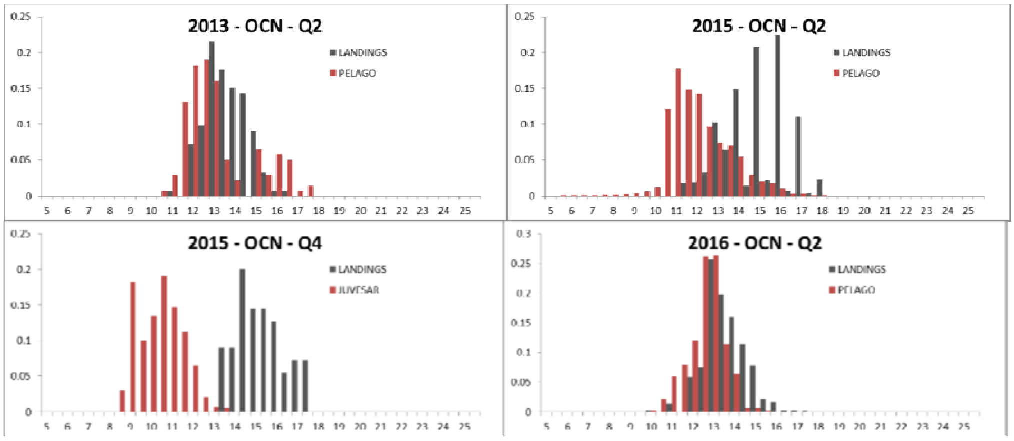

Figure 4.1.2.1 – Comparison of anchovy length distribution (percent contribution per length class) by commercial landings and in the acoustic surveys of anchovy caught in sub-division 9aCN (OCN) during the same year and quarter.

Length distribution of anchovy in 9a.N sub-division Fig. 4.2.1.2) from landings and the PELACUS survey during the same quarter is only available for 2011 and 2012. During these years, length frequency distribution was similar between landings and survey. Regarding age composition (Fig. 4.2.1.3), the proportion of age 1 individuals is higher than those estimated in the PELACUS survey for the two years with available data, while the proportion of age 2 anchovy was higher for the PELACUS survey, particularly during 2012.

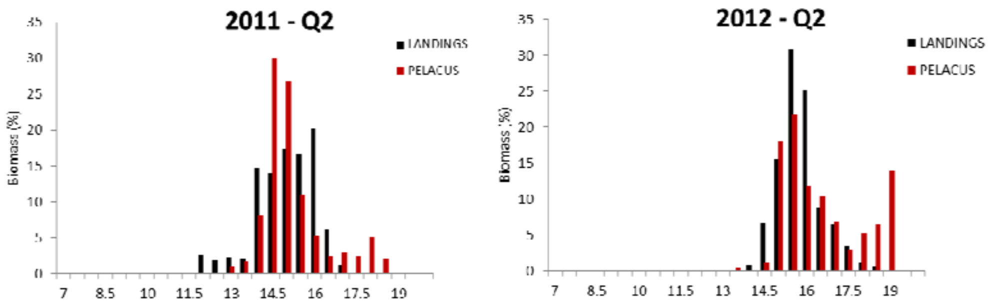

Figure 4.2.1.2 – Comparison of anchovy length distribution (percent contribution per length class) by commercial landings and in the acoustic PELACUS survey of anchovy caught in sub-division 9aN during the same year and quarter.

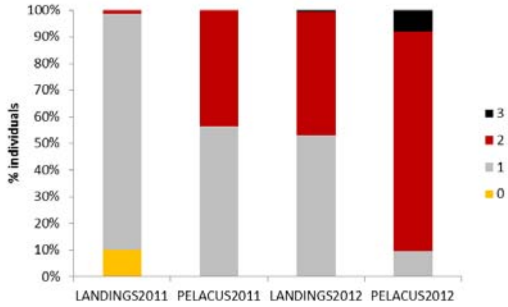

Figure 4.2.1.3 – Comparison of anchovy age distribution (percent contribution per age) by commercial landings and in the acoustic PELACUS survey of anchovy caught in sub-division 9aN during the same year and quarter.

The correlation between annual landings and anchovy abundance estimated by the spring acoustic surveys for the western component of Division 9a was highly significant (spearman correlation=0.942, 95% confidence interval: -0.75 to 0.99, p=0.0001).

4.2 – AGE COMPOSITION OF SURVEYS

4.2.1. - AGE READINGS

It is acknowledged that ageing anchovy otoliths from Division 9a is very difficult. During the last workshop on otolith exchange for anchovy age reading (ICES WKARA 2, ICES 2017b) it was suggested threshold values of agreements around 80% and of CVs around 20% in the training process as a minimum for age readers to be deliver inputs for assessment and the target should be for agreements >90% and CV≤10%. IEO and IPMA age readers of anchovy in Division 9a showed a 75.7% agreement (CV=33.0%), which is a reasonable result. However, other exchange workshops are commended in the near future, particularly at IPMA, where there is currently only 1 experienced reader.

4.2.2 – TIME SERIES OF AGE COMPOSITIONS

Age composition of anchovy in the western component of Division 9a determined by the spring acoustic surveys since 2008 shows that age 1 largely dominates during all years, followed by age 2 (Fig. 4.2.2.1). Age 3 has a very low abundance during all years (>10% of the stock). Age 2 was comparatively more abundant during the year of peak abundance for the stock (2016).

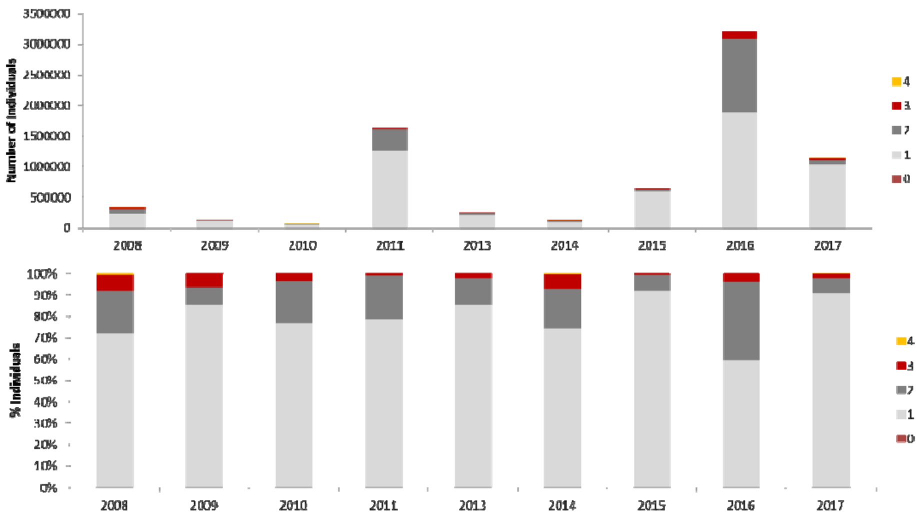

Fig 4.2.2.1 – Age composition in number (upper panel) and percentage (lower panel) of survey stock indicator for the western component of Division 9a.

4.3 – REPRODUCTION

4.3.1 – MACROSCOPIC MATURITY SCALE

Maturity stage assignment criteria were agreed between national institutes involved in the biological study of the species during the Workshop on Small Pelagics (*Sardina pilchardus, Engraulis encrasicolus*) maturity stages (WKSPMAT; ICES, 2008b).

When analysing all data available from surveys of the maturity scale applied to anchovies in the western Iberia sub-division 9a.CN (PELAGO, SAR, JUVESAR), pooled by year regardless of survey, data is not in accordance to contiguous areas of distribution of the species (e.g. Bay of Biscay and Gulf of Cadiz), because the spawning season appears to be more protracted than that described for those areas (Table 4).

A validation exercise of the macroscopic maturity scale has recently been started. Anchovies are being collected regularly at Matosinhos fishing port (9a.CN) and through histology, the accuracy of attribution of maturity stages at IPMA will be assessed.

Table 4 – Percentage of fish engaged in spawning for all samples collected during the PELAGO acoustic survey in 9aCN sub-division according to the macroscopic maturity scale, regardless of the survey and year. Only fish > 12 cm (roughly above size at first maturity) were selected.

Month	% Spawning
February	95
March	87
April	95
May	99
June	100
July	100
August	96
October	89
November	43
December	32

4.3.2 - MATURITY OGIVES

As explained in section 2.5 of this Working Document, there is not enough biological data from landings, such as the macroscopic maturity of sardines. For this reason, it was decided to use data from the PELAGO survey to construct the maturity ogives at length, which are available since 1998 to present. Maturity at age can only be currently estimated from 2008 to present, although a collection of otoliths collected in the acoustic surveys off Portugal is currently being analysed to be able to have age data at least from 1998 to present.

Anchovy maturity at length is very steep. Data collected by the PELAGO survey at sub-divisions 9a.CN (Fig. 4.3.2.1) and 9a.CS (Fig. 4.3.2.2), L_{50} generally occurs between 10 and 12 cm and is similar between the two sub-divisions.

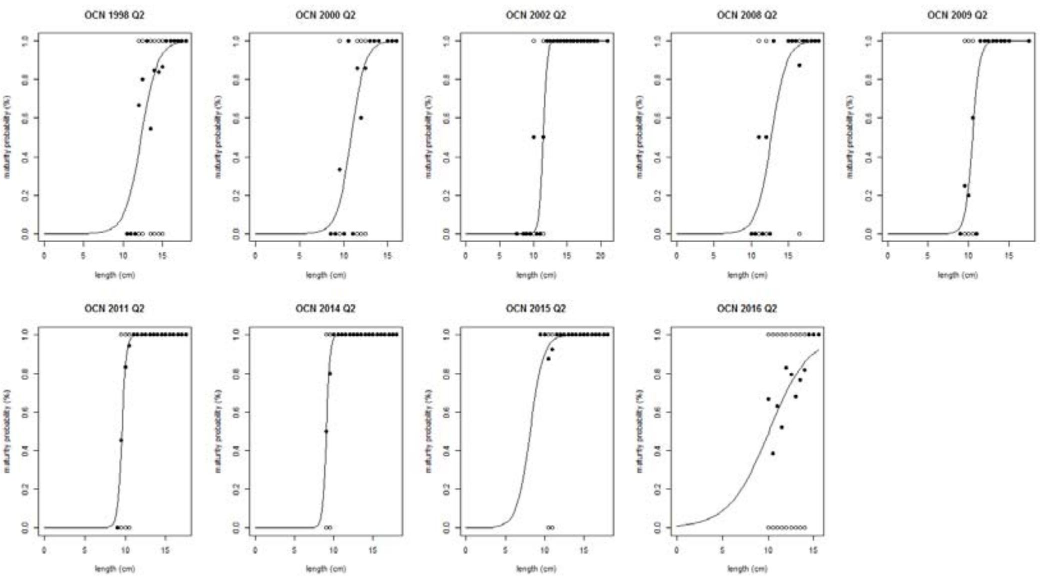

Figure 4.3.2.1 – Maturity ogives of anchovy determined by the PELAGO survey series in the sub-division 9a.CN (OCS)

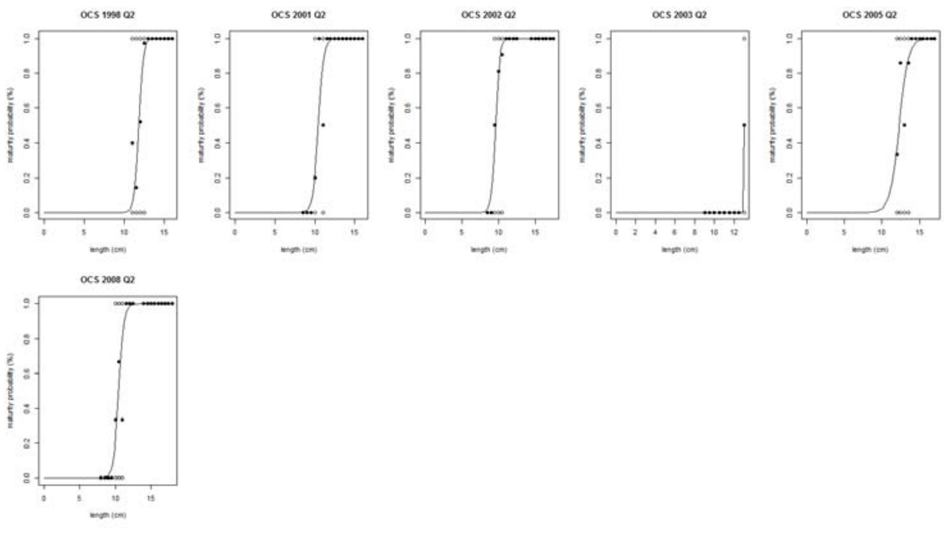

Figure 4.3.2.2 – Maturity ogives of anchovy determined by the PELAGO survey series in the sub-division 9a.CS (OCS).

4.3.3 – SPAWNING CYCLE

Until recently, the only information available before on the spawning cycle of anchovy off western Iberia came from data published in the literature, particularly studies carried out in the Mira Estuary (Ré et al. 1996, Ribeiro et al. 1996). In these studies, spawning was defined as occurring from March to May, peaking in April. However, this study might correspond to an inshore population, like the ones described for the Bay of Biscay (Montes et al. 2016), residing in this estuary located in the 9a.CS sub-division, which may have a different dynamics of the oceanic population that dominates the western Iberia, particularly in the 9a.CN sub-division. During 2017, anchovy sampling by IPMA was more intense in the main fishing port of sub-division 9a.CN (Matosinhos), in part as a consequence of the increase of landings in this area. This allowed obtaining data to better defining the anchovy spawning cycle off the western Iberia (Fig. 4.3.3.1).

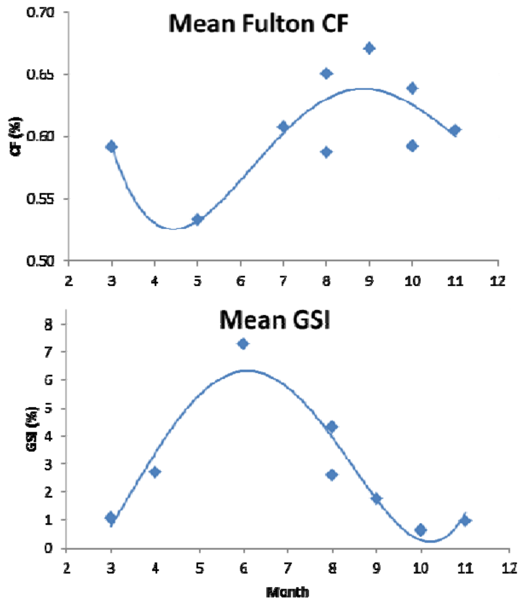

Figure 4.3.3.1 – Mean Fulton condition factor (upper panel) and Gonadossomatic index (lower panel) of anchovy landings in sub-division 9a during 2017.

According to the cycle of the Condition factor and Gonadossomatic index of anchovies collected during 2017 in Matosinhos (modal size classes, 12 to 15 cm), the spawning cycle seems to start in March, April, peak in June and end in July/August (Fig. 4.3.3.1).

According to Ribeiro et al. (1996), mean batch fecundity of anchovy spawning in the Mira estuary is 11710 eggs and decreases throughout the spawning season. Eggs were found in the water in water temperatures ranging from 15 to 19.5ºC (Ré et al. 1996).

4.3.4 – ESTIMATES OF EGG DISTRIBUTION AND ABUNDANCE

There is no routine acoustic survey carried in the western Iberia at the peak of anchovy spawning according to the presented information (May-June) as these surveys mainly target sardine in this area. The PELAGO survey is carried out at the beginning of the anchovy spawning season, allowing the analysis of the abundance and distribution of eggs (Fig. 4.3.4.1). This shows that the main centre of distribution of eggs in the western Iberia is at the northwest, in the central region off Ria de Aveiro – River Mondego area. Anchovy eggs also appear recurrently in the area from Cape Carvoeiro to Cape Espichel and also, in some years, off River Mira (south of Cape Sines) in the southwestern coast. The anchovy egg distribution is highly variable between years. During years of higher abundances anchovy eggs may be observed almost across the whole platform (e.g. in 2017) while during low density periods eggs are only observed in the core areas. Unplanned delays occurred in surveying in the last couple of years, may have contributed to the higher anchovy egg abundances observed since the survey was carried out more into the spawning season for the species. In fact, 2017 was the year with the maximum number of anchovy egg estimated during the PELAGO survey series. The higher egg densities were observed in the northwestern coast and in good agreement with the detection of anchovy schools where high fish abundances were also registered during the previous spring.

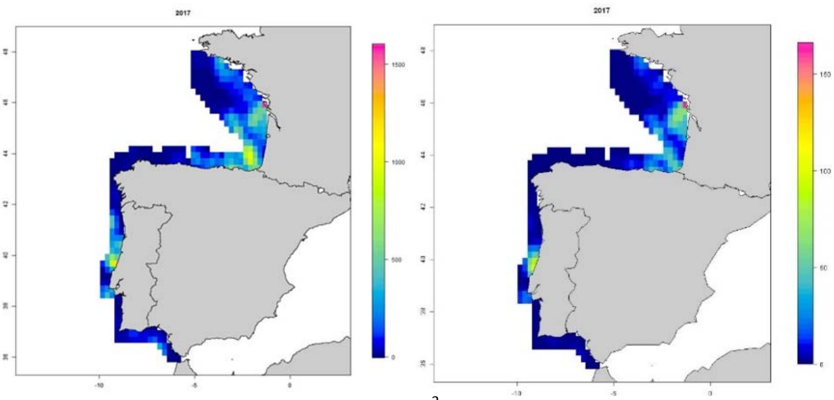

Figure 4.3.4.1 - Anchovy, egg density (eggsm^{-3}), from CUFES sampling, and acoustic energy (SA m2/nm2) distributions, during the acoustic surveys of the PELAGO series (IPMA) for the period 2013-2017. Egg distributions are represented by density classes according to the colour scale depicted and acoustic energies are shown in pink circles with areas proportional to SA. Source: ICES WGACEGG.

4.4 – GROWTH PARAMETERS

No growth parameters are currently available for anchovy in the western component of Division 9a.

4.5 – NATURAL MORTALITY

Natural mortality, M, is unknown for this stock.

Cohort tracking of the stock indicator by pooling all cohorts per age (Fig. 4.5.1) indicates that total mortality is -1.76, therefore natural mortality should be below this value. However, the total mortality estimated by cohort analysis shows high variability and occasionally inconsistent data (see above).

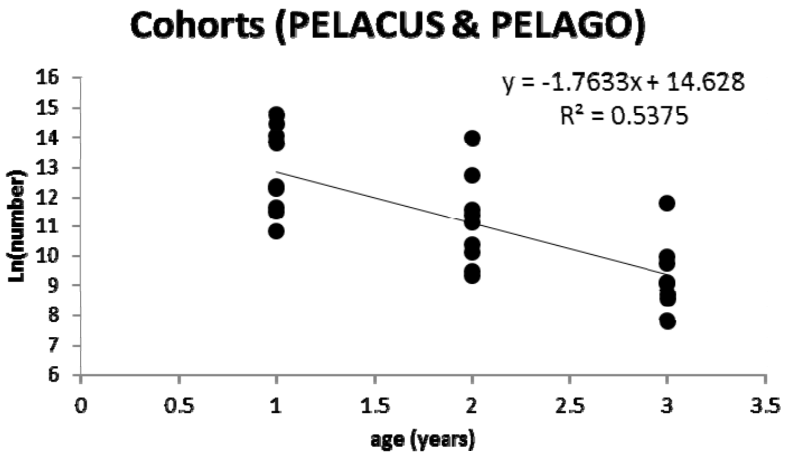

Figure 4.5.1 - Anchovy in 9a Western component (PELACUS and PELAGO surveys). Cohorts (ln(N) per age group) tracked by the survey series.

In case of tracking individual abundances at age by cohorts (Table 5), it can be seen that mean values seem to be highly influenced by abnormal extreme values of Z (as for instance the positive values which are simply impossible). For this reason, the Median value is preferred. The mean of these median values (for ages 2/1 and 3/2) is around 1.79, which is very similar to the one obtained in Figure 4.5.1. Therefore, M has to be lower than 1.8 (approximately) and can be around 1.2. Provisionally, we have adopted the M pattern at age used for the anchovy in the Bay of Biscay which is 1.2 for age 0, 0.8 for age 1 and 1.2 for older ages.

Table 5 - Z estimates between successive abundance at ages by cohorts for ages 1 to 2 (Zage2/1) and for age 2 to 3 (Zage3/2). Z is presented per year (e.g. Z ending up in until 2009 refers to Zage2/1 of fish with age 2 in 2009 and age 1 in 2008, and Zage3/2 refers to the difference between fish of age 3 in 2009 and age 2 in 2008.

Z ending up until:	Zage2/1	Zage3/2	Zage Total	Zage Mean
2009	-3.06	-2.03	-2.81	-2.5
2010	-2.20	-1.49	-2.12	-1.8
2011	1.91	0.27	1.69	1.1
2012				
2013				
2014	-2.17	-1.30	-2.01	-1.7
2015	-0.74	-1.39	-0.91	-1.1
2016	0.68	1.04	0.71	0.9
2017	-3.08	-4.04	-3.36	-3.6
N	7	7	7	7.0
Mean	-1.24	-1.28	-1.26	-1.26
std	1.93	1.64	1.87	1.79
CV	156%	128%	148%	142
Median	-2.18	-1.39	-2.01	-1.79

In addition, for the purposes of carrying a Yield per recruit analysis later, a sensitivity analysis to other M patterns at age will be presented covering some other plausible alternative fixed M at ages at 0.8 (a) and at 1.2 (b) and the values considered for the anchovy in Cadiz (c & d) (Table 6).

Table 6 - Potential Natural mortality patterns at age. Base case adopts the ones applied to the anchovy in the Bay of Biscay. Other cases: a. M=0.8, b M=1.2, c. Values proposed for Cadiz as used in the assessment of the Alboran Sea anchovy (Giráldez et al., 2009) and d. A variant of the base case at higher M values, also explored for the assessment of the anchovy in Cadiz.

	M0	M1	M2	M3	M4+
base	1.2	0.8	1.2	1.2	1.2
a	0.8	0.8	0.8	0.8	0.8
b	1.2	1.2	1.2	1.2	1.2
c	1.2	0.5	0.8	1	1
d	1.5	1	1.5	1.5	1.5

6 - HISTORY OF FISHERY MANAGEMENT

No EU management plan exists for the anchovy fisheries in Division 9.a. The recent history of the regulatory measures in force for the anchovy fishery in the Division are described in the ane 27.9a Stock Annex (see also pil.27.8c9a Stock Annex for the Portuguese fishery). Updated information of the Spanish technical measures is given in the 2014 WGHANSA report (ICES, 2014b). The regulatory technical measures in force for the Spanish (ES) and Portuguese (PT) anchovy purse-seine fishing in the Division 9a (since mid 1980's) are summarized as follows:

- Minimum landing size: 9a N (ES), 9a CN-9a CS-9a S (PT): 12 cm.
- Minimum vessel tonnage: of 20 GRT with temporary exemption (ES).
- Maximum engine power: 450 hp (ES).
- Purse-seine maximum length: 600 m (9a N, ES); 800 m (PT).
- Purse-seine maximum height: 130 m (9a N, ES) 150 m (PT).
- Minimum mesh size: 14 mm (ES); 16 mm (PT).
- Fishing time: 5 days per week (PT, ES).
- Seasonal closures: PT (for sardine): 1.5-2 months (winter/spring) in 9a CN. Since 2015 in 9a CN-9a CS.
- Spatial closures: PT: ¼ nm distance to the coastline. 1 nm if below 20 m depth. ES: inside bays and estuaries and internal waters in 9a N.

Since April 2013 Spain implemented a new management plan for fishing vessels operating in its national fishing grounds, affecting the purse-seine fishing in Galicia (9a N). One of the main measures in this new plan is the introduction of an individual quota (IQ) system to allocate annual national quotas.

An exemption concerned has been included in the Commission Delegated Regulation (EU) No 1394/2014 of 20 October 2014 establishing a discard plan for certain pelagic fisheries in southwestern waters was set to Article 15(1) of Regulation (EU) No 1380/2013, aiming to progressively eliminate discards in all Union fisheries. Purse seine fishery in ICES zones 8, 9. and 10 and in CECAF areas 34.1.1, 34.1.2 and 34.2.0 targeting anchovy has a final de minimis exemption to the quantities that may be discarded of up to a maximum of 2% in 2015 and 2016, and 1% in 2017, of the total annual catches of this species. The joint recommendation includes a minimum conservation reference size (MCRS) of 9 cm for anchovy caught in ICES Subarea 9 and CECAF area 34.1.2 with the aim of ensuring the protection of juveniles of that species.

7 – ASSESSMENT

7.1 - TREND-BASED QUALITATIVE ASSESSMENT: STOCK SIZE AND HARVEST RATE INDICATORS

The anchovy stock in Division 9a (ane.27.9a) has not been yet analytically assessed. ICES considers this stock as an ICES Stock Data Category 3, and it is qualitatively assessed through a survey biomass trend-based assessment without catch advice (ICES, 2017a). No catch advice can be given for the next year to the assessment year because of lack of available data for the year classes that will constitute the bulk of the biomass and catches.

From 2009 to 2014 the provision of advice for the whole Division 9a has been restricted to Sub-division 9a south which was the only area where a more persistent and stable population and fishery existed, where sufficient information from age and length composition of landings could be provided. The advice relied in an update of the qualitative assessment carried out in 2008 and accepted by the ICES Review Groups (RG) of the 2008 and 2009 ICES WGANC (2008 & 2009 RGANC). Since 2015, stock size biomass indicators for the western (subdivisions 9a N, 9a CN and 9a CS) and southern (subdivision 9a S) components of the stock have been computed to illustrate biomass trends at a regional scale. For the western component this indicator is estimated as the sum of spring acoustic estimates from PELACUS and PELAGO spring acoustic surveys (Fig. 7.1.1). The adoption of this approach has some limitations, described in the WD dedicated to the Southern component of the stock, section 5.10 and delivered to this benchmark. Particularly with regards of the western component of the stock, ICES WGACEGG 2017 meeting provided the suggestion to sum the PELACUS (9aN) and PELAGO (9aCN-9aCS) estimates to derive the Stock Size Indicator for the western component in the trend-based qualitative assessment (Fig. 7.1.1).

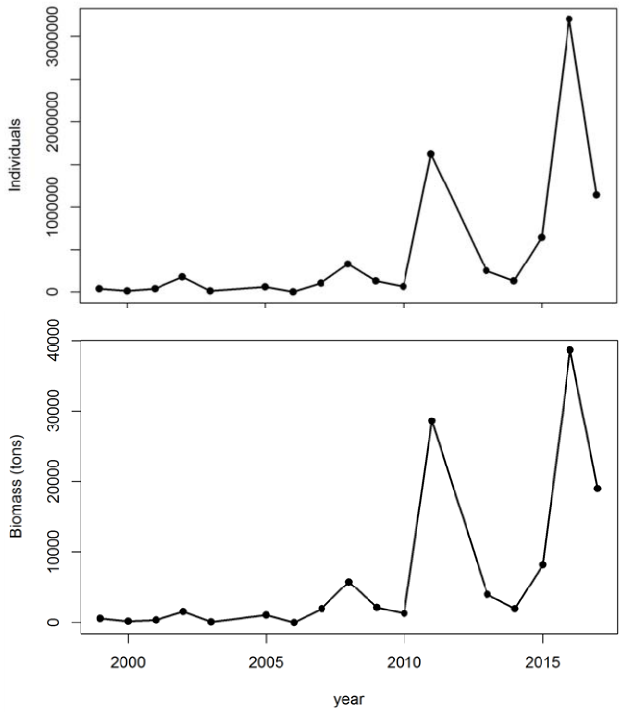

Figure 7.1.1 - Stock biomass size indicator (in thousand tonnes) for the western component of the stock or stock unit 9a West (sum of survey biomass estimates, from spring acoustic -PELACUS and PELAGO - surveys).

Based on this indicator, anchovy estimated acoustically in the western component of Division 9a ranged between 0 in 2006 and 38507 tons (3206121 individuals) in 2016. Anchovy abundance was very low from the beginning of the series until 2006, and increased afterwards, with 3 high peaks in 2016, 2011 and 2017 (with 38507, 28558 and 19006 tons, respectively).

Anchovy in Division 9a has had a yearly TAC since 2011 (Table 5),that ranged from from 7600 tonnes in that year to 12500 in 2016, corresponding to the peak of stock size for this western component (38507 tonnes). In recent years, Harvest Rates ranged from 0.66 in 2014 and 0.03 in 2009. Old data point to some years of significantly higher HR, such as in 2003 (2.69) and in 1999 (2.46), probably as result of abnormal observation errors of the surveys (under estimation errors).

Table 5 - TAC for the 9a anchovy stock, catches, stock size and Harvest Rates for the 9a western component.

		Western component		
		Subdiv. 9.a N + 9.a CN + 9.a CS		
Year	TAC 9a stock	Catches	Stock size	HR
1999		1466.3	596.0	2.46
2000		141.8		
2001		443.6	368.0	1.21
2002		543.4	1542.0	0.35
2003		301.0	112.0	2.69
2004		226.4		n.a
2005		92.2	1062.0	0.09
2006		109.9	0	
2007		843.9	1945.0	0.43
2008		303.3	5810.5	0.05
2009		58.6	2114.9	0.03
2010		281.1	1230.4	0.23
2011	7600	3781.5	28558.4	0.13
2012	8600	778.7		n.a
2013	8800	392.4	4284.2	0.09
2014	9700	1281.4	1947.0	0.66
2015	10600	2717.0	8237.0	0.33
2016	12500	7140.0	38507.4	0.19

7.2 - EXPLORATORY ASSESSMENT WITH SPICT

SPICT (Production model in Continuous Time, Pedersen and Berg, 2017) was explored to assess the 9.a-west anchovy and derive proxy MSY reference points.

The surveys considered to be reliable indicators of 9.a-west anchovy biomass are the two spring acoustic surveys: PELACUS, that covers the northern part of the area (9.a-North, Galicia) and, PELAGO that covers the remaining 9.a western area corresponding to the west Portuguese waters (9.a-Central-North and 9.a-Central South) (see Section on surveys).

Model runs were carried out with the following data (Fig. 7.2.1):

- Annual catches in 9.a-west 1989 – 2016
- Spring acoustic survey biomass 1999 – 2016

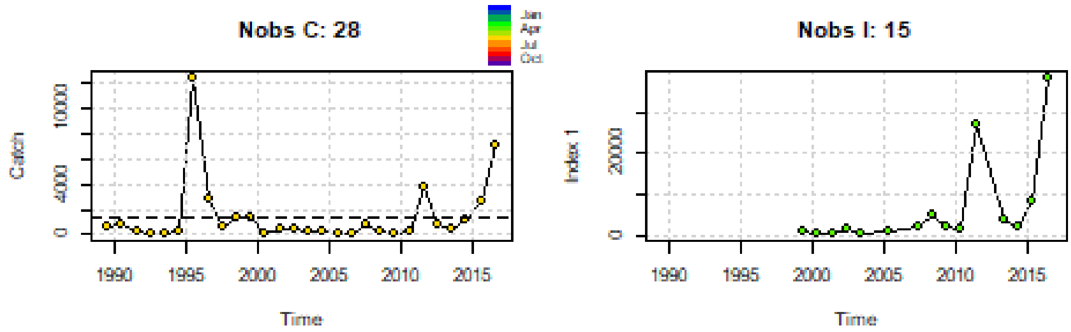

Figure 7.2.1 – Times series of anchovy catch (left) and survey biomass (both tonnes) in 9.a-west.

Catches were assumed to be observed in mid-June to reflect the concentration of the fishery in the second semester. The biomass was assumed to be observed in mid-April, a compromise between the dates of the two surveys. To obtain indices of exploitable biomass, fish with total length below 11 cm were excluded from the survey biomass. This cutting point was based on the catches-at-length in recent years (see section on catch-at-length). In that period, when both years with low and with high abundance of juveniles are covered, 11 cm was the smallest size class appearing consistently in catches (the minimum landing size in the west coast is 12 cm). In PELACUS there were no fish below 11 cm. In the PELAGO, the differences between total and exploitable biomass are below 14.3%; for the combined PELAGO +PELACUS index the differences are below 9.7%.

Due to the short time series of data, the main aim of the exercise was to set up a model that didn't show signs of over-parametrization. Six runs were carried out (Table 6): in the first 3 runs, *n*, the parameter for the shape of the production curve, was fixed to 1, corresponding to the Fox curve (log biomass decreases linearly with effort increase), and in the other 3 runs *n*=2, corresponding to the Schaffer curve (biomass decreases linearly with effort increase). Each of the three runs explored different options about the ratios of observation noise to process noise in biomass and in fishing mortality and about survey catchability. These options were:

(1) - survey catchability estimated as a free parameter
- observation error of biomass index equal to process error of stock biomass
- observation error of catches equal to process error of fishing mortality

The options for error ratios =1 are recommended if there is no information on the parameters (Pedersen and Berg, 2017).

(2) survey catchability estimated as a free parameter
- observation error of the biomass index assumed to be ¼ of process error of biomass
- observation error of catches equal to process error of fishing mortality

Table 6 – Summary of SPICT runs. n- curve shape parameter, alfa- the ratio of index observation error to biomass process error, beta- the ratio of catch observation error to fishing mortality process error. CV-coefficient of variation, sd-Standard deviation.

RUN	FIXED PARAMETERS				RESULTS									
	n	alfa	beta	q	Residuals	Bmsy	cv_Bmsy	Fmsy	cv_Fmsy	MSY	cv_MSY	q	sd_q	Objective functio
1	2	1	1	no prior	Catch residuals correlated at lag 2	423244	1.26	0.34	0.66	142268	1.28	0.03	2.66	63.37
2	2	0.25	1	no prior	Catch residuals correlated at lag 2	277823	1.17	0.78	0.22	216437	1.17	0.07	1.84	62.6
3	2	0.25	1	prior (1,0.5)	Catch residuals non-normal and correlated at lag 2	21290	1.09	0.99	0.00	21012	1.09	0.85	0.46	63.5
4	1	1	1	no prior	ALL checks OK	-	-	-	-	-	-	-	-	Model does not f
5	1	0.25	1	no prior	ALL checks OK	9682	1.18	0.74	0.14	7159	1.13	1.75	1.03	60.6
6	1	0.25	1	prior (1,0.5)	ALL checks OK	15764	1.16	0.61	0.36	9627	1.13	1.09	0.47	61.0

Under the assumption of equal observation and process error in biomass as in (1), observation error was estimated to be around 0.85, a value that appears to be high considering estimates from other surveys and species. For example, CVs of anchovy biomass in PELGAS 2000-2017 were in the range 5-17% (mean=11%), varying inversely with the biomass (the highest biomasses observed in 9.a-west are at the level of the lowest biomasses observed in Biscay). In the case of sardine, an average CV=0.25 has been estimated with geo-statistics in PELAGO surveys.

(3) - survey catchability estimated using a prior with mean =1 and StDev=0.5

- observation error of the biomass index assumed to be ¼ of process error of biomass
- observation error of catches equal to process error of fishing mortality

The acoustic survey is assumed to be an absolute index of biomass a priori. Although there is no basis for this assumption the aim was to constrain *q* to realistic estimates and further stabilize the model.

In all cases, parameters were fixed by setting priors with very small standard deviation, 0.001.

The model was fit using the R script SPICT available from https://github.com/mawp/spict

Guidelines of the user manual were followed
https://github.com/mawp/spict/blob/master/spict/vignettes/vignette.pdf.

Results

In all the three runs assuming the Schaeffer model, catch residuals violated the normality assumption (Table 5). In run 3 with a prior on survey catchability catch residuals were in addition correlated at lag 2. In runs 1 and 2, q was estimated to be much lower than 1, 0.03 (CV=0.98) and 0.07 (CV=0.28), respectively. Therefore, estimates of biomass and Bmsy were one order of magnitude higher than the largest observed survey values.

Assuming the Fox model, the model failed to fit in run 4, the run assuming no prior on catchability and equal observation to process noise. Although the reasons for the failure of the model to fit are not clear, it is possible that no solution was found with the constraint of both noise ratios to 1.

In runs 5 and 6, the models showed a good fit to the data and there are no violations of assumptions (Fig. 7.2.2.). However, all estimated parameters and derived quantities have very wide confidence intervals (Table 5) raising doubts on the perception of the stock and fishery provided by the models. Confidence intervals are especially wide for biomass-related quantities and estimates of MSY. The issue of wide confidence intervals is seen in all previous model runs.

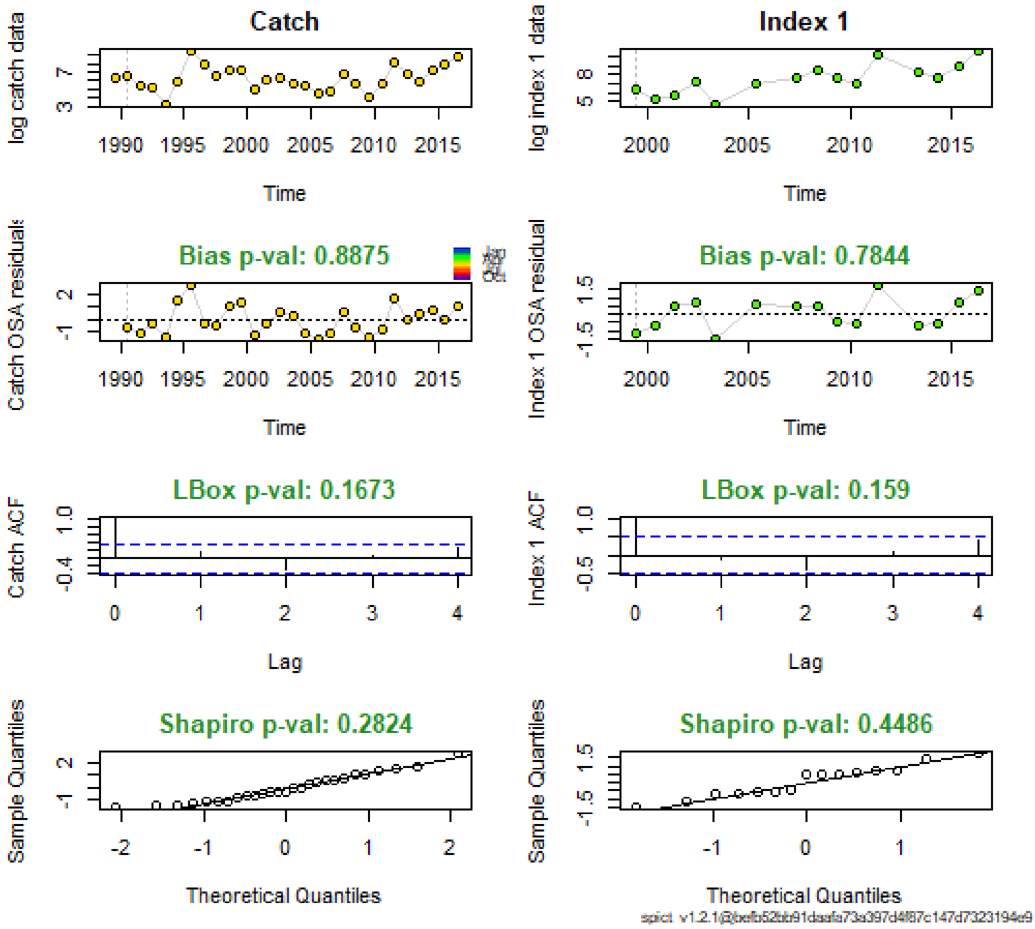

Figure 7.2.2 – Residual plots for the catch (left panels) and survey index (right panels) for run 5.

Stochastic reference points were not calculated for models assuming n=1 (Pedersen and Berg, 2017). Only the stochastic Fmsy was estimated in runs with n =2.

Despite some differences, the various runs show similar biomass and F trends: the biomass has an increasing trend with some large single year peaks in 1996, 2011 and 2016 that are closely fitted by all models except Run 1 (Fig. 7.2.3). Fishing mortality fluctuated at a relatively high level until the early 2000s and decreased thereafter (Fig. 7.2.4). Model fit to catches is shown in Figure 7.2.5.

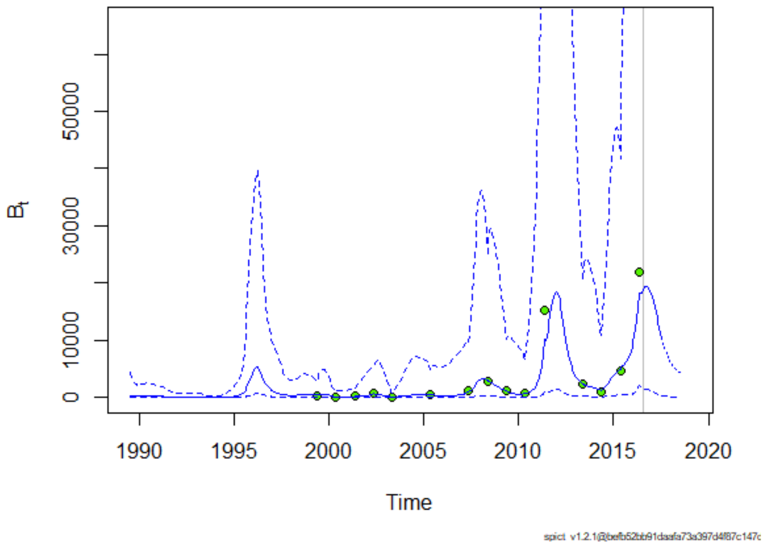

Figure 7.2.3 – Observed and estimated exploitable biomass of 9a.west anchovy in 1989 – 2016 from SPICT run 5. Dashed lines are 95% confidence limits.

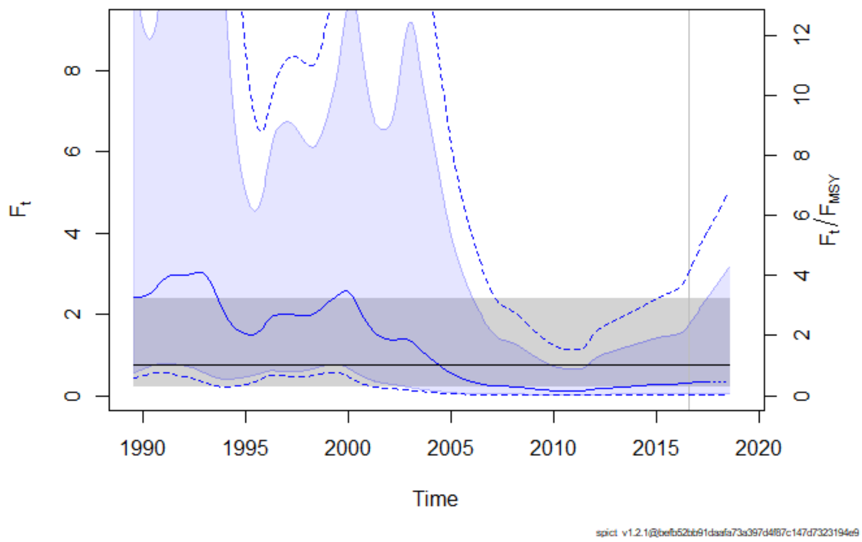

Figure 7.2.4 – Time series of fishing mortality and F/Fmsy of anchovy in 9a.west in 1989 – 2016 estimated in SPICT run 5. Dashed lines and the shadowed bands are 95% confidence limits of fishing mortality and F/Fmsy, respectively. The line indicates Fmsy.

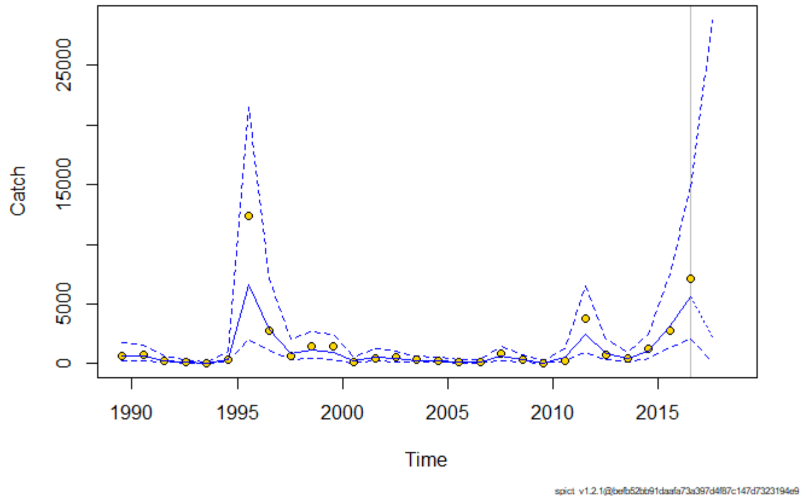

Figure 7.2.5 – Observed and estimated time series of catches of anchovy in 9a.west in 1989 – 2016 from SPICT run 5. Dashed lines are 95% confidence limits.

Considering run 5, which shows relatively good model fit and parameters with uncertainties among the lowest of all runs (similarly to run 6), Bmsy is estimated to be 9682 tonnes (CV=1.18), Fmsy=0.74 (CV=0.14) and MSY= 7152 (CV=1.13). The survey q is estimated to be 1.75 (Stdev=1.03) (Table 1). B2016/Bmsy=1.94 and F2016/Fmsy=0.42 suggest the stock is in good status.

Conclusions

The runs carried out in this work lead to converging models in most cases. Compared to the Schaeffer type models, the Fox models had better behaved residuals, complying with normality and independence assumptions. Moreover, parameter estimates were slightly more precise and the estimates of survey catchability and biomass as well as derived quantities such as Bmsy looked more realistic.

However, in all model runs the parameters had large confidence intervals. Although some uncertainty is to be expected given the typical large fluctuations of this stock, the group considered that none of the runs provided a reliable assessment of 9a-west anchovy.

Further exploration, fixing additional parameters (e.g B/K, acoustic survey observation error) might improve confidence limits. In addition, seasonal catch data and the use of autumn surveys (demersal or acoustic) might be worth exploring in the future.

SPICT is one of the tools recommended to assess and provide proxy reference points for Category 3 stocks (ICES 2016). It has been explored to assess several stocks in the Celtic Seas Ecoregion with variable success (ICES 2017a, WGCSE). The majority of these stocks correspond to medium and long lived species. Sprat in the English Channel is the only short-lived species we're aware of, that SPICT was explored to assess the stock (ICES 2017b, HAWG). Similarly to what we found in the present exercise with anchovy the confidence intervals around the estimated parameters and derived variables from SPiCT were huge in several of the trial assessments conducted in WGCSE and HAWG. In the case of Sprat, HAWG concluded that the data were not informative and the results were not reliable.

WKLIFE7 discussed that SPICT might be appropriate to assess short lived stocks using seasonal data and there are plans for a workshop in 2018 to work on seasonal Spict versions using Sprat as a case study (WKLIFE7 2017).

8 – REFERENCE POINTS AND ADVICE

8.1 – CATCH ADVICE BASED ON SURVEY TRENDS

Variants of DLS Method 3.2 (indicated if there are survey data on abundance but there are no survey-based proxy for MSY $B_{trigger}$ and F values or proxies are not known), have been applied to advise on catches for other short lived species such as sprat. For example, for sprat in 27.3a, in-year catch advice is based on a comparison of the latest index value with the four preceding values, multiplied by the recent advised catch (ICES, 2017).For 9.a anchovy, there was a proposal to consider a variant where the in-year catch advice (Cy) was the ratio between the mean catch in the previous three years over the mean biomass index during the last three years multiplied by the biomass estimates in year y.

For 9.a west anchovy, a variant may be considered where the denominator is the biomass in year y-1 to reflect the fast changes in biomass. The survey biomass has a CV of 129% therefore working with a mean of 3 years may result in trends that are biased upwards or downwards in relation to the trends in biomass. Similarly, the recent catch, could be actually the catch in y-1.

An additional constraint that takes into account the historical harvest rates could be applied on top of the previous trend rule: the harvest rate corresponding to the catch should not exceed the upward range of historical harvest rates (hr=0.43 since 2007). This kind of approach has been followed by ICES to give in-year advice for 9.a anchovy in 2016 and 2017.

8.2 - Reference points derived from the biomass dynamics model

See section 7.2 above.

8.3 Advice based on SPR analysis.

This analysis will be delivered to the benchmark in Uriarte et al_ WD2018_title_of_the_WD.

9 - ENVIRONMENTAL DRIVERS

The Western Iberia is located at the northern limit of the Canary eastern boundary upwelling ecosystem and is comprised of several sub-regions distinguishable by their coastline morphology, freshwater input, exposure to prevailing winds and dominant water masses pelo (Mason et al.2006): i) the northern Iberian shelf, characterized by a narrow shelf with summer upwelling events off limited to the west (Galicia); ii) the western Iberian shelf, characterized by a wide platform and high river runoff, particularly off in the northwestern coast, wider platform, and a narrower shelf towards the south, both exposed to frequent and intense spring/summer upwelling events.

At least for the 1995 event, It seems probable that a variation in the usual thermo-haline conditions in the northwestern coastal waters of the Iberian Peninsula favoured reproduction and larval survival (ICES, 1997) and hence an increase of anchovy abundance in these areas.

In the west Portuguese coast the European anchovy populations is very smaller than in the Gulf of Cadiz (except for 2017) and contingent upon their spawning areas, which are situated in the main Portuguese estuaries (Ré, 1984; Ribeiro et al., 1996; Ré, 1996). In these areas, the combined effect of a low salinity plume and a poleward current during winter upwelling events creates the proper conditions for retention of egg and larvae close to the shelf break (Santos et al., 2004) favouring some population outbursts.

As recently done for the Iberian sardine (Garrido et al. 2017), an attempt to explore relationships of satellite-derived SST and Chla with anchovy abundance/recruitment. The first approach of this analysis was studying the relation between mean Chla (satellite-derived) during April-May (peak spawning season according to Ré 1996) and the abundance of fish < 12 cm (roughly first year of life) estimated in the PELAGO survey of the following year for the same area. Although the dataset is very small, the largest outburst of anchovy abundance in the western coast was coincident with the maximum Chlorophyll concentration estimated during the spawning season. These relationships will be further explored to try to understand the environmental conditions related to anchovy outbursts (and low abundances) in the western coast.

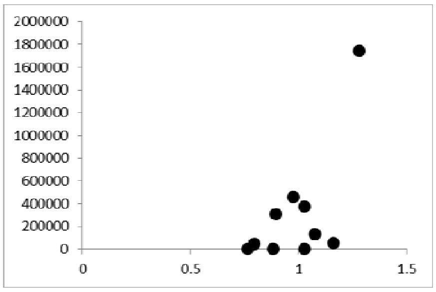

Figure 9.1 – Relationships between satellite-derived Chlorophyll concentration and anchovy recruitment in the following year estimated by the PELAGO survey in the 9a.CN area.

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