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Investigation of consistency of juvenile surveys (e.g. JUVESAR, JUVENA, ECOCADIZ RECLUTAS) for potential future incorporation in the assessments

By

SUSANA GARRIDO, LAURA WISE, MARGARITA RINCÓN, ISABEL RIVEIRO, ANA MORENO, PABLO CARRERA, FERNANDO RAMOS, PEDRO AMORIM

1. ABSTRACT

The present WD evaluates the consistency of the SAR/JUVESAR/IBERAS and the ECOCADIZ-RECLUTAS series, both within-consistency and between-consistency with the acoustic surveys carried out during spring (PELACUS/PELAGO) and summer (ECOCADIZ) to estimate adult stock biomass. The ultimate goal is to provide evidence to support or reject the inclusion of these recruitment surveys in the assessment of the Iberian sardine and anchovy stocks. Recruitment surveys are carried out in the western and southern Iberian coasts during autumn aiming at the acoustic estimation of sardine and anchovy juveniles. The JUVESAR survey was conducted by IPMA during the autumn in the part of the western Iberia considered to be a recruitment hotspot for both species in this coast (9aCN and part of 9aCS). This survey has been recently expanded (JUVESAR/IBERAS from 2018) to the entire western coast (9a N, 9aCN and 9aCS). The ECOCADIZ-RECLUTAS is the autumn acoustic survey series conducted by the IEO in the Gulf of Cadiz shelf waters (GoC, ICES subdivision 9aS, 20 – 200 m depth). In the case of anchovy, no significant correlation of recruitment surveys and spring acoustic surveys was found for both for the west and south components, and the available data of recruitment surveys in the south (ECOCADIZ-reclutas) is still low. For this reason, some more years should be included in the analysis so that the potential of juvenile surveys is evaluated again. For the sardine, a high and significant correlation was found between the abundance of juvenile sardines estimated in the recruitment surveys carried out in the main recruitment area for the stock (subdivision 9aCN, survey series SAR+JUVESAR+IBERAS) and the abundance of sardine estimated in the spring acoustic surveys that are used in the assessment (PELAGO & PELACUS) in the following year. This high correlation supports the progress of this work and testing the inclusion of the western recruitment survey series in the assessment.

2. INTRODUCTION

2.1. SPATIAL DISTRIBUTION OF SOUTHERN ANCHOVY AND SARDINE STOCKS

The Southern sardine stock distribution ranges from the west Cantabrian Sea (division 8c) to western and southern Iberian Peninsula, including the Gulf of Cadiz (division 9a). Iberian anchovy stock covers the division 9a, from West Galicia (9aN) to the northern Gulf of Cadiz. Given the independent dynamics of the populations from the west Iberian coast (9aN, 9aCN and 9aCS) and South Iberian coast (9aS), advice is given separately for the western and southern components of the stock.

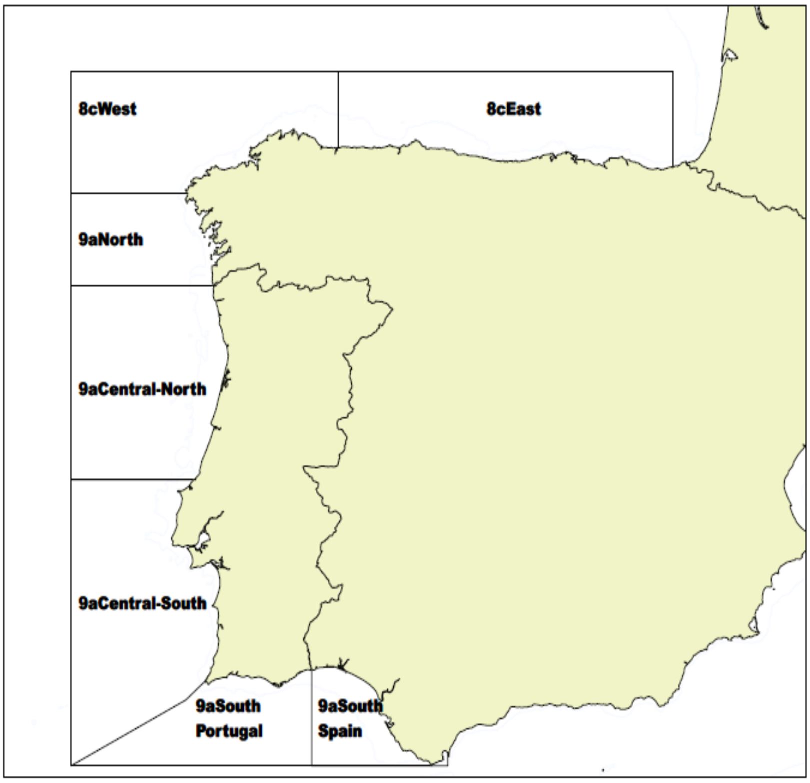

Figure 1. ICES Statistical Divisions and Subdivisions in Southern Europe. Note that subdivision 9a South (which includes the European waters of the Gulf of Cadiz) is also differentiated between Portuguese (Algarve coast, 9aSA) and Spanish waters (9aSC).

Sardine distribution off the Iberia shows two core habitats; the central Portuguese shelf (37–41°N), coastal areas in northern and southern Biscay (outside the distributional range of the southern stock) and the Gulf of Cadiz. The major core area of the southern sardine stock is the central Portuguese shelf, where mean abundance is the highest. The coastal waters off the Galician Rias (42–43°N) are considered as a secondary habitat. In contrast, the northern coast of Spain is an area with very low abundance and high interannual variability (Fig. 2).

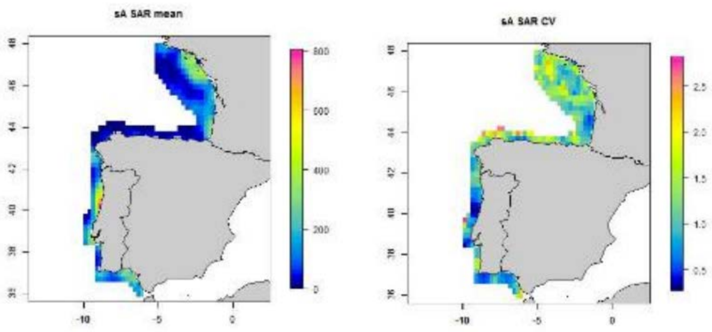

Figure 2. Distribution (gravity centres of spatial patches) of sardine from spring acoustic surveys, time average (left) and CV (right). From the CCR document at
http://www.ices.dk/sites/pub/Publication%20Reports/Cooperative%20Research%20Report%20(CRR)/CRR%20332.pdf

Off the Iberia, anchovy is mainly concentrated on the French shelf south of 47°N, close to the Gironde estuary (45°N) and in the Bay of Cadiz. These are recurrent high concentration areas or core habitats. Within the spatial limits of the southern Iberian anchovy stock there is one area considered as a secondary habitat at the north of Portugal (41°N), where anchovy abundance is occasionally high but where the species does not always occur (Fig. 3).

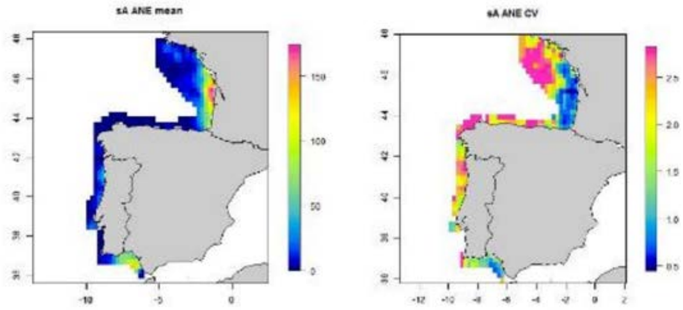

Figure 3. Distribution (gravity centres of spatial patches) of anchovy from spring acoustic surveys, time average (left) and CV (right). From the CCR document at http://www.ices.dk/sites/pub/Publication%20Reports/Cooperative%20Research%20Report%20(CRR)/CRR%20332.pdf

2.2. ACOUSTIC SURVEYS

2.2.1. ADULT ACOUSTIC SURVEYS

2.2.1.1. PELACUS survey series

The PELACUS (PELagic ACoUStic in northwestern Spanish waters) acoustic survey series started in 1991 (previously, since 1984, an acoustic survey was carried out in the area, aimed at sardines and called SARACUS). It is conducted by the Instituto Español de Oceanografía (IEO) in the RV Cornide de Saavedra and covers the divisions 9.a North, 8.c West (western part), and 8.c East (eastern part). During 1994 to 1996 the survey took place in spring but covered mainly the shelf-break area from the Spanish-Portuguese border to Brittany. The acoustic estimate of sardine abundance and biomass was again the objective of the survey in 1995 (IBERSAR 95) and took place on RV "Noruega". From 1997 to 2012, PELACUS was carried out on RV "Thalassa". The Planning Group for Pelagic Acoustic Surveys in ICES Subareas 8 and 9 (ICES, 1999) agreed that acoustic data would only be recorded during daylight, leaving the night-time available for physical, chemical, and plankton characterization of the water column. This recommendation was implemented in 1998. In 2000, the 120-kHz frequency began to be used to help discriminate between different fish species. In 2005, RV "Thalassa" was equipped with the new EK60 with a series of new transducers (18, 70, and 200 kHz). In 2013 the R/V used for PELACUS was substituted by the Spanish vessel Miguel Oliver (MO), built in 2007. In addition the surveyed area was extended from the 200 m isobath to the 1000 m one in order to make available the bulk of the blue whiting distribution. Since 2007, top predators data have also been routinely collected,as well as floating litter and other human pressures such as fishing (e.g. number of boats, type, activity).

The survey design consists of a grid of parallel transects, eight nautical miles apart and perpendicular to the coastline, and covering the continental shelf up to a depth of 200 m. The starting point of each transect is located close to the coast (1–1.5 nautical miles from the shoreline), although the exact location can be modified due to adverse weather conditions or the presence of shallows. The end point of each transect can be also extended if shoals are detected in deeper waters.

Since the beginning of the time series, biological data (length, weight, sex, maturity, etc.) are registered for the assessment of sardines and all other target species. The Spanish spring acoustic survey series PELACUS is the only survey that samples yearly the waters off the subdivision 9aN and division 8c since 1984. These surveys are currently funded by DCF. This survey series provides the size composition (LFD) of the estimated population in numbers and biomass. Age composition is also available since 2008.

2.2.1.2. PELAGO survey series

The PELAGO survey covers the majority of the 9a Division, from subdivisions 9aCN to the Gulf of Cadiz, only excluding the 9aN subdivision. The PELAGO survey (spring Portuguese acoustic survey) series started in 1996 carried out by IPMA in RV Noruega, surveying the waters of the Portuguese continental shelf and those of the Spanish Gulf of Cadiz (subdivisions 9.a.CN, 9.a.CS and 9.a.S), between 20 and 200 m depth. Two surveys were carried out only in Portuguese waters in 1986 and 1988. There was no PELAGO survey in 2004 and 2012. In 2020 the PELAGO survey was carried out with the IEO RV Miguel Oliver (abundance and biomass estimations were considered comparable with previous years (Carrera et al. 2020). PELAGO is co-funded by the European Community Data Collection Framework (DCF) to provide biomass estimates of anchovy and sardine since the mid-2000's.

Acoustic surveying is undertaken along 71 transects perpendicular to the coast, covering the whole platform, and separated approximately 8 nm. Average survey speed is 8 knots and the acoustic signals were integrated over one nautical mile intervals. Echo integration is carried out with a scientific echo sounder Simrad EK500 (38 kHz transducer) until 2017, Simrad EK60 (38 kHz and 120 KHz transducers) between 2017 and 2019 and Simrad EK60 (18, 38, 70, 120, 200 kHz transducers) in 2020. Fishing hauls are carried out for species ground-truthing and fish size composition. Population estimates are provided without a measure of dispersion. This series provides the size composition (LFD) and age-structure of the estimated population in numbers and biomass for sardine and anchovy. 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. Fish egg samples are collected underway every 3nm, with the CUFES system (water pumped from 3m from the surface, system fitted with a 335µm mesh size net), concurrently to the acoustic surveying along the trajectory of the acoustic transects. At night, when acoustics surveying was not running, CTD profiles for hydrography and zooplankton samples (Bongo 60) were collected, opportunistically, in some of the transects.

2.2.1.3. ECOCADIZ

The ECOCADIZ survey is a Spanish survey series conducted by IEO, formerly with the RV Cornide de Saavedra (2004-2013) and afterwards with the RV Miguel Oliver. This is a pelagic community survey conducted in the GoC shelf waters (20–200 m depth) only. Survey dates were planned to be coincident with the GoC anchovy peak spawning. The series started in 2004, but with gaps in 2005, 2008, 2011 (because available ship-time had to be invested in the conduction of the DEPM survey BOCADEVA, see below) and 2012 (no survey). This survey series is currently financed by DCF. Population estimates are provided without a measure of dispersion. This series provides the size composition (LFD) and age-structure of the estimated population in numbers and biomass for sardine and anchovy.

The series of Spanish acoustic surveys in ICES Division 9.a South started in its current form in 2004, although the IEO had already conducted two previous surveys in 1993 and 2002 with the RV "Cornide de Saavedra", surveying only the Spanish waters of the Gulf of Cadiz. The

ECOCADIZ 0693 survey, carried out in June 1993, was aimed at the acoustic assessment of anchovy (Baro et al., 1993). The main objective of the ECOCADIZ surveys since 2004 was the acoustic assessment (by echo integration) and mapping of the abundance and biomass of the populations of the main neritic pelagic fish species in the Gulf of Cadiz over the continental shelf (depths of 20–200 m), including both Portuguese and Spanish waters (ICES Division 9.a South).

The surveys in this new series were planned to be routinely performed on a yearly basis. However, the series had some gaps in those years (2005, 2008, and 2011). All the surveys in the series have been carried out with the IEO's RV "Cornide de Saavedra", a 66.7-m stern trawler. The acoustic sampling scheme adopted in the ECOCADIZ surveys has experienced some changes and attempts to improve the spatial coverage through its relatively short history. The standard surveyed area comprises the Gulf of Cadiz, both Portuguese (Algarve) and Spanish waters, with an acoustic sampling grid consisting of a systematic parallel grid of 21 transects, equally spaced by 8 nautical miles and perpendicular to the shoreline.

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2.2.2. RECRUITMENT SURVEYS

During the 2007 and 2008 meetings of the ICES Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES subareas 8 and 9 (WGACEGG) it was proposed to carry out, since 2009 on, internationally coordinated yearly surveys aiming at the direct estimation anchovy and sardine recruitment in Division 9a (ICES, 2007, 2008). The general objective of these autumn surveys should initially be focused in the acoustic assessment by vertical echo-integration and mapping of the abundance and biomass of recruits of small pelagic species (especially anchovy and sardine), as well as the mapping of both the oceanographic and biological conditions featuring the recruitment areas of these species in the division 9a. The long term objective of the surveys would be to be able to assess the strength of the incoming recruitment to the fishery the next year.

2.2.2.1. SAR-PT-AUT

The Portuguese autumn acoustic surveys were mainly designed to estimate the abundance of age group 0 sardines. The SAR time-series started in 1984 covering the Portuguese continental shelf but was interrupted in 1988. A survey was carried out in 1992 covering also the Spanish Gulf of Cadiz, after which the surveys resumed with a system tic periodicity in 1997–2008. The acoustic methodology was the echo integration of the acoustic targets and fish schools, surveyed along transects. The earlier surveys design until the 1992 survey, varied between "zig-zag" and parallel transects 10 nm apart. In 1997 changed to acoustic transects perpendicular to the coast line spaced ca. 8 nautical miles. Surveys were conducted both day and night.

For acoustic data collection, a Simrad EK500 echosounder with 38-kHz frequency was used. The acoustic data were stored and processed using the software MOVIES+ (Weill at al., 1993). For species identification and biological sampling, trawl hauls were performed with a pelagic or bottom trawl net. The estimation of anchovy in the SAR time-series started in 1999.

2.2.2.2. JUVESAR

The JUVESAR autumn survey series was an acoustic survey restricted to the subdivisions 9aCN and 9aCS. This time-series started in 2013 and ended in 2017 to be incorporated into the IBERAS surveys, which extended the JUVESAR surveyed area since 2018. In 2014, due to bad weather, only a small area was covered. The work area ranged from Póvoa do Varzim in the subdivision 9aCN and Cape Espichel in subdivision 9aCS, , from shoreline (12 m) to 60-100 m isobath over an adaptive grid with tracks spaced 4 or 8 nmi (4nm in the main sardine recruitment areas). The methodology was similar to that of the PELAGO surveys. Acoustic equipment consisted of a Simrad EK-500 scientific echosounder, operating at 38 and 120 kHz. The backscattering acoustic energy from marine organisms was measured continuously during daylight. Pelagic or bottom trawls were carried out whenever possible to help identify the species (and size classes) that reflect the acoustic energy. This series provides the size composition (LFD) and numbers and biomass for age 0 sardine and anchovy.

2.2.2.3. IBERAS

IBERAS survey is conducted by IEO and IPMA. IBERAS main objective is to get a recruitment index for both species in Atlantic waters of the Iberian Peninsula, aiming to improve the estimation of the strength of the recruitment of the Iberoatlantic sardine and the western component of the southern anchovy population. In 2018 the survey was undertaken in November. However both the bad weather conditions, that limited the number of effective survey days, and the aggregation and distribution patterns of the fish, with rather isolated and big schools that made it difficult either to find and, specially, to improve the precision of the biomass estimates, led to change the period of the survey. Therefore, from 2019 the survey was shifted to September, at the same time of JUVENA, which in turn allows a synoptic coverage of the Iberian Peninsula at the end of summer, beginning of fall. The survey was carried out in R/V Ramon Margalef in 2018 and 2020, and in a similar vessel, Angeles Alvariño, in 2019.

The work area ranged from Finisterra cape (in 2020 from Estaca de Bares cape) until Sao Vicente cape, from shoreline (20 m) to 100 m isobath over an adaptive grid with tracks distanced between 4-8 nmi on account the potential recruitment distribution area of both sardine and anchovy. Tracks were enlarged or shortened accordingly. This series provides the size composition (LFD) and age-structure of the estimated population in numbers and biomass for anchovy and sardine, in particular of age 0 individuals.

The methodology was similar to that of the previous surveys and is summarised in ICES (2018). Acoustic equipment consisted of a Simrad EK-80 scientific echosounder, operating at 18, 38, 70, 120 and 200 kHz. The backscattering acoustic energy from marine organisms was measured continuously during daylight except in the northern area where some tracks were steamed at night. Pelagic trawls were carried out whenever possible to help identify the species (and size classes) that reflect the acoustic energy. During daylight hours, concurrently to acoustics, a trained observer recorded marine mammals, seabirds, floating litter and vessel presence and abundance. At night, when acoustics surveying was not running, CTD profiles for hydrography and zooplankton samples (Bongo 60 and Manta trawl nets) were collected, opportunistically, in some of the transects.

2.2.2.4. ECOCADIZ-RECLUTAS

The ECOCADIZ-RECLUTAS Spanish survey series is conducted by IEO, formerly with RV Emma Bardán (2012 survey) and afterwards with the RV Ramón Margalef. The survey series, although planned as a pelagic community survey, is aimed at the acoustic estimation of both GoC anchovy and sardine juveniles and restricted to the Subdivision 9a S (20 – 200 m depth). The surveys series, conducted during the second fortnight of October, is still a very short series: started in 2012 (only Spanish waters sampled) and continued in 2014. A serious breakdown in the RV's propeller system prevented from deriving an acoustic estimate from the 2017 survey. This survey series is currently financed by DCF. Population estimates are provided without a measure of dispersion. This series provides the size composition (LFD) and age-structure of the estimated population in numbers and biomass for anchovy and sardine.

The survey ECOCADIZ-RECLUTAS started 2009 with the objective of acoustically assessing the abundance of anchovy and sardine juveniles in their recruitment areas off the Gulf of Cadiz. That first 2009 survey was unsuccessful for technical problems and only the 6 easternmost transects were conducted. No survey of this series was carried out in 2010 and 2011. In 2012, the ECOCADIZ-RECLUTAS survey was financed by the Spanish Fisheries Secretariat and conducted by IEO aiming at obtaining an autumn estimate of Gulf of Cadiz anchovy biomass and abundance. The survey was restricted to the Spanish waters only. No survey was carried out in 2013. In 2014, 2015 and 2016 the survey took place as planned. In 2017 technical problems restricted the surveyed area to the one comprised by the seven Spanish easternmost transects only. In 2018 ECOCADIZ-RECLUTAS has also experienced methodological problems related with the acoustic sampling coverage (ping rate), meaning that it should be carefully taken into account when dealing with the final acoustic estimates and interpreting their trends. The recently installed EK80 echo-sounder was utilized for the first time and a misconfiguration of the echo-sounder ping rate was detected a posteriori causing an erroneous generation of an active layer with a range deeper than the recording depth or visualization scale. Such an error entailed to slow down the ping rate (1.5-2.0 seconds) in relation to the standard values (at about 0.3 seconds), resulting in an acoustic sampling rate much lower than it should be, which can result in an underestimation of the acoustic densities.

The length of the survey series is still short. The whole survey's area was only surveyed in 2014, 2015, 2016, 2018 and 2019, 5 non consecutive data points (a gap in 2017). Data from the 2020 survey are still being processed. A time-series with at least 6-7 observations will not be available until 2021.

3. MATERIAL AND METHODS

3.1. Data availability

Table 3.1 shows the list of surveys series providing direct estimates of southern sardine and anchovy stocks and the corresponding subdivisions covered within its area of distribution. These surveys are coordinated and standardized (updated surveys protocols) since 2005, within the frame of the ICES Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in subareas 7, 8 and 9 (WGACEGG).

Table 3.1 – Acoustic surveys providing direct estimates for sardine and anchovy in subdivision 9a.

Survey	PELACUS	PELAGO		SAR	JUVESAR	IBERAS	ECOCADIZ		ECOCADIZ-RECLUTAS
Institute (Country)	IEO (Spain)	IPMA (Portugal)		IPMA (Portugal)	IPMA (Portugal)	IEO (Spain)	IEO (Spain)		IEO (Spain)
Subdivisions	9.a N	9.a CN-9.a S		9.a CN-9.a S	9.a CN	9.a N 9.a CN 9.a CS	9.a S		9.a S
Year/Quarter	Q2	Q1	Q2	Q4	Q4	Q4	Q2	Q3	Q4
1998		Mar		Nov					
1999		Mar							
2000		Mar		Nov					
2001		Mar		Nov					
2002		Mar							
2003		Feb		Nov					
2004			Jun				Jun		
2005			Apr	Nov					
2006			Apr	Nov			Jun		
2007			Apr	Nov				Jul	
2008	Apr		Apr	Nov					
2009	Apr		Apr				Jun	Jul	Oct
2010	Apr		Apr					Jul	
2011	Apr		Apr						
2012	Apr								Nov
2013	Mar		Apr		Nov			Ago	
2014	Mar		Apr		Nov			Jul	Oct
2015	Mar		Apr		Dec			Jul	Oct
2016	Mar		Apr		Dec			Jul	Oct
2017	Mar		Apr		Dec			Jul	Oct
2018	Mar		Apr			Nov		Jul	Oct
2019	Mar		Apr			Sep		Jul	Oct
2020			Apr			Sep		Jul	Oct

3.2. Survey consistency

Two methods of examining JUVESAR/IBERAS and ECOCADIZ-RECLUTAS survey consistency have been used for sardine in 8c 9a: within-survey consistency and between-survey consistency. These methods mainly follow those adopted in the 2004 ICES Study Group on Assessment Methods Applicable to Assessment of Norwegian Spring-Spawning Herring and Blue Whiting Stocks (SGAMHBW; ICES, 2004; see also Payne et al., 2009).

3.2.1. Within-survey consistency

Na,y,s is the abundance index for age a, year y, and survey s. Within-survey consistency may be expressed as correlation coefficients calculated over years between the Na,y,s and Na+1,y+1,s. These correlation coefficients offer an indication of the ability of surveys to track year class strength effects. This has been done in the linear domain to allow for zeros as these are often present in the data, if correlation of log(N) was preferred, the log of (N+k) would need to be used, where k is a small constant depending on the scaling of N. A value of k of half of the min{N} might be preferred (ICES, 2004). In the current analyses k was set equal to 3 fish (min{N} = N1,2015=3 millions) In addition to the correlation coefficients, bi-variate plots were examined to check for linearity and the absence of a spuriously high correlation resulting from one or two outliers.

To visualize the correlation in the surveys, plots were made, where the numbers at age a are plotted versus the numbers at age a+1 in the series. The points are marked as the year class so it is possible to follow the year classes through the time series. A linear regression was made where the line is forced through the origin. The fitted line is shown.

Within-survey consistency is completed with survey-based catch curves for each of the year classes (i.e. cohorts) present in the assessed population and an analysis of survey's catchabilities at age. In the first case, natural logarithms of abundance indices (ln(N+k)) for successive ages composing the cohort are plotted and a regression line and model is fitted to the right descending limb of the curve. The abundance index for age 0 (not fully recruited to the adult population), was neither plotted nor fitted to the regression line for the purposes of graphical representation.

3.2.2. Between-survey consistency

The approach followed here differs from the described one in ICES (2004). In that report, the between-survey consistency for a given age was analysed by estimating the correlation between abundance indices for that age provided by two surveys, s1 and s2. Numbers at age 0 in the autumn recruitment surveys were compared to the numbers at age 1 in the following year in the spring PELACUS and PELAGO and summer ECOCADIZ surveys. An additional correlation was also made between juvenile age 0 fish from the autumn survey and the estimate of the recruitment in the following year as estimated by the assessment analytical model (Stock Synthesis, see ICES 2019). A linear regression was made where the line was forced through the origin. The fitted line is shown in the plots.

4. SARDINE SURVEY CONSISTENCY

4.1. INTRA-SURVEY CONSISTENCY - SARDINE

4.1.1. PELACUS INTRA-SURVEY CONSISTENCY - SARDINE

Sardine abundance estimated in PELACUS in ICES divisions 9aN and 8c is used as a relative fishery-independent index for assessment purposes. This index shows a decreasing trend in both abundance and distribution area from 2009 to 2015 and an increasing trend in recent years (Fig 4.1.1.1).

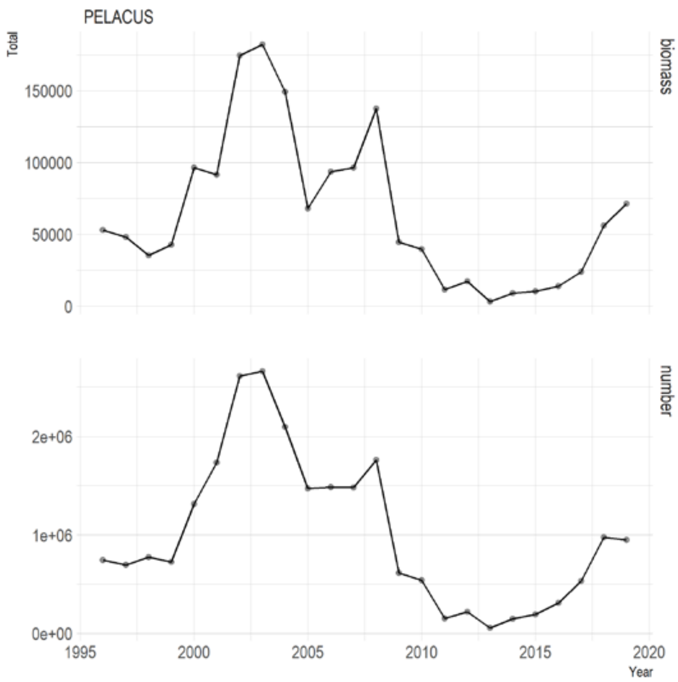


Figure 4.1.1.1 - PIL8c9a stock. PELACUS spring survey series. Time series of biomass (t; top panel) and abundance (millions; bottom panel) acoustic estimates. In 2020 PELACUS survey was not carried out due to the COVID-19 pandemic.

Sardine age composition estimated in PELACUS shows that the ICES subdivision 9aN is strongly influenced by the contribution of young individuals that come from the important recruitment area located in the north of Portugal (subdivision 9aCN), especially in those years of strong age classes. These contributions are reflected in considerable abundances of age 1 the following year. In the Cantabrian area, especially in the 8cE subdivision, there is a greater contribution of older sardines.

There is a high and significant correlation between ages in consecutive years (age x in year n with age x+1 in year n+1) in the PELACUS survey, from age 1 until age 8 (Fig. 4.1.1.2 shows relationships of age 1 and 2 in the left panel and ages 2 and 3 in the right panel).

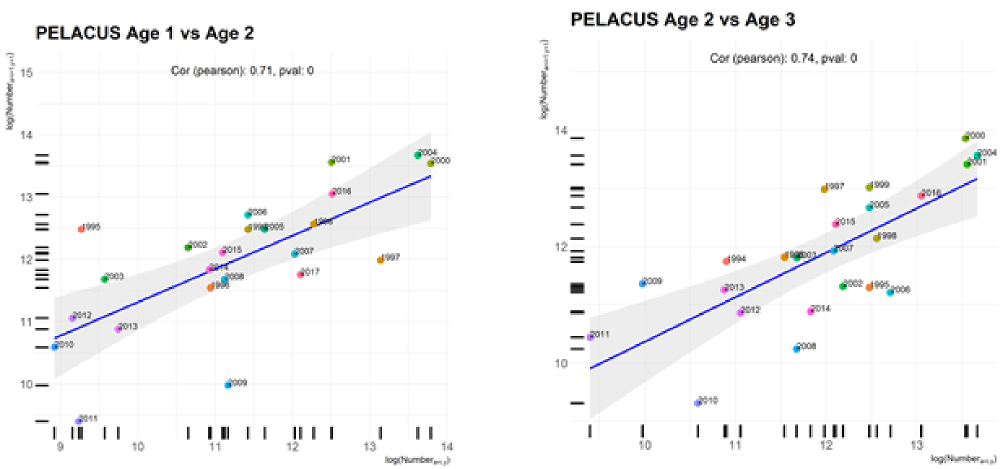


Figure 4.1.1.2 - PIL8c9a stock. PELACUS spring survey series. Correlation of consecutive ages (age x in year n with age x+1 in year n+1) for Age 1 and Age 2, left panel and Age 2 and Age 3, right panel. In 2020 PELACUS survey was not carried out due to the COVID-19 pandemic.

There is a reasonable cohort tracking for the PELACUS survey series where the most abundant cohorts, i.e. 2000, 2004 and 2017 cohorts, can be visually tracked for several years (Fig. 4.1.1.3).

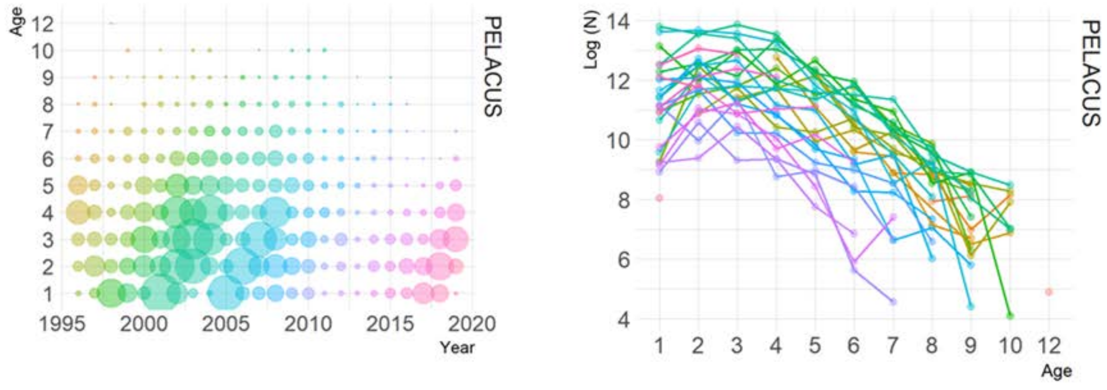


Figure 4.1.1.3 - PIL8c9a stock. PELACUS spring survey series. Cohort tracking (Log number) by age. In 2020 PELACUS survey was not carried out due to the COVID-19 pandemic.

4.1.1.1. PELAGO INTRA-SURVEY CONSISTENCY - SARDINE

Sardine abundance estimated in PELAGO in ICES subdivisions 9aCN, 9aCS and 9aS is used as a relative fishery-independent index for assessment purposes. This index shows a decreasing trend in both abundance and distribution since 2006 until 2017 and an increase in recent years.

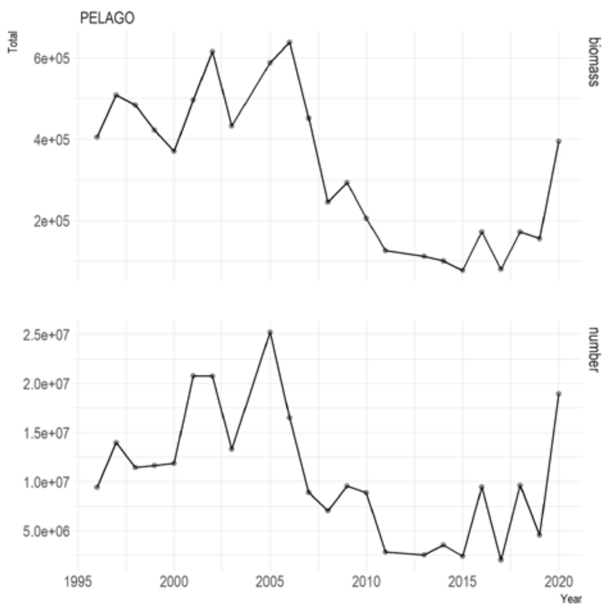


Figure 4.1.1.1.1 - PIL8c9a stock. PELAGO spring survey series. Time series of biomass (t; top panel) and abundance (millions; bottom panel) acoustic estimates.

There is a high and significant correlation between ages in consecutive years (age x in year n with age x+1 in year n+1) in the PELAGO survey, from age 1 until age 7 (Fig. 4.1.1.2 shows relationships of age 1 and 2 in the left panel and ages 2 and 3 in the right panel).

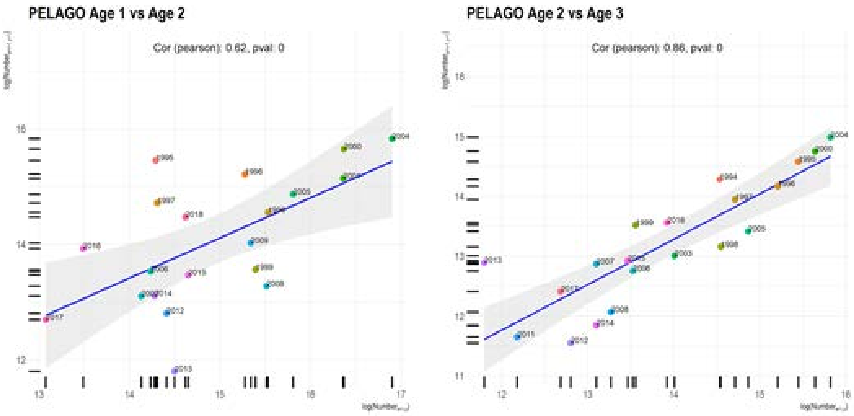


Figure 4.1.1.1.2 - PIL8c9a stock. PELAGO spring survey series. Correlation of consecutive ages (age x in year n with age x+1 in year n+1) for Age1 and Age 2, left panel and Age 2 and Age 3, right panel.

There is a reasonable cohort tracking for the PELAGO survey series where the most abundant cohorts can be visually tracked for several years (Fig. 4.1.1.6).

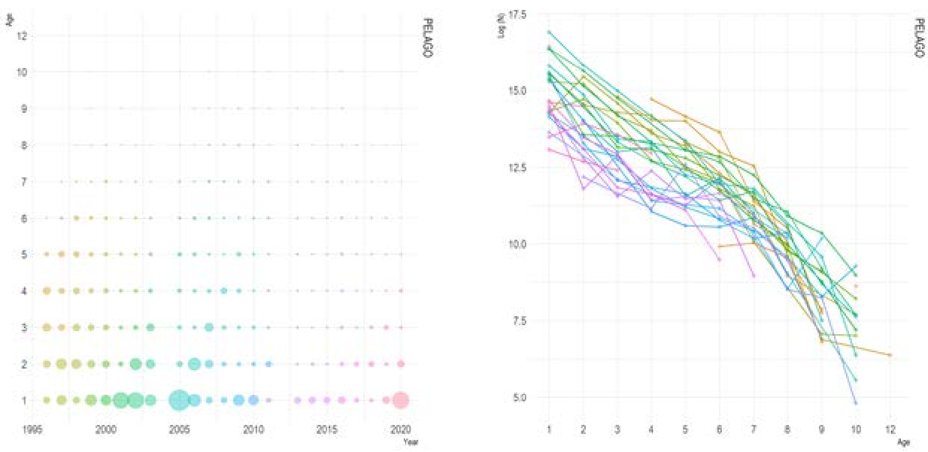


Figure 4.1.1.1.3 - PIL8c9a stock. PELAGO spring survey series. Cohort tracking (Log number) by age.

4.1.1.2. ECOCADIZ INTRA-SURVEY CONSISTENCY – SARDINE

Sardine abundance estimated in ECOCADIZ in ICES divisions 9aS is currently not used for assessment purposes. Sardine abundance estimated in ECOCADIZ shows a stable and low abundance in the beginning of the time series and a sharp increase in 2018 (Fig.4.1.1.2.1).

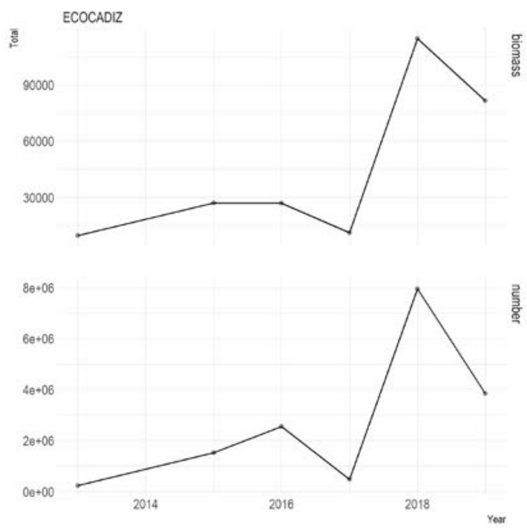


Figure 4.1.1.2.1 - PIL8c9a stock. ECOCADIZ summer survey series. Time series of biomass (t; top panel) and abundance (millions; bottom panel) acoustic estimates.

There is not a significant correlation between ages in consecutive years (age x in year n with age x+1 in year n+1) in the ECOCADIZ survey (Fig. 4.1.1.1.2 shows relationship of age 0 and 1 in the left panel and ages 1 and 2 in the right panel).

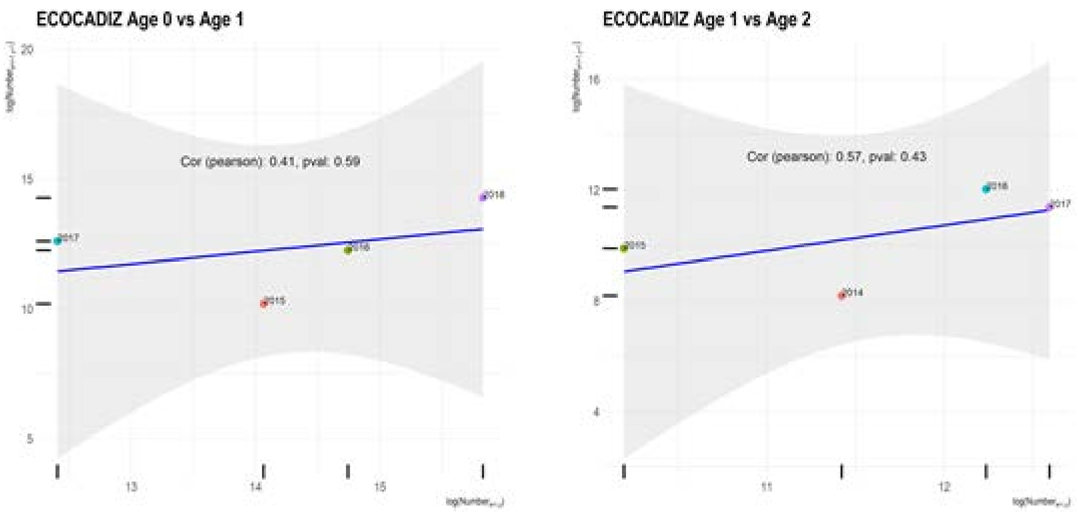


Figure 4.1.1.2.2 - PIL8c9a stock. ECOCADIZ summer survey series. Correlation of consecutive ages (age x in year n with age x+1 in year n+1) for Age 0 and Age 1, left panel and Age 1 and Age 2, right panel.

The small number of years in the time series, together with the short longevity of the sardine in this area, makes it difficult to monitor the cohorts (Fig. 4.1.1.2.3).

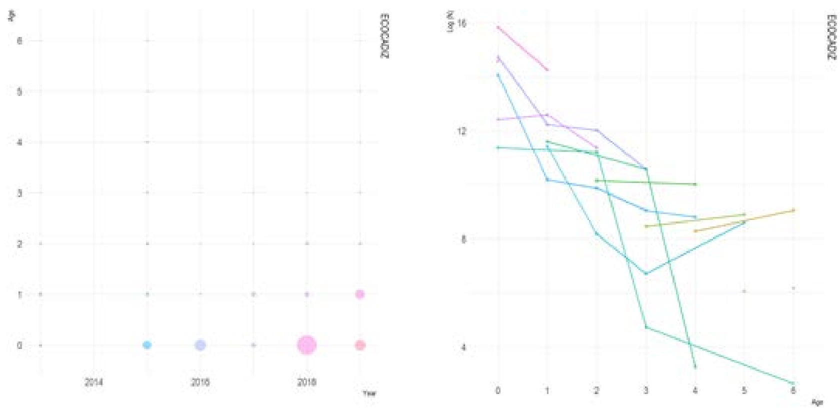


Figure 4.1.1.2.3 - PIL8c9a stock. ECOCADIZ summer survey series. Cohort tracking (Log number) by age.

4.1.1.3. SAR-PT-AUT INTRA-SURVEY CONSISTENCY - SARDINE

The SAR survey was carried out from 1997 to 2007 and aimed to cover the sardine early spawning and recruitment season in the division 9a. It fluctuated during the whole time series with maximum abundance in 2000 (Fig. 1.1.3.1).

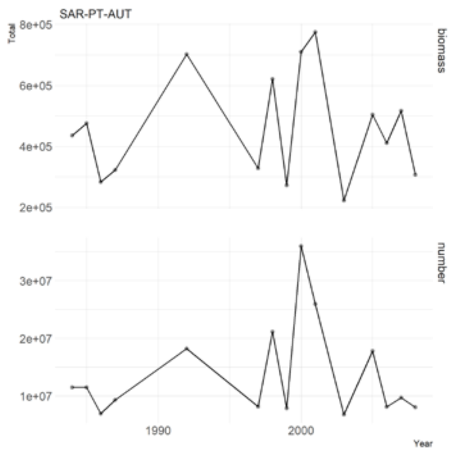


Figure 4.1.1.3.1 - PIL8c9a stock. SAR-PT-SUM fall survey series. Time series of biomass (t; top panel) and abundance (millions; bottom panel) acoustic estimates.

There is no significant correlation between ages in consecutive years (age x in year n with age x+1 in year n+1) in the SAR-PT-AUT survey for any of the ages except between age 1 and age 2 (Fig. 4.1.1.2 shows relationships of age 1 and 2 in the left panel and ages 2 and 3 in the right panel). Being a recruitment survey it does not cover the entire area of adult distribution and therefore this result is expected as the distribution area of the adults is not fully covered.

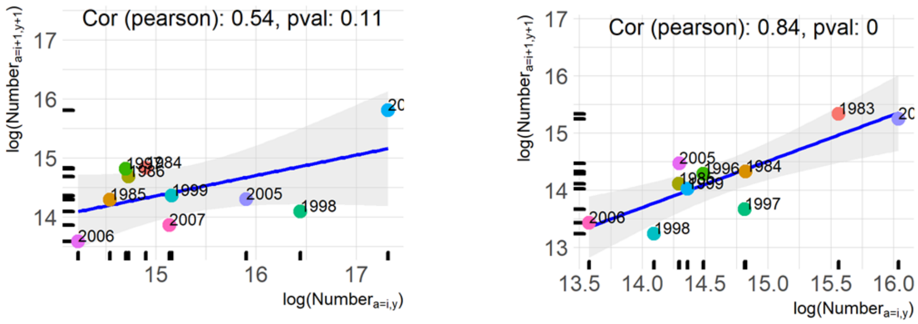


Figure 4.1.1.3.2 - PIL8c9a stock. SAR-PT-AUT fall survey series. Correlation of consecutive ages (age x in year n with age x+1 in year n+1) for Age 0 and Age 1, left panel and Age 1 and Age 2, right panel.

There is a reasonable cohort tracking for the SAR-PT-AUT survey series where the most abundant cohorts can be visually tracked for several years (Fig. 4.1.1.3.3).

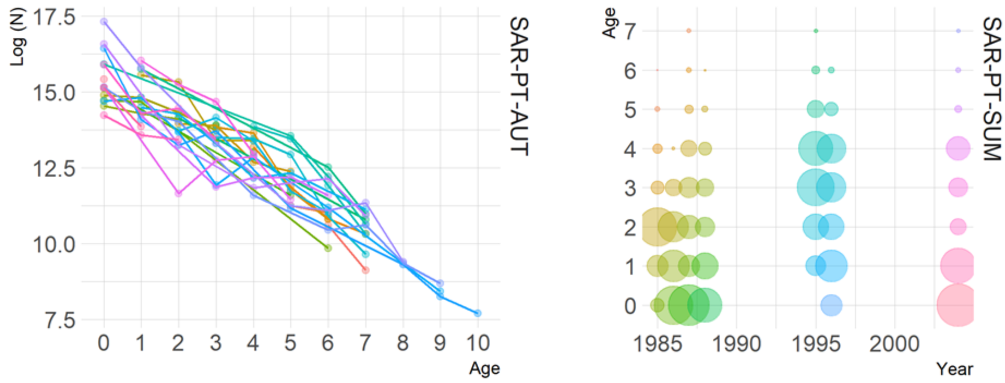


Figure 4.1.1.3.3 - PIL8c9a stock. SAR-PT-AUT autumn survey series. Cohort tracking (Log number) by age.

4.1.1.4. JUVESAR INTRA-SURVEY CONSISTENCY - SARDINE

Sardine abundance estimated in JUVESAR shows a minimum value of abundance in 2015 and an increase in both numbers and total in 2017 (Fig. 4.1.1.4.1).

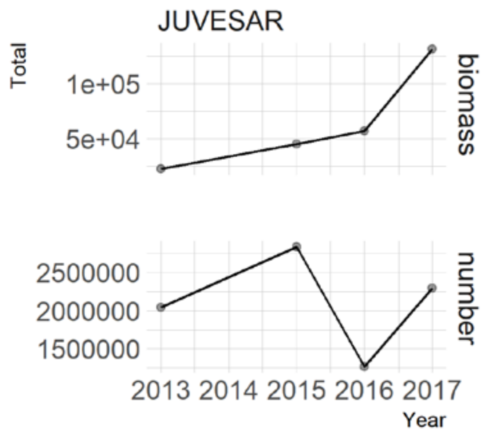


Figure 4.1.1.4.1 - PIL8c9a stock. JUVESAR fall survey series. Time series of biomass (t; top panel) and abundance (millions; bottom panel) acoustic estimates.

There are not enough consecutive years in the JUVESAR survey series to assess the correlation of ages in consecutive years (Fig. 4.1.1.4.2), although this is not expected for a juvenile survey as the area of distribution of adults is not properly covered.

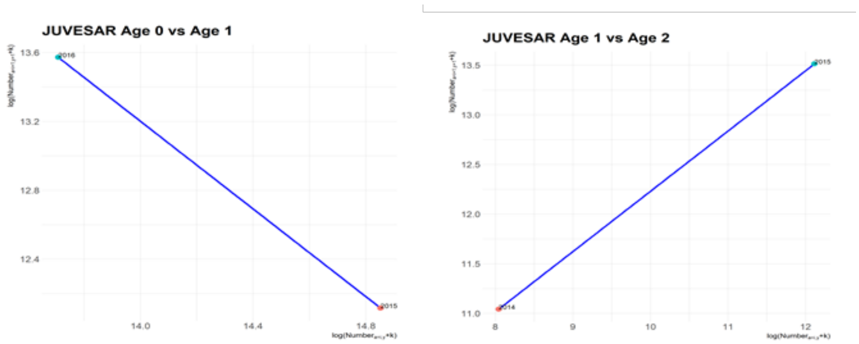


Figure 4.1.1.4.2 - PIL8c9a stock. JUVESAR fall survey series. Correlation of consecutive ages (age x in year n with age x+1 in year n+1) for Age 0 and Age 1, left panel and Age 1 and Age 2, right panel.

There are not enough consecutive years to properly follow cohorts (Fig. 4.1.1.4.3). Moreover, this survey has low spatial coverage for adults given that it is limited to the main recruitment area (9aCN and northern part of 9aCS).

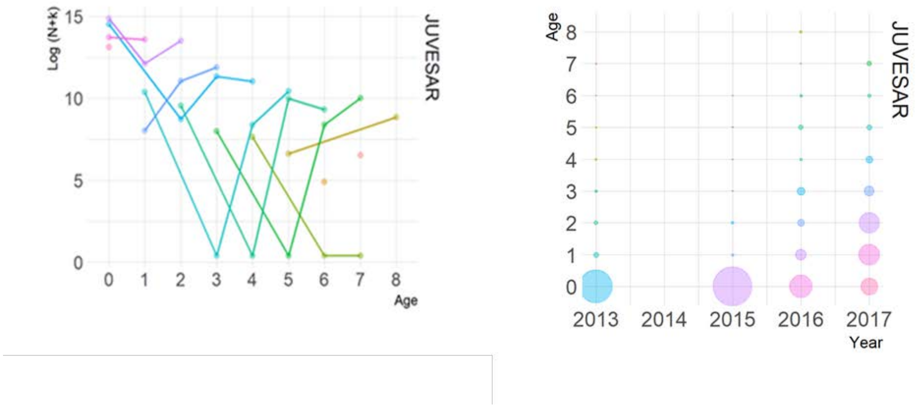


Figure 4.1.1.4.3 - PIL8c9a stock. JUVESAR autumn survey series. Cohort tracking (Log number) by age.

4.1.1.5. IBERAS INTRA-SURVEY CONSISTENCY – SARDINE

The IBERAS survey series started in 2018 so at 2020, the time series has only 3 years. During the 3 years a sharp increase of abundance occurred, with a maximum in 2020 (Fig. 4.1.1.5.1).

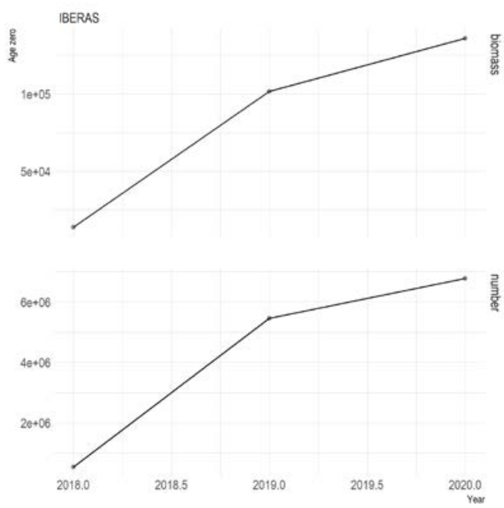


Figure 4.1.1.5.1 - PIL8c9a stock. IBERAS fall survey series. Time series of biomass (t; top panel) and abundance (millions; bottom panel) acoustic estimates.

There are not enough consecutive years in the IBERAS survey series to assess the correlation of ages in consecutive years (Fig. 4.1.1.5.2) , although this is not expected for a juvenile survey as the area of distribution of adults is not properly covered.

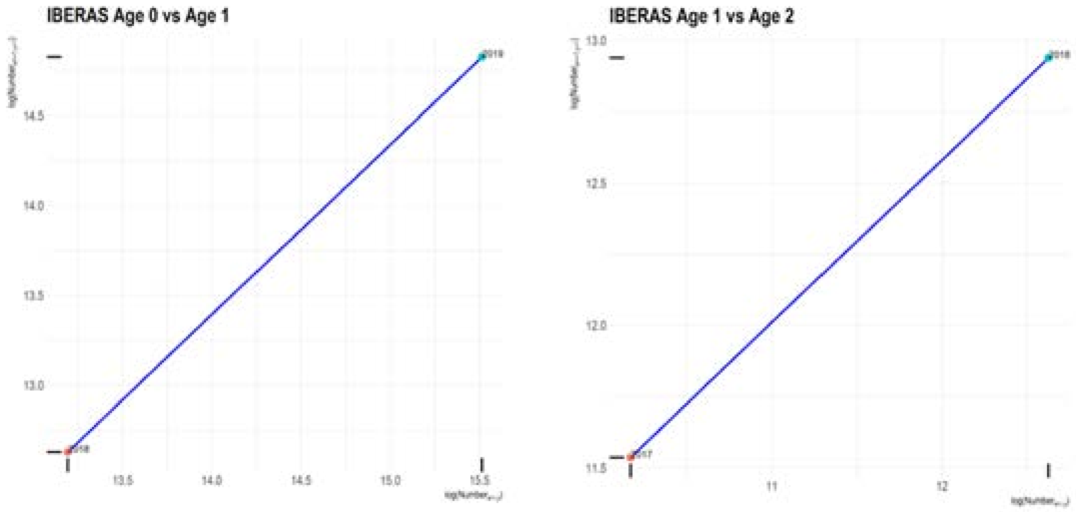


Figure 4.1.1.5.2 - PIL8c9a stock. IBERAS fall survey series. Correlation of consecutive ages (age x in year n with age x+1 in year n+1) for Age 0 and Age 1, left panel and Age 1 and Age 2, right panel.

IBERAS just have 3 consecutive years, which is not enough data to follow enough cohorts (Fig. 4.1.1.5.2).

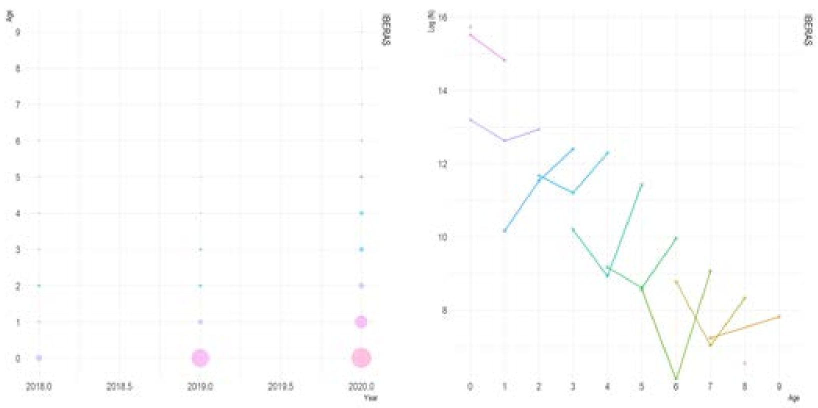


Figure 4.1.1.5.3 - PIL8c9a stock. IBERAS autumn survey series. Cohort tracking (Log number) by age.

4.1.1.6. ECOCADIZ-RECLUTAS INTRA-SURVEY CONSISTENCY - SARDINE

The ECOCADIZ-RECLUTAS survey series shows a sharp increase in abundance in 2016 which represents the abundance peak and the abundance sharply decreased in 2017 increasing in 2018 and 2019 (Fig. 4.1.1.6.1).

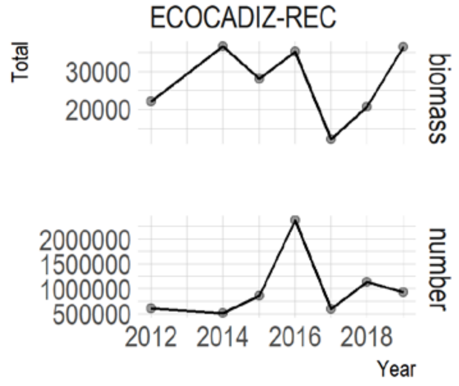


Figure 4.1.1.6.1 - PIL8c9a stock. ECOCADIZ-RECLUTAS fall survey series. Time series of biomass (t; top panel) and abundance (millions; bottom panel) acoustic estimates.

Poor correlation of consecutive ages (Fig. 4.1.1.6.2) and poor cohort tracking (Fig. 4.1.1.6.3) for ECOCADIZ-RECLUTAS was observed, mainly due to technical problems with the 2017 and 2018 surveys. Without those points it is not possible to investigate survey consistency due to the lack of consecutive years.

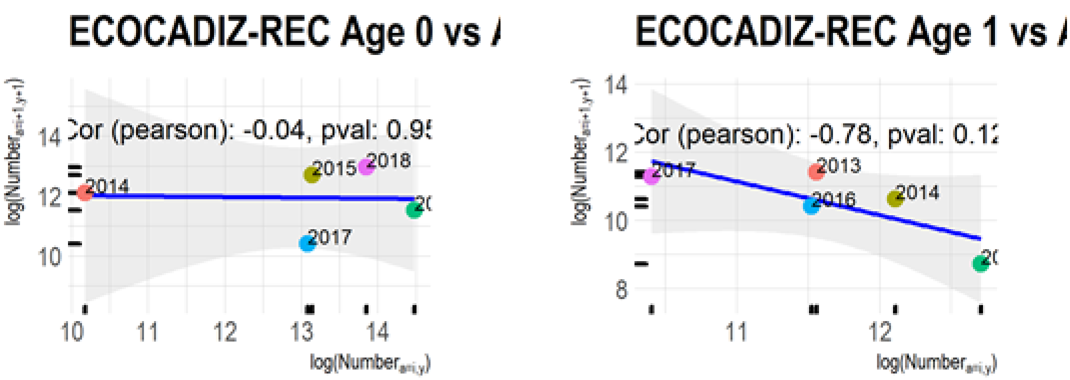


Figure 4.1.1.6.2 - PIL8c9a stock. ECOCADIZ-RECLUTAS fall survey series. Correlation of consecutive ages (age x in year n with age x+1 in year n+1) for Age 0 and Age 1, left panel and Age 1 and Age 2, right panel.

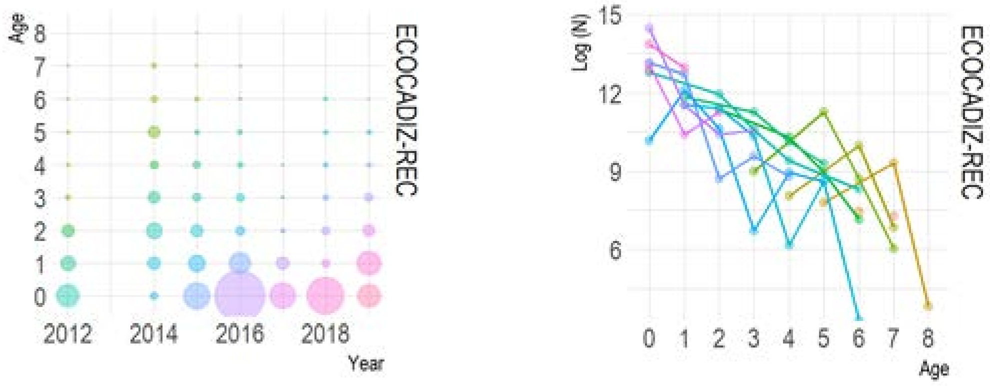
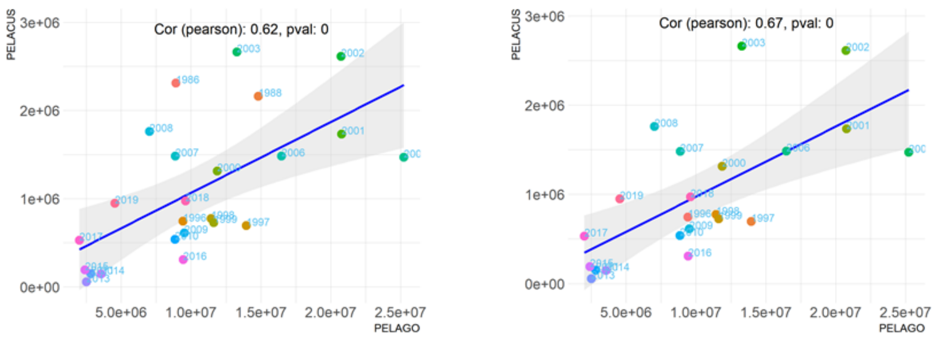


Figure 4.1.1.5.3 - PIL8c9a stock. ECOCADIZ-RECLUTAS autumn survey series. Cohort tracking (Log number) by age.

4.2. INTER-SURVEY CONSISTENCY - SARDINE

4.2.1. PELACUS AND PELAGO INTER-SURVEY CONSISTENCY - SARDINE

There is a significant correlation in the abundance of sardine between the PELAGO and PELACUS spring acoustic surveys registered in the same year(Fig. 4.2.1.1).



Pearson's product-moment correlation
t = 3.7475, df = 22, p-value = 0.001114
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
0.2951216 0.8208983
sample estimates:
cor
0.6242059

Pearson's product-moment correlation
t = 4.0697, df = 20, p-value = 0.0005977
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
0.3510548 0.8526933
sample estimates:
cor
0.6730471

Figure 4.2.1.1 - PIL8c9a stock. Correlation of the abundance of sardine (from 1989 in the left panel, from 1996 in the right panel) between the PELAGO and PELACUS surveys.

4.2.2. PELACUS+PELAGO (8c9a) VS RECRUITMENT SURVEYS (9a) INTER-SURVEY CONSISTENCY – SARDINE

Only three pairs of years when all recruitment surveys (those estimating recruitment strength in the north western Iberia area and the ECOCADIZ-RECLUTAS estimating recruitment strength in the Gulf of Cadiz recruitment area) coincide in the same years with coincident PELAGO+PELACUS in the following year, so it is currently not possible to investigate correlation between ages in consecutive years integrating recruitment of the western and southern coasts (Fig. 4.2.1.1).

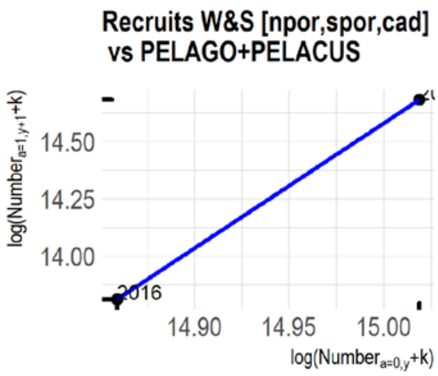


Figure 4.2.2.1 - PIL8c9a stock. Relationship between recruits estimated in year n with the number of individuals estimated in spring acoustic surveys of the following year (combined PELACUS + PELAGO). (Log number) by age.

4.2.3. PELACUS+PELAGO (8c9a) VS JUVENILE ABUNDANCE IN THE MAIN RECRUITMENT AREA (9aCN) OF THE SOUTHERN SARDINE STOCK - SARDINE

Three Autumn surveys series (SAR, JUVESAR AND IBERAS) were carried out in a common area, the subdivision 9aCN, which is the major recruitment area in the division 9a, followed by 9aCS and 9aSC (Table 2, Fig.2). The majority of the biomass of recruits was found in subdivision 9aCN for the majority of the years, particularly the most recent ones of the survey series IBERAS (Table 2, Fig.2). Moreover, high recruitment years were mostly dominated by a high proportion of recruitment in the Northwest Portugal (Fig. 4.2.3.1). Using these three survey series, a time series of recruitment data with more than 20 years, in the major recruitment area of the stock, may be considered.

Table 2 - Proportion (%) of Age 0 in Atlanto-Iberian waters in Recruitment surveys (SAR, JUVESAR, IBERAS) divided by subdivisions (ngal-north Galicia 8cW, sgal – south Galicia, 9aN, nport – Northwest Portugal 9a CN, swport – South West Portugal, 9aCS, sport – South of Portugal, 9aS-alg, cad – Gulf of Cadiz, 9aS-cad). In orange years before analytical assessment started for sardine.

survey	year	ngal	sgal	npor	swpor	spor	cad
SAR-PT-AUT	1984			1	61	38	
SAR-PT-AUT	1985			49	24	27	
SAR-PT-AUT	1986			50	48	2	
SAR-PT-AUT	1987			48	43	9	
SAR-PT-AUT	1992			61	15	2	23
SAR-PT-AUT	1997			36	64	0	
SAR-PT-AUT	1998			40	17	6	37
SAR-PT-AUT	1999			63	33	1	3
SAR-PT-AUT	2000			84	8	1	7
SAR-PT-AUT	2001			18	32	8	42
SAR-PT-AUT	2003			63	36	1	
SAR-PT-AUT	2005			92	5	3	
SAR-PT-AUT	2006			26	40	17	17
SAR-PT-AUT	2007			53	19	1	26
SAR-PT-AUT	2008			63	2	0	35
JUVESAR	2013			28	72		
JUVESAR	2015			75	25		
JUVESAR	2016			13	87		
JUVESAR	2017			19	81		
IBERAS	2018			98	2		
IBERAS	2019		8	92	0		
IBERAS	2020	0	2	96	2		

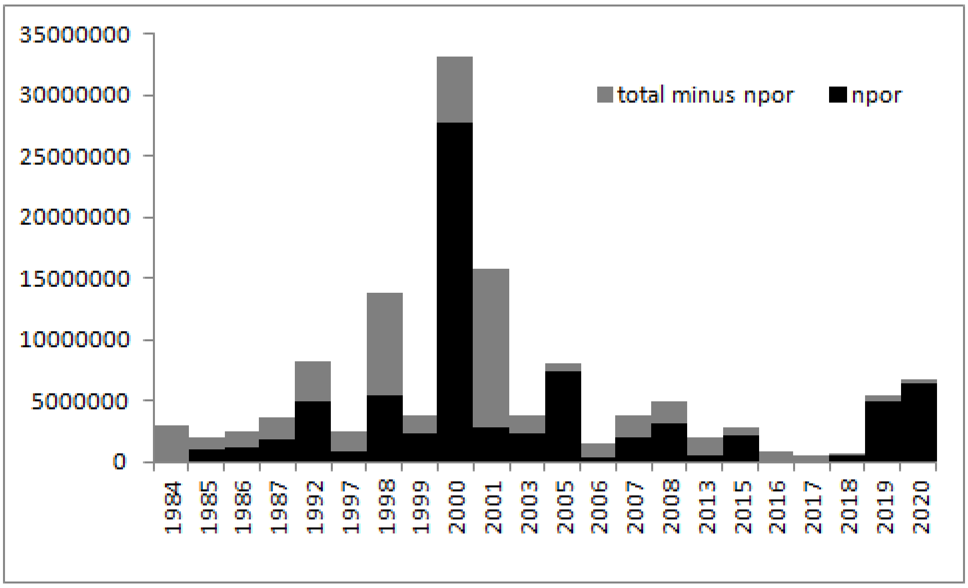


Figure 4.2.3.1 Recruitment in the 9aCN subdivision (black) and in the rest of the division 9a (gray).

The time series of recruitment abundance in the major recruitment area in the division 9a (subdivision 9aCN) shows that during the year 2000 the maximum number of recruitment was registered, far above any other level (Fig. 4.2.3.2). During the SAR survey only 3 other years presented recruitments above the geometric mean of the whole time series. During the JUVESAR survey series all recruitments were estimated below the geometric mean whereas in recent years, during the IBERAS survey series high recruitments were registered in 2019 and 2020, both above the mean.

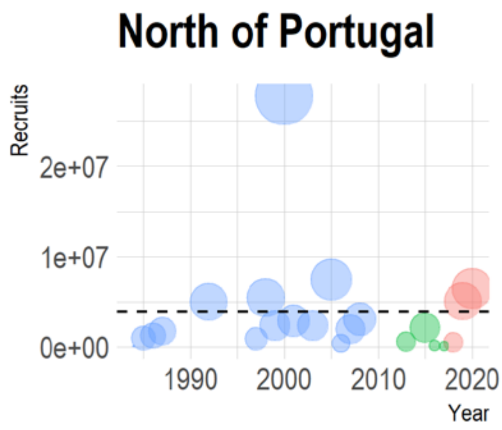


Figure 4.2.3.2 Time series of the recruitment estimated in the 9aCN subdivision (blue SAR-PT_AUT, green JUVESAR, red IBERAS) and in the rest of the division 9a.

The number of recruits (Age0) estimated in the autumn surveys (SAR, JUVESAR, IBERAS) in subdivision 9aCN is highly correlated to Age1 sardines estimated in the PELACUS+PELAGO spring acoustic surveys (9aN, 9aCN, 9aCS and 9aS) in the following year (Fig. 4.2.3.3).

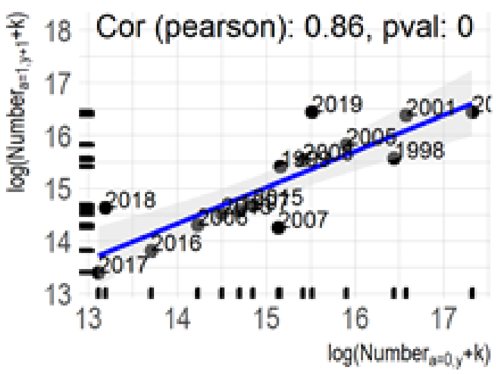


Figure 4.2.3.3 Relationship between the number of recruits estimated in the subdivision 9aCN and the number of Age1 sardines estimated in the spring acoustic surveys of the following year (PELACUS+PELAGO).

The number of recruits estimated in the autumn surveys (SAR, JUVESAR, IBERAS) off sub-division 9aCN is highly correlated to Age1 sardines estimated in the spring acoustic survey PELAGO(9aCN, 9aCS and 9aS) in the following year (Fig. 4.2.3.4).

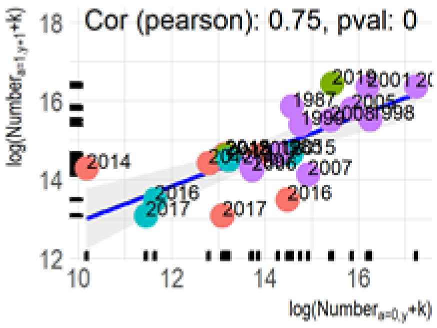


Figure 4.2.3.4 Relationship between the number of recruits estimated in the subdivision 9aCN and the number of adults estimated in the spring acoustic survey PELAGO of the following year.

There is also a significant correlation between recruitment surveys (NW Portugal) and Recruitment estimates of the assessment model (Fig. 4.2.3.5).

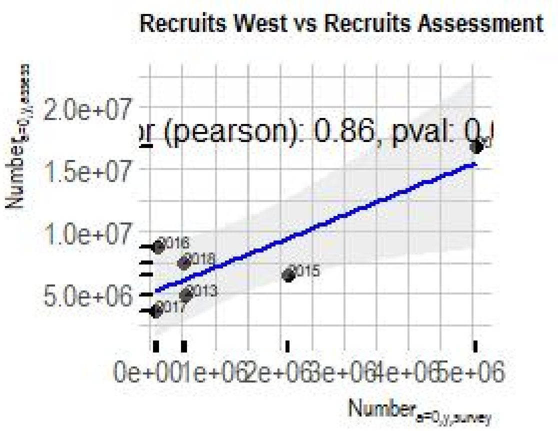


Figure 4.2.3.5 Relationship between the number of recruits estimated in the subdivision 9aCN by Autumn research surveys and the number of Age 1 individuals estimated by the assessment model in the following year.

This correlation is also significant even if removing the year 2000 (when there was a peak in the recruitment) (Fig. 4.2.3.6).

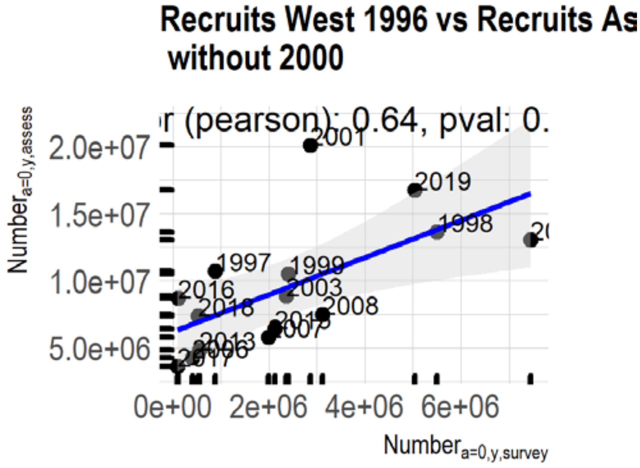


Figure 4.2.3.6 Relationship between the number of recruits estimated in the subdivision 9aCN in the Autumn research surveys and the number of Age 1 individuals estimated by the assessment model in the following year, removing the influential year of 2000 when there was a peak in recruitment as can be seen in Fig. 4.2.3.2.

Finally, if only taking into account the two most recent survey series (JUVESAR and IBERAS) starting in 2013, the correlation of recruits with Age 1 of the following year is slightly lower (R=0.81 vs. R=0.86) but also significant (Fig. 4.2.3.7).

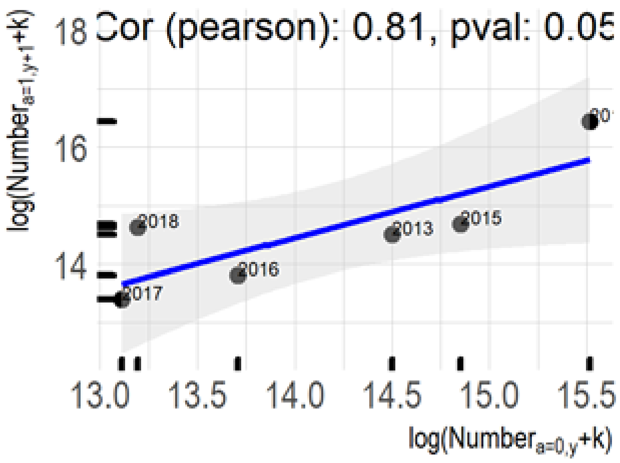


Figure 4.2.3.7. Relationship between the number of recruits estimated in the subdivision 9aCN by the JUVESAR and IBERAS survey series and the number of Age 1 sardines estimated by the spring acoustic surveys (PELACUS+PELAGO) in the following year.

5. ANCHOVY SURVEY CONSISTENCY

5.1. ANCHOVY SURVEY CONSISTENCY - WESTERN COMPONENT

5.1.1. INTRA-SURVEY CONSISTENCY – ANCHOVY WEST

Due to a low abundance of anchovy in the beginning of the time series and the fact that not all anchovy otoliths of the acoustic surveys were yet analysed, only age composition data for anchovy from 2008 are available for the PELACUS and PELACUS surveys series and from 2015 for the JUVESAR survey series (Table 5.1.1.1). The 2020 PELACUS survey was not carried out due to COVID-19 restrictions.

Table 5.1.1.1 – Available data of age composition for the acoustic surveys carried out in the western Iberian (Subdivision 9a N, CN and CS).

YEAR	JUVESAR IBERAS	PELACUS 9aN	PELAGO
2008		X	X
2009		X	X
2010		X	X
2011		X	X
2012		X	
2013		-	X
2014		-	X
2015	X	-	X
2016	X	X	X
2017	X	X	X
2018	X	X	X
2019	X	X	X
2020			X

5.1.1.1. PELACUS INTRA-SURVEY CONSISTENCY – ANCHOVY WEST

Anchovy abundance estimated in PELACUS survey shows very low values in the beginning of the series and a peak in abundance in 2018 (Fig. 5.1.1.1.1).

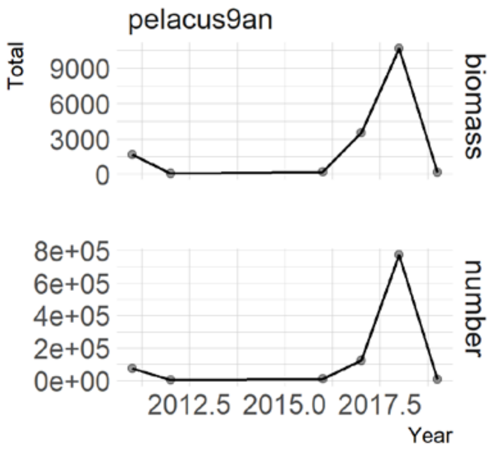


Figure 5.1.1.1.1 - ane.9awest stock component. PELACUS spring survey series. Time series of biomass (t; top panel) and abundance (millions; bottom panel) acoustic estimates.

There is no correlation of consecutive ages (Fig. 5.1.1.1.2) and poor cohort tracking (Fig. 5.1.1.1.3) for PELACUS for the western component of the anchovy (9aN).

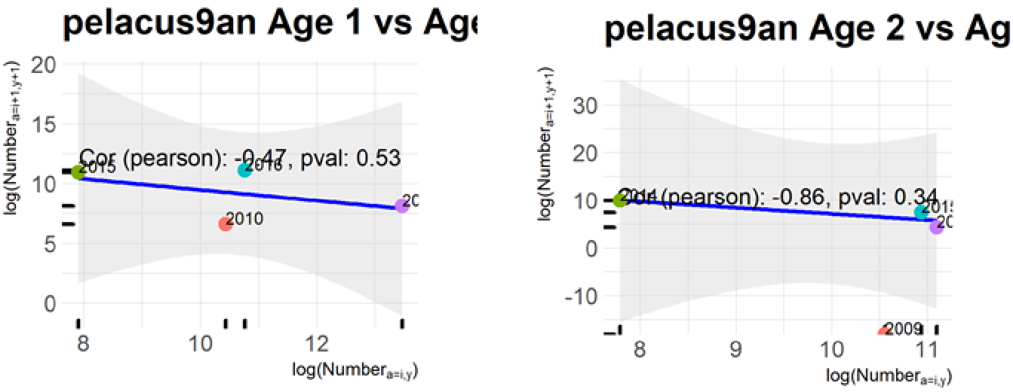


Figure 5.1.1.1.2 - ane.9awest stock component. PELACUS spring survey series. Correlation of consecutive ages (age x in year n with age x+1 in year n+1) for Age 0 and Age 1, left panel and Age 1 and Age 2, right panel.

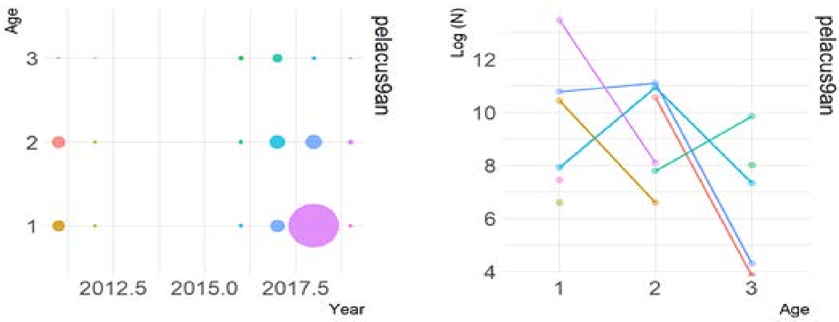


Figure 5.1.1.1.3 - ane.9awest stock component. PELACUS spring survey series. Cohort tracking (Log number) by age.

5.1.1.2. PELAGO INTRA-SURVEY CONSISTENCY – ANCHOVY WEST

The presence and abundance of anchovy was low in the beginning of the PELAGO time series, with the exception of a peak in 2011. In the last decade the abundance of anchovy registered in the PELAGO has been increasing as well as the frequency of occurrence of peaks in abundance. The highest peak was registered in 2018 followed by 2020. These peaks are generally preceded and followed by years of very low abundance (Fig. 5.1.1.2.1).

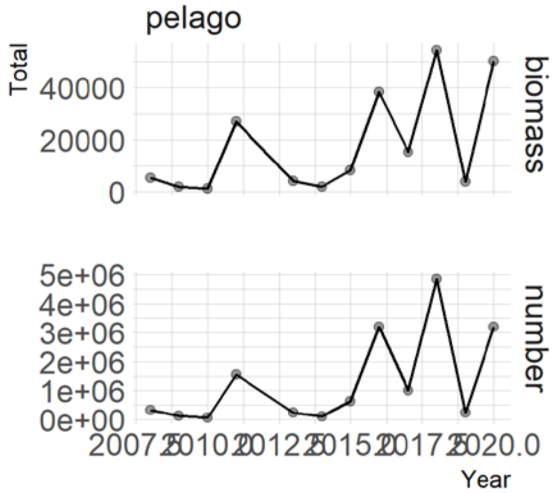


Figure 5.1.1.2.1 - ane.9awest stock component. PELACUS spring survey series. Time series of biomass (t; top panel) and abundance (millions; bottom panel) acoustic estimates.

There is no correlation of consecutive ages (Fig. 5.1.1.2.2) and poor cohort tracking (Fig. 5.1.1.2.3) for PELAGO for the western component of the anchovy (9aCN and 9aCS).

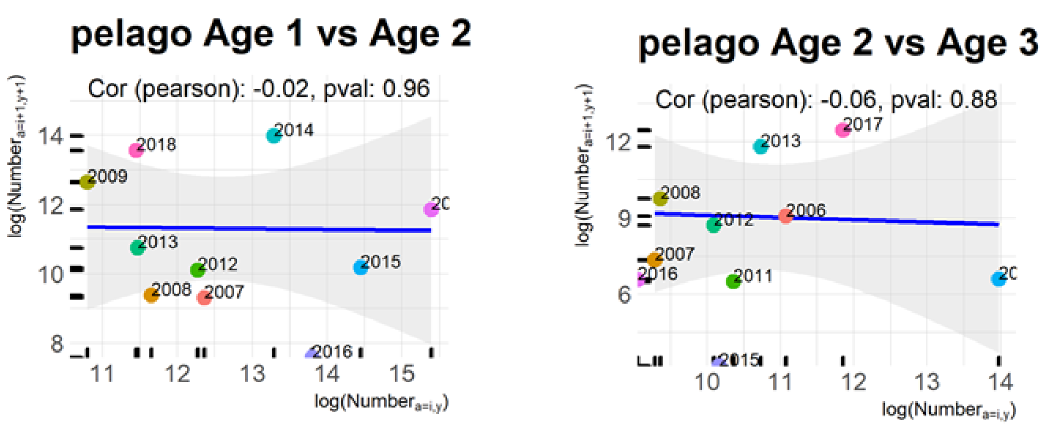


Figure 5.1.1.2.2 - ane.9awest stock component. PELAGO spring survey series. Correlation of consecutive ages (age x in year n with age x+1 in year n+1) for Age 0 and Age 1, left panel and Age 1 and Age 2, right panel.

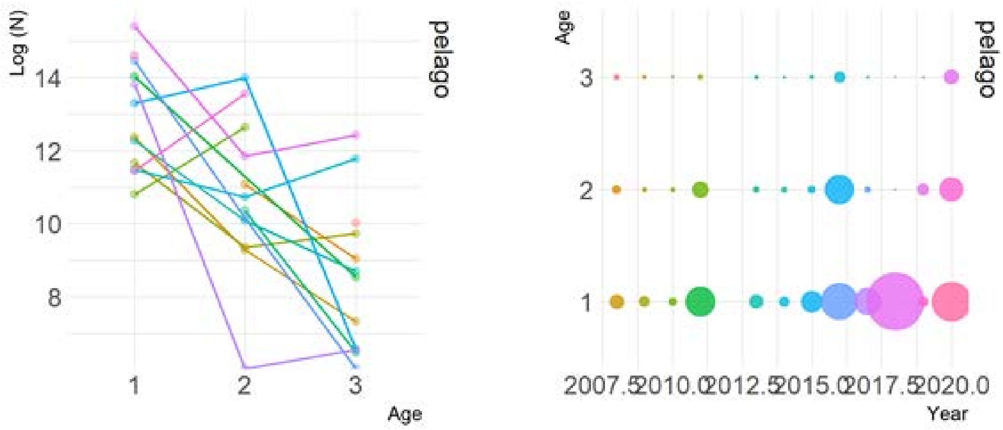


Figure 5.1.1.2.3 - ane.9awest stock component. PELAGO spring survey series. Cohort tracking (Log number) by age.

5.1.1.3. PELACUS+PELAGO INTRA-SURVEY CONSISTENCY - ANCHOVY WEST

There is no significant correlation of ages when considering the abundance of anchovy in the entire western component index, obtained by the sum of the abundances registered in the PELACUS (9aN) and the PELAGO (9aCN + 9aCS) surveys series (Fig. 5.1.1.3.1).

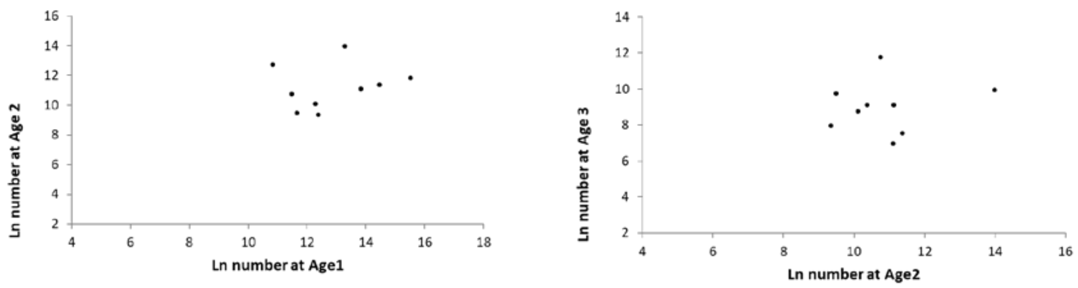


Figure 5.1.1.3.1 - ane.9awest stock component. PELAGO spring survey series. Correlation of consecutive ages (age x in year n with age x+1 in year n+1) for Age 0 and Age 1, left panel and Age 1 and Age 2, right panel.

5.1.1.4. JUVESAR AND IBERAS INTRA-SURVEY CONSISTENCY – ANCHOVY WEST

Even considering the survey series JUVESAR and IBERAS pooled, few data points exist to infer the intra-survey consistency of the recruitment surveys and the correlation between consecutive ages is not significant (Fig. 5.1.1.4.1).

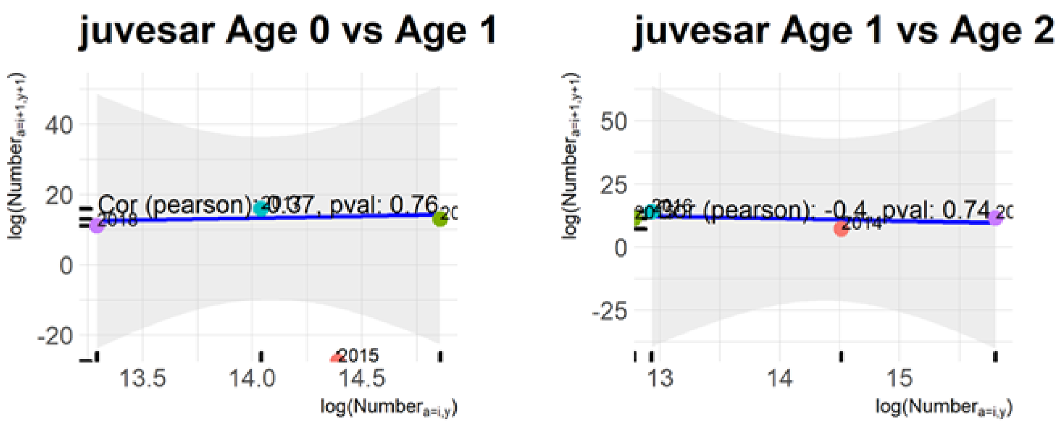


Figure 5.1.1.4.1 - ane.9awest stock component. JUVESAR and IBERAS autumn survey series. Correlation of consecutive ages (age x in year n with age x+1 in year n+1) for Age 0 and Age 1, left panel and Age 1 and Age 2, right panel.

5.1.2. INTER-SURVEY CONSISTENCY – ANCHOVY WEST

5.1.2.1. PELACUS VS JUVESAR/IBERAS– ANCHOVY WEST

No relationship of Age 0 of recruitment surveys (JUVESAR and IBERAS) with Age 1 of the PELACUS in the following year.

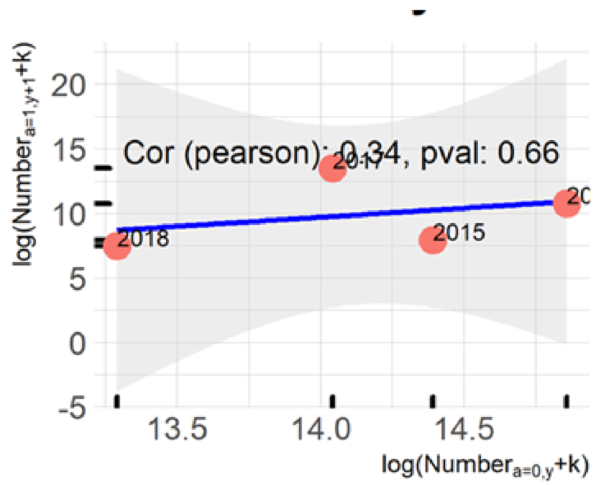


Figure 5.1.2.1.1 - ane.9awest stock component. Correlation of anchovy abundance of at Age 0 for juvenile surveys (JUVESAR and IBERAS) and Age 1 in the PELACUS spring acoustic survey the following year.

5.1.2.2. PELAGO VS JUVESAR/IBERAS– ANCHOVY WEST

No significant correlation was found between the abundance of Age 0 estimated in the recruitment surveys with Age 1 of the PELAGO in the following year.

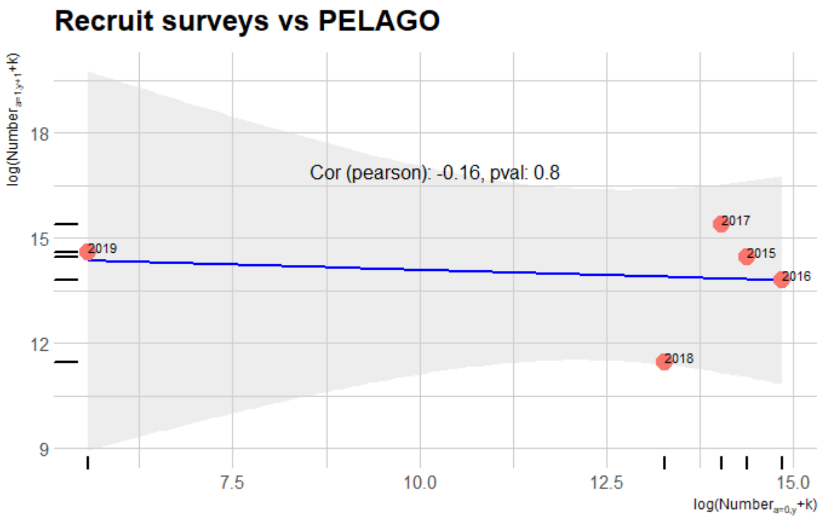


Figure 5.1.2.2.1 - ane.9awest stock component. Correlation of anchovy abundance of at Age 0 for juvenile surveys (JUVESAR and IBERAS) and Age 1 in the PELAGO spring acoustic survey the following year.

5.1.2.3. PELACUS+PELAGO VS JUVESAR/IBERAS – ANCHOVY WEST

No significant correlation was found between the abundance of Age 0 estimated in the recruitment surveys (JUVESAR and IBERAS) with Age 1 of the stock indicator (PELACUS+PELAGO) in the following year.

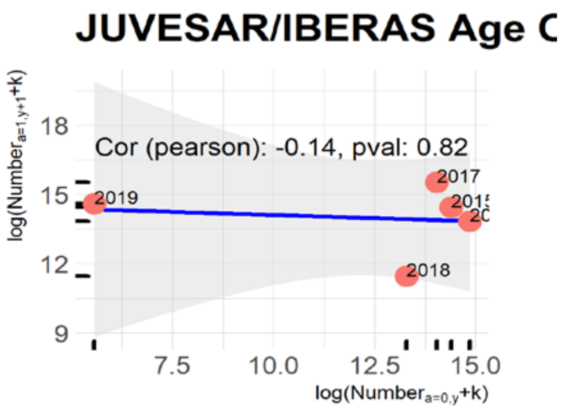


Figure 5.1.2.3.1 - ane.9awest stock component. Correlation of anchovy abundance of at Age 0 for juvenile surveys (JUVESAR and IBERAS) and Age 1 in the stock index (PELAUS+PELAGO spring acoustic surveys) the following year.

5.2. ANCHOVY SURVEY CONSISTENCY – SOUTHERN COMPONENT

5.2.1. INTRA-SURVEY CONSISTENCY – ANCHOVY SOUTH

Age composition of anchovy from acoustic survey estimates exists since 2004 for the ECOCADIZ survey series with several gaps (2005,2008,2011,2012) whereas for the PELAGO survey series age data is only available since 2014, due to the fact that anchovy otoliths of the acoustic surveys from the beginning of the PELAGO survey series (1989 to 2013) were yet analysed, which is planned to take place during 2021. Age composition of the recruitment survey series (ECOCADIZ-RECLUTAS) has existed since 2012 with gaps in 2013 and 2017 (Table 5.2.1.1).

Table 5.2.1.1 – Available data of age composition for the acoustic surveys carried out in the southern Iberian (Subdivision 9a.S).

YEAR	PELAGO	ECOCADIZ	ECOCADIZ-RECLUTAS
2004		X	
2005			
2006		X	
2007		X	
2008			
2009		X	
2010		X	
2011			
2012			X
2013		X	
2014	X	X	X
2015	X	X	X
2016	X	X	X
2017	X	X	
2018	X	X	X
2019	X	X	X
2020	X		

5.2.1.1. PELAGO INTRA-SURVEY CONSISTENCY - ANCHOVY SOUTH

Anchovy abundance estimated in PELAGO in ICES division 9.a S is used as an abundance index in the inputs of the Gadget model used for the assessment. This index shows an increasing trend in both abundance and distribution from 2010 until 2020 except for one year, 2016, where a sharp decrease is observed (Figure 5.2.1.1.1).

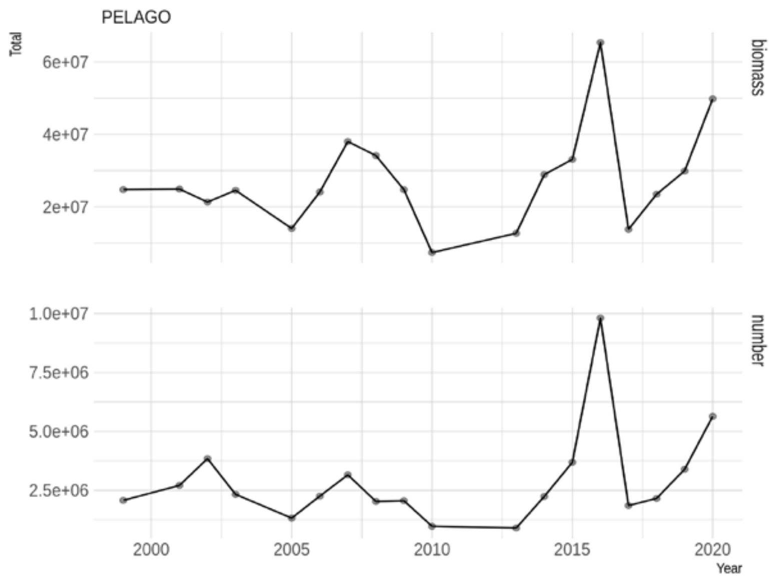


Figure 5.2.1.1.1 - ane.9aS stock. PELAGO spring survey series. Time series of biomass (t; top panel) and abundance (millions; bottom panel) acoustic estimates.

There is not a significant correlation between ages in consecutive years (age x in year n with age x+1 in year n+1) in the PELAGO survey. Figure 5.2.1.1.2 shows relationships of age 1 and 2 in the left panel and ages 2 and 3 in the right panel, the first one shows a negative correlation, while the second one shows a positive trend but mainly driven by only three years in the time series.

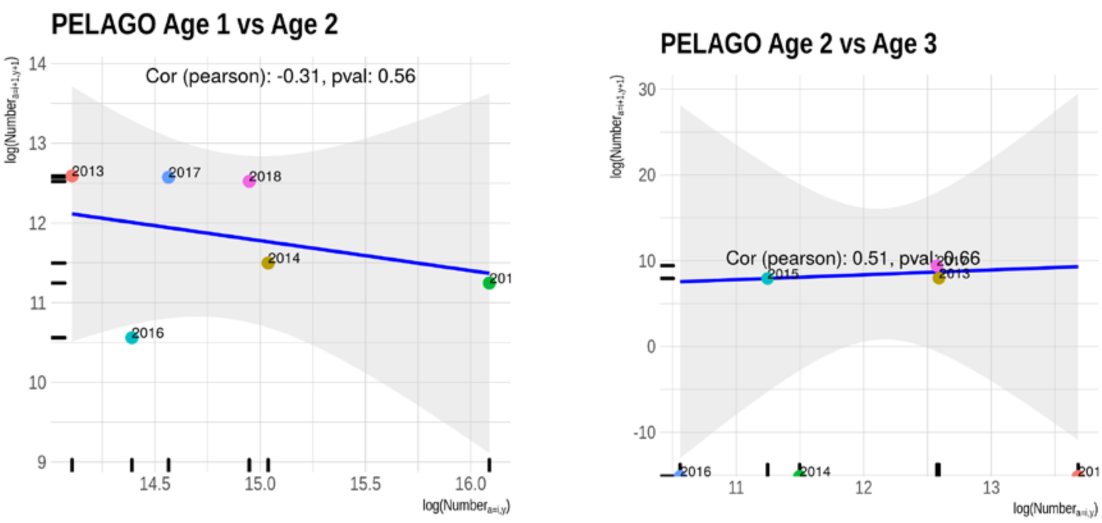
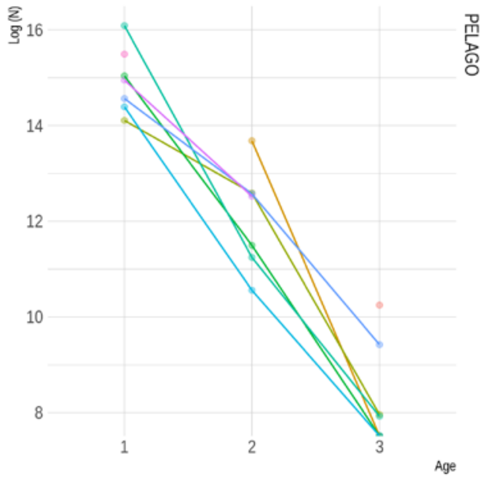
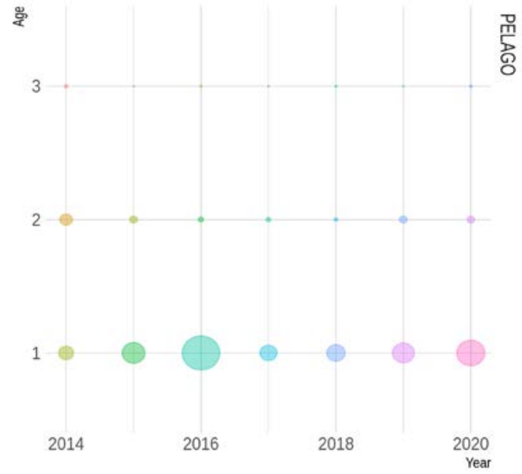


Figure 5.1.1.1.2 - ane.9aS stock. PELAGO spring survey series. Correlation of consecutive ages (age x in year n with age x+1 in year n+1) for Age1 and Age 2, left panel and Age 2 and Age 3, right panel.

There is a consistent cohort tracking for the PELAGO survey series with higher abundances at age 1 decreasing reasonably until age 3 (Figure 5.2.1.1.3).

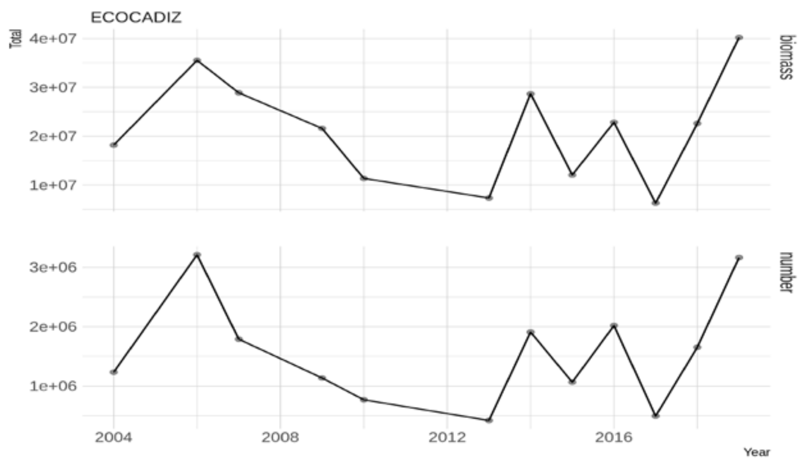




- ane.9aS stock. PELAGO spring survey series. Cohort tracking (Log number) by age.

5.2.1.2. ECOCADIZ INTRA-SURVEY CONSISTENCY - ANCHOVY SOUTH

Anchovy abundance estimated in ECOCADIZ in ICES division 9aS is used as an abundance index in the inputs of the Gadget model used for the assessment. Anchovy abundance estimated in ECOCADIZ shows a decreasing pattern from 2006 to 2013, no clear trend until 2017 when biomass increases until 2019, the year of the maximum observed biomass in the time series (Fig.5.2.1.2.1). It is important to remark that data for 2010



correspond only to Spanish waters.

Figure 5.2.1.2.1 - ane.9aS stock. ECOCADIZ summer survey series. Time series of biomass (t; top panel) and abundance (millions; bottom panel) acoustic estimates.

There is a coherent trend but not a significant correlation between ages 1 and 2 in consecutive years (age 1 in year n with age 2 in year n+1) in the ECOCADIZ survey. For ages 2 and 3 there are only two points available, thus not enough data to calculate a correlation coefficient (Fig. 5.2.1.2.2 shows relationship of age 1 and 2 in the left panel and ages 2 and 3 in the right panel).

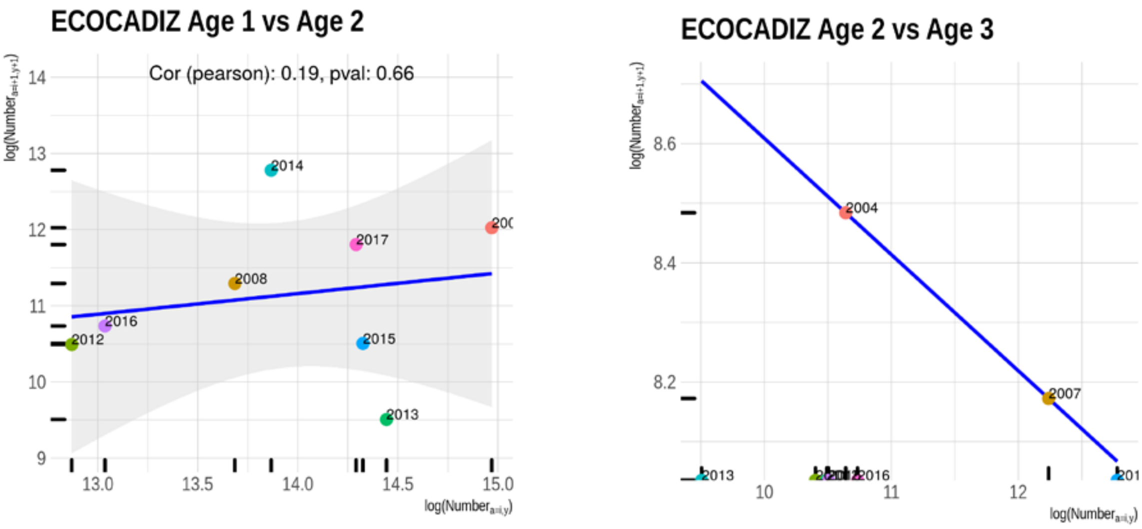


Figure 5.2.1.2.2 - ane.9aS stock. ECOCADIZ summer survey series. Correlation of consecutive ages (age x in year n with age x+1 in year n+1) for Age 1 and Age 2, left panel and Age 2 and Age 3, right panel.

There is a consistent cohort tracking for the ECOCADIZ survey series with higher abundances at age 1 decreasing reasonably until age 3 (Figure 5.2.1.2.3).

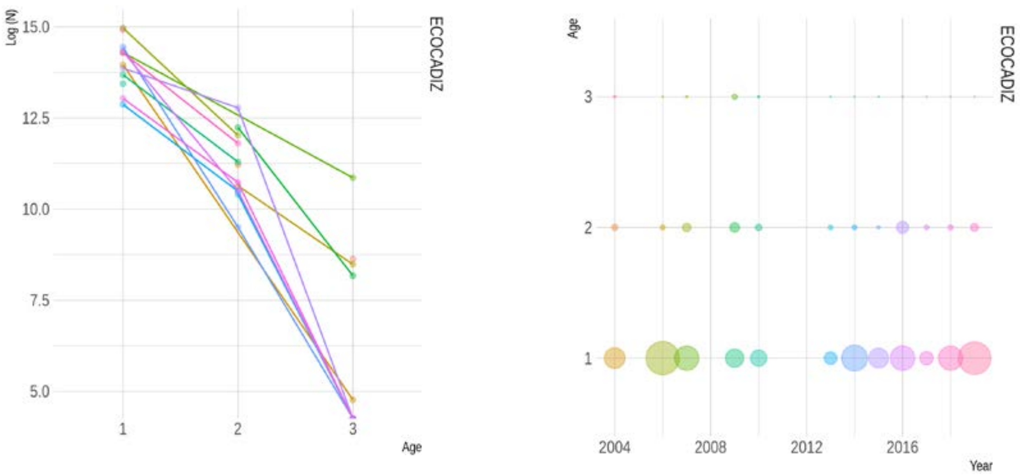


Figure 5.2.1.2.3 - ane.9aS stock. ECOCADIZ summer survey series. Cohort tracking (Log number) by age.

5.2.1.3. ECOCADIZ-RECLUTAS INTRA-SURVEY CONSISTENCY - ANCHOVY SOUTH

Anchovy abundance estimated in ECOCADIZ-RECLUTAS in ICES division 9.a S is currently not used for assessment purposes. This index does not show a clear trend, the higher estimated value corresponds to year 2019 (Fig.5.2.1.3.1). It is important to remark that data for 2012 corresponds only to Spanish waters.

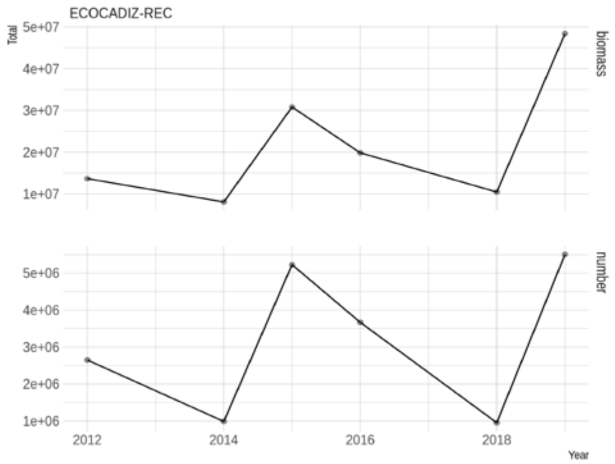


Figure 5.2.1.3.1 - ane.9aS stock. ECOCADIZ-RECLUTAS fall survey series. Time series of biomass (t; top panel) and abundance (millions; bottom panel) acoustic estimates.

There is a coherent trend but not a significant correlation between ages 1 and 2 in consecutive years (age 1 in year n with age 2 in year n+1) in the ECOCADIZ-RECLUTAS survey. For ages 0 and 1 a poor correlation is observed (Fig. 5.2.1.3.2 shows the relationship of age 0 and 1 in the left panel and ages 1 and 2 in the right panel).

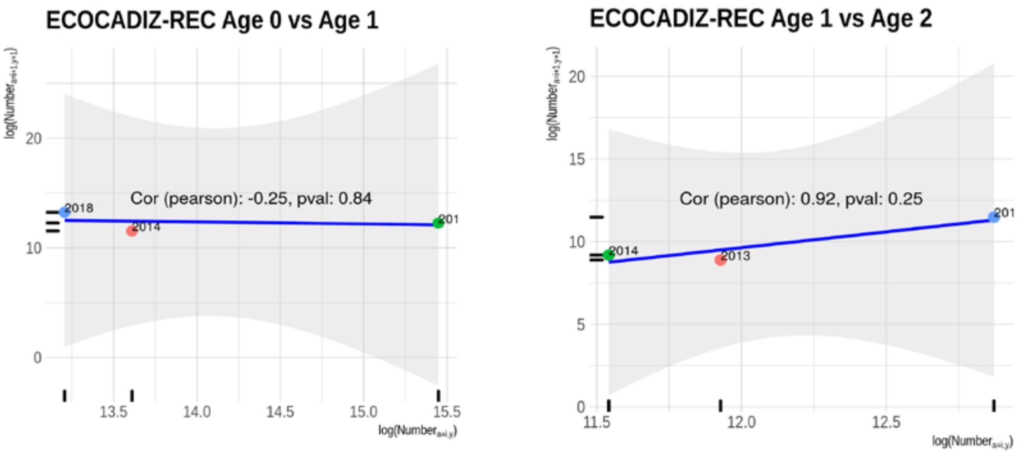


Figure 5.2.1.3.2 - ane.9aS stock. ECOCADIZ-RECLUTAS fall survey series. Correlation of consecutive ages (age x in year n with age x+1 in year n+1) for Age 0 and Age 1, left panel and Age 1 and Age 2, right panel.

There is a consistent cohort tracking for the ECOCADIZ-RECLUTAS survey series with higher abundances at age 0 decreasing reasonably until age 3 (Figure 5.2.1.3.3).

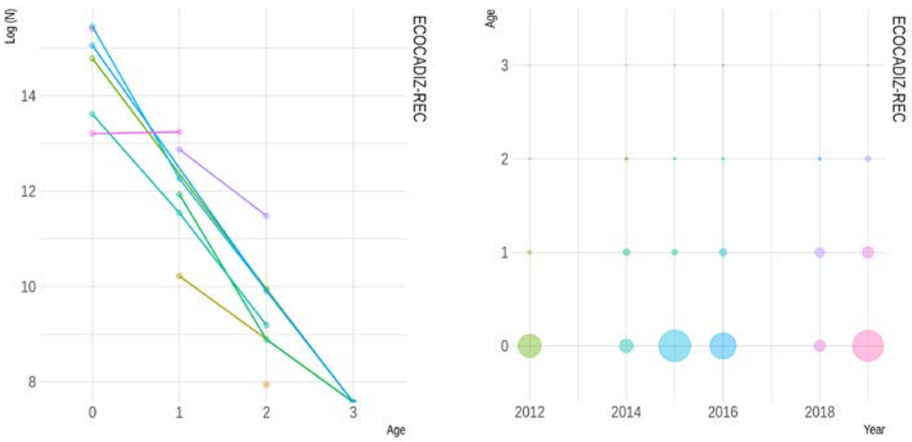


Figure 5.2.1.3.3 - ane.9aS stock. ECOCADIZ-RECLUTAS autumn survey series. Cohort tracking (Log number) by age.

5.2.1.4. INTER-SURVEY CONSISTENCY - ANCHOVY SOUTH

5.2.1.4.1. ECOCADIZ-RECLUTAS VS PELAGO-ANCHOVY SOUTH

There is a correlation between the abundance of anchovy in the ECOCADIZ-RECLUTAS and PELAGO acoustic surveys, nevertheless it is not significant enough (Figure 5.2.1.4.1.1).

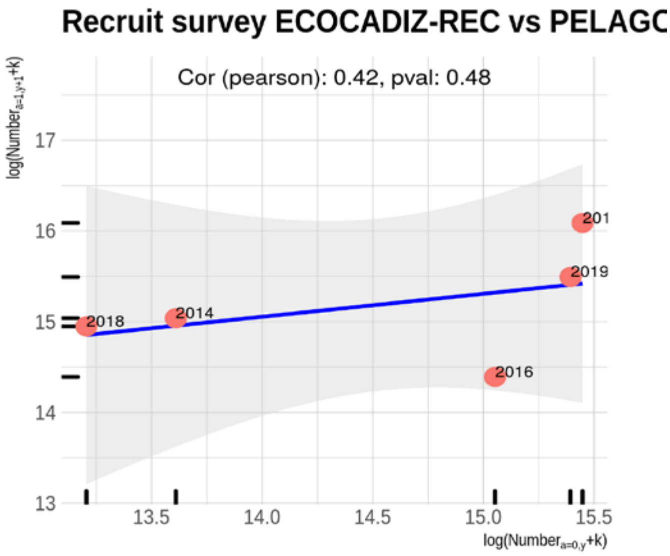


Figure 5.2.1.4.1.1 - ane.9aS stock. Correlation of the abundance of anchovy between the ECOCADIZ-RECLUTAS and PELAGO surveys.

5.2.1.4.2. ECOCADIZ-RECLUTAS VS ECOCADIZ - ANCHOVY SOUTH

There is a negative and non significant correlation between the abundance of anchovy in the ECOCADIZ-RECLUTAS and ECOCADIZ acoustic surveys (Figure 5.2.1.4.2.1).

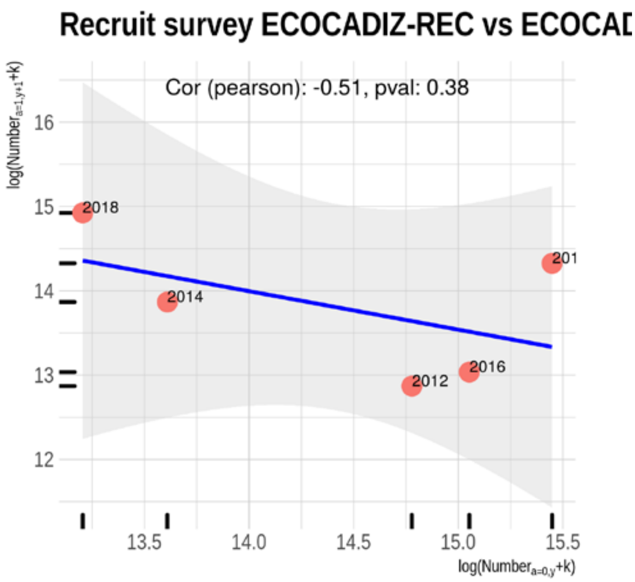


Figure 5.2.1.4.2.1 - ane.9aS stock. Correlation of the abundance of anchovy between the ECOCADIZ-RECLUTAS and ECOCADIZ surveys.

6. CONCLUSIONS

Different conclusions can be drawn for sardine and anchovy.

6.1. SARDINE

The main conclusions of the analysis of survey consistency for the southern sardine stock are:

There was a high within survey consistency for the acoustic surveys PELACUS, PELAGO and SAR and a low within survey consistency for JUVESAR and IBERAS, which is expected since recruitment survey series target only juveniles and do not cover the entire area of distribution of the adults.

There was a high and significant correlation of the abundance of Age 0 individuals estimated in the recruitment surveys (SAR, JUVESAR, IBERAS) in the main recruitment area of the stock (subdivision 9aCN) with the abundance of sardine estimated in the acoustic surveys on the following year (PELACUS + PELAGO). Although these survey series have differences in the design and methods, all cover the main recruitment area, in the 9aCN which suggests that the potential use in the assessment should be investigated.

ECOCADIZ-RECLUTAS survey series provides information on the second recruitment hotspot of the stock, located in the Gulf of Cadiz. This survey series is still short and more years are necessary to evaluate its use as an estimator of recruitment for this species.

6.2. ANCHOVY

The main conclusions of the analysis of survey consistency for the western component of the 9a anchovy stock are:

There is a low within survey consistency for the PELACUS, PELAGO AND JUVESAR+IBERAS.

No significant correlation exists between the abundance of anchovy in the recruitment survey series (JUVESAR+IBERAS) and the abundance of anchovy in the following year estimated for the stock index (PELACUS+PELAGO spring survey series). The data availability of recruitment is still short and the available data is not sufficient to evaluate if the recruitment surveys can be used to estimate anchovy recruitment in the western component.

The main conclusions of the analysis of survey consistency for the southern component of the 9a anchovy stock are:

There is a low within survey consistency for the PELAGO, ECOCADIZ and ECOCADIZ-RECLUTAS. There is a non significant correlation between the abundance of anchovy in the ECOCADIZ-RECLUTAS and both the PELAGO and the ECOCADIZ acoustic surveys. The data availability of recruitment is still short and the available data is not sufficient to evaluate if the recruitment surveys can be used to estimate anchovy recruitment in the southern component.

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