6.15 BLUE AND RED SHRIMP IN GSAS 1&2

6.15.1 STOCK IDENTITY AND BIOLOGY

The assessment of blue and red shrimp carried out during the STECF EWG 22-09 considered the stock shared by GSA 1 & 2 (Figure 6.15.1.1). No information was documented regarding stock delimitation of blue and red shrimp, *Aristeus antennatus* (Risso, 1816).

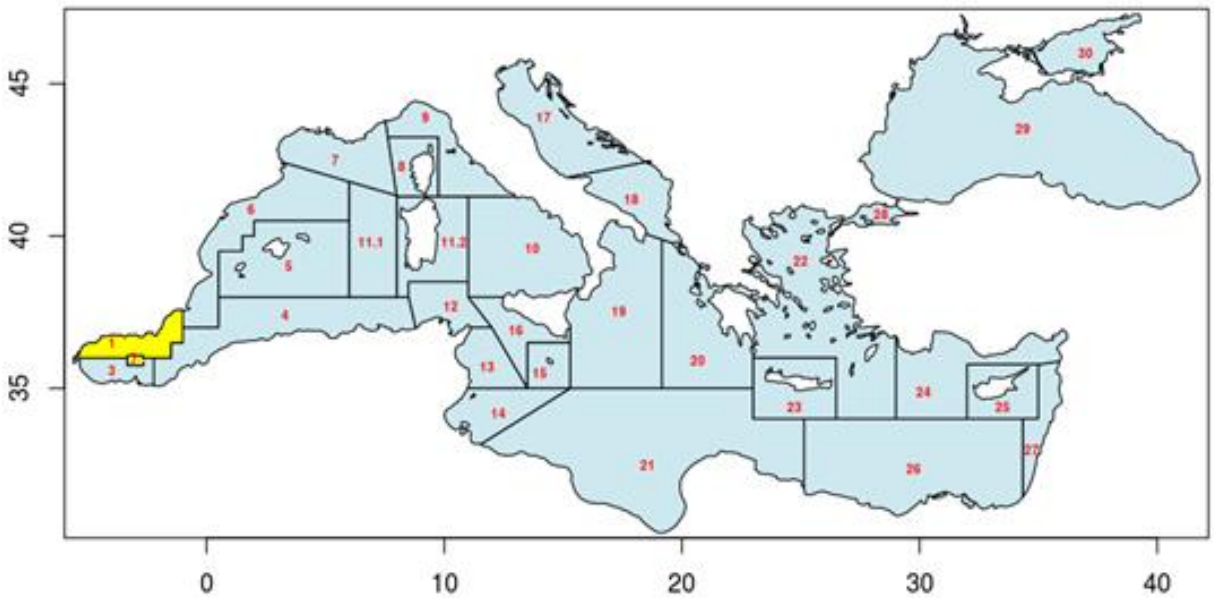


Figure 6.15.1.1. Blue and red shrimp in GSAs 1&2. Geographical location of GSAs 1&2.

The blue and red shrimp assessment in GSA 1 and 2 input data was revised from last year's assessment. Females reach larger sizes than males, and in EWG24-10, contrary to previous EWG decisions, after further analysis, it was decided to use growth parameters and length-weight relationship by sex, using the ones available in the Stock Assessment Form (SAF) from the GFCM working group in 2023:

Table 6.15.1.1. Blue and red shrimp in GSA 1 & 2. Growth parameters and length-weight relationship by sex.

	L_{inf} (mm)	k (year^{-1})	t_0 (year)	a	b
Females	77	0.380	-0.082	0.002	2.526
Males	51	0.277	-0.583	0.002	2.500

The length slicing for assessment was run, adding t_0 correction (+0.5) to provide correct length transitions for the 1st of January to coincide with the Jan-Dec assessment year. It should be noted that the natural mortality was calculated with t_0 set +0.032.

Length frequency distributions from the Spanish OTB fleet and survey data (MEDITS) were sliced to catch-at-age, using those growth parameters separated by sex and with t_0 correction and age boundaries set to 1,2,3, etc. This indicates that it is rare to catch red and blue shrimp in the commercial catch at age zero, and they are never observed in the survey. The sample length from which growth parameters and length-weight relationship were estimated ranged between 15 and 64 mm CL.

The proportion of mature individuals at age was not available from the DCF data for blue and red shrimp in GSA 1 & 2 and in 2021, was taken from the 2015 assessment of GSA 1 that was based on the DCF data; this was applied in the present assessment (Table 6.15.1.1). A fixed maturity ogive is used for all years.

Table 6.15.1.2. Blue and red shrimp in GSA 1 & 2. Proportion of mature specimens (Pmat) at age.

Age	0	1	2	3	4	5
Pmat	0.0	0.7	1.00	1.00	1.00	1.00

The natural mortality of blue and red shrimp in the present assessment was calculated as a vector using the Chen Watanabe (1989) model (Table 6.15.1.2). These are calculated using the t0 =+0.032. It noted that age zero natural mortality is for a full 12 months while the actual mortality is lower, only occurring in the last 6 months of the year after spawning.

Table 6.15.1.3. Blue and red shrimp in GSA 1 & 2. Natural mortality (M) at age.

Age	0	1	2	3	4	5
M	1.916	0.838	0.580	0.479	0.425	0.428

6.15.2. DATA

6.15.2.1 CATCH (LANDINGS AND DISCARDS)

General description of Fisheries

The blue and red shrimp (*Aristeus antennatus*) is present in GSA 1 & 2 at depths ranging from 400 to 800 m. The stock is exploited only by deep bottom otter trawl and particularly by the fleet segment composed of the largest trawlers. The blue and red shrimp fishery can be considered as monospecific with no significant discards (less than 0.01 tonnes per year), due to the very high price of the species. Catch is landings taken as landings with negligible discards (typically 0.02% with a max 0.3%) reported in few years that can be safely taken as zero in all years (Table 6.15.2.1.1). The SoP correction is applied and catch is used throughout this report. The total OTB landings per year, as reported by DCF, are shown in Figure 6.15.2.1.1

Table 6.15.2.1.1. Blue and red shrimp in GSA 1 & 2. Blue and red shrimp DCF landings (t) and discards (t) by OTB (all metiers) in GSA 1 & 2.

Year	OTB Landings (t) for GSA1	OTB Landings (t) for GSA 2	OTB Discards (t) for GSA1	OTB Discards (t) for GSA 2
2002	157.0	89.8		
2003	335.7	114.4		
2004	225.2	69.3		
2005	232.1	82.2	0.65	
2006	288.8	137.5		
2007	178.4	78.6		
2008	133.5	49.3		
2009	144.6	67.7		2.58
2010	152.1	48.7	0.01	0.57

2011	131.4	47.4	0.14	0.03
2012	148.6	45.0	0.06	0.06
2013	125.0	63.9	0.05	0.03
2014	184.0	41.0	0.01	0.01
2015	170.2	51.9	0.03	0.22
2016	138.2	40.1	0.01	0.29
2017	99.2	48.0	0.01	0.21
2018	123.2	47.5	0.01	0.04
2019	132.1	72.0	0.07	0.07
2020	137.4	31.7	0	0
2021	86.7	47.9	0.03	0.15
2022	107.7	66.5	0.02	0.21
2023	145.0	52.6	0.04	0.07
2024	127.0	71.1	0.19	0.05

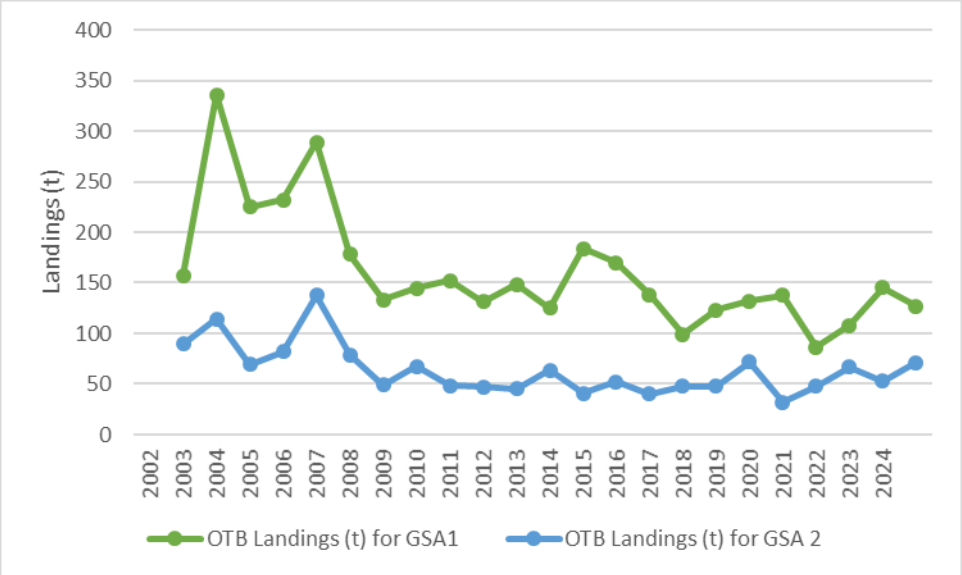
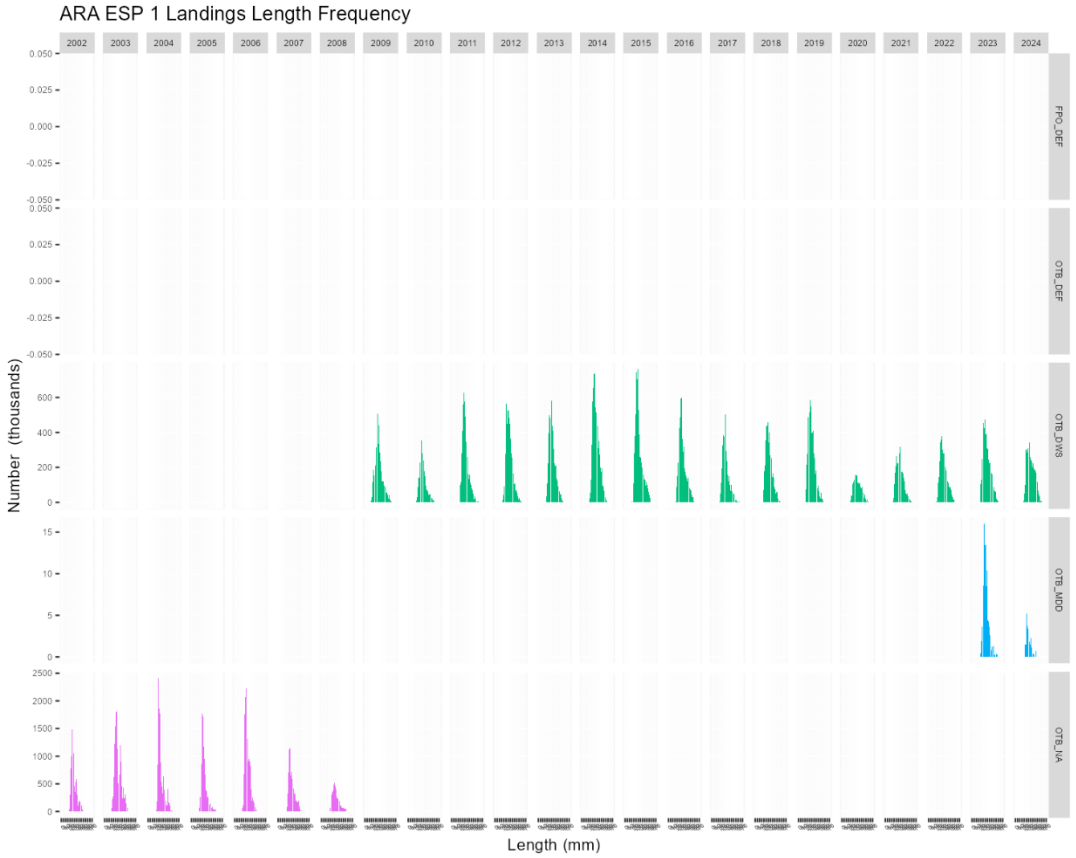


Figure 6.15.2.1.1. Blue and red shrimp in GSA 1 & 2. Blue and red shrimp DCF landings (t), in GSA 1 & 2 (2002-2024).

Figure 6.15.2.1.2 shows the LFD per gear and metier before reconstruction for both GSA 1 and 2. Figure 6.15.2.1.3 shows the length structure of blue and red shrimp landed in GSA 1 and 2 from 2002 to 2024 by fishing gear and fishery, as reconstructed.


ARA ESP 1 Landings Length Frequency
2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024
FPO_DEF
OTB_DEF
OTB_DWS
OTB_MDD
OTB_IVA
Number (thousands)
Length (mm)

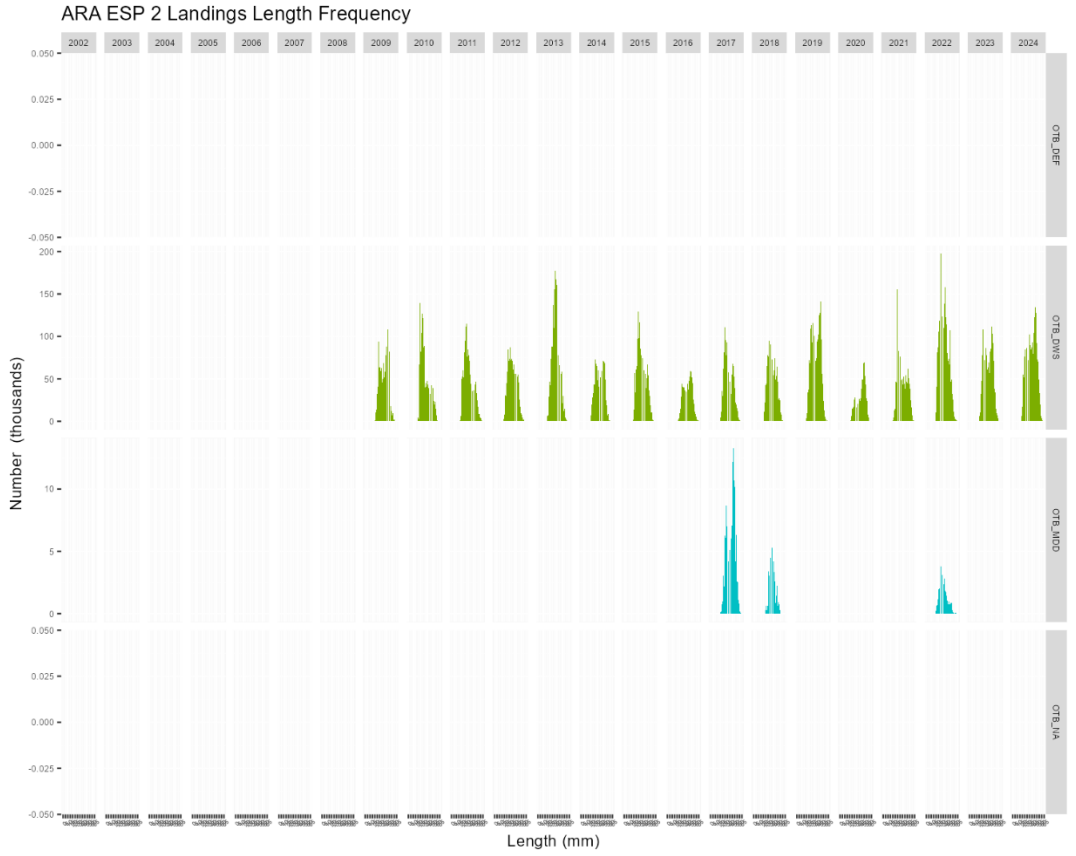

ARA ESP 2 Landings Length Frequency
2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024
CTB_DEF
OTB_DWS
OTB_MDD
OTB_IVA
Number (thousands)
Length (mm)

Figure 6.15.2.1.2. Blue and red shrimp in GSA 1 & 2: Length structure of Blue and red shrimp landed in GSA 1 & 2 from 2002 to 2024 by fishing gear and fishery.

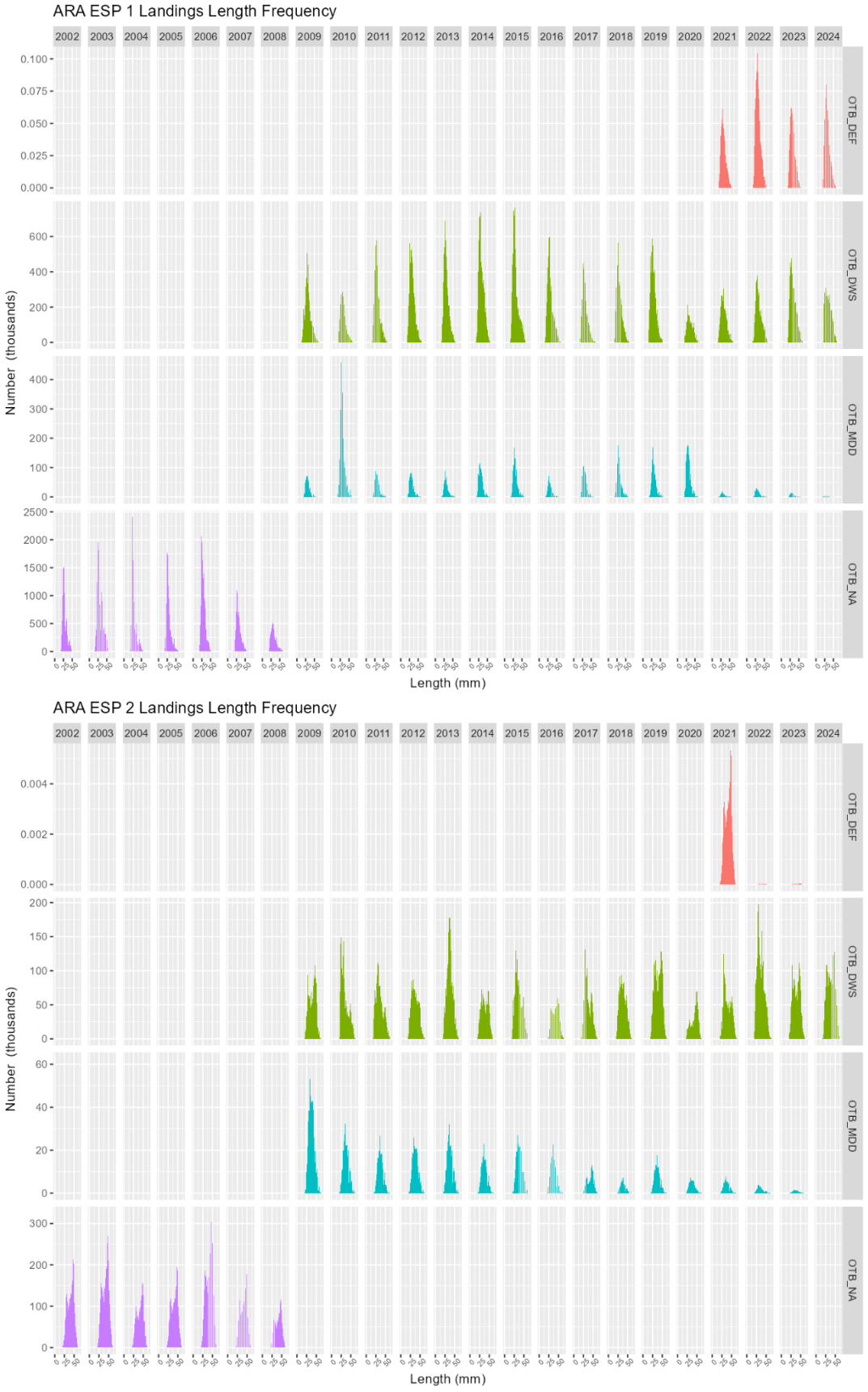


Figure 6.15.2. 1.3. Blue and red shrimp in GSA 1 & 2: Length structure of blue and red shrimp landed in GSA 1 & 2 from 2002 to 2024 by fishing gear and fishery as reconstructed.

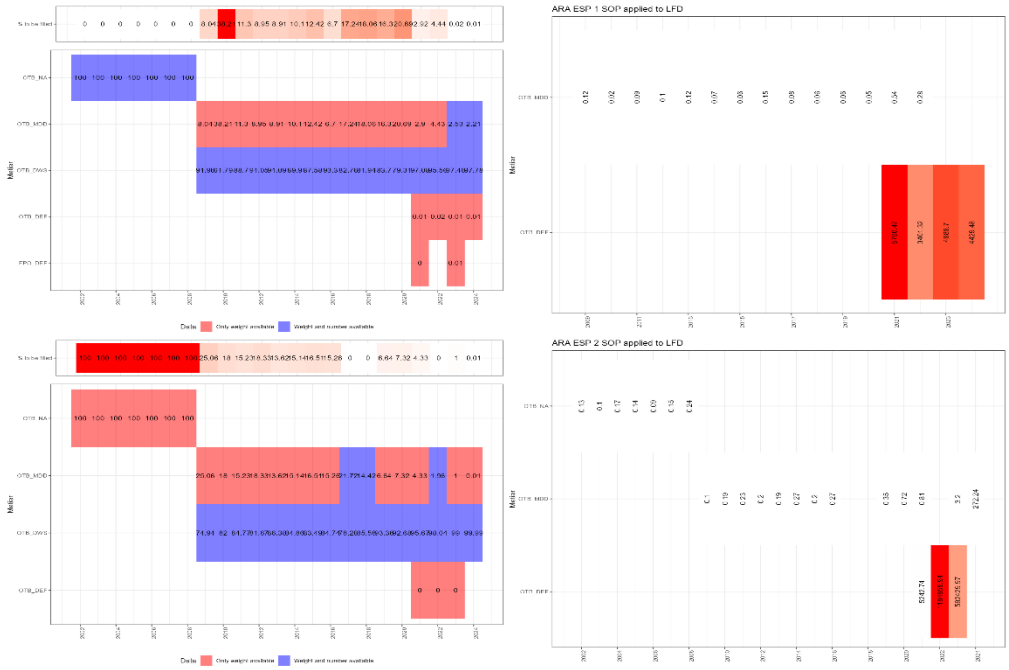


Figure 6.15.2.1.4. **Blue and red shrimp in GSA 1 & 2**. Percentages of total landings LFDs that were reconstructed by year and gear and SoP applied to LFD for Spain in GSA 1 & 2.

6.15.2.2 EFFORT DATA

Fishing effort data for 2024 will be reported to STECF EWG 25-11 through the FDI data call within the DCF framework.

6.15.2.3 SURVEY DATA

The MEDITS survey has been carried out annually from April to June (Figure 16.15.2.3.1) by the Spanish Institute of Oceanography (IEO) since 1994 at fixed haul positions. Tables TA, TB, and TC were provided according to the MEDITS protocol. Data were assigned to strata based on the shooting position and average depth between shooting and hauling depth.
The abundance and biomass indices by GSA were calculated using stratified means. This implies weighting the average values of the individual standardised catches and the variation of each stratum by the respective stratum areas in each GSA. In 2020, no MEDITS survey was carried out.

Figure 6.15.2.3.1 Month of the year when the hauls of MEDITS survey are being conducted in GSA 1 & 2.

The time series of abundance and biomass indices of blue and red shrimp from MEDITS bottom trawl survey in GSA 1 & 2 are shown in the following figures (Figure 6.15.2.3.2 and 6.15.2.3.3). Both estimated abundance and biomass indices show similar trends, maximised in 2000 and fluctuated around a mean for the last five years. The total biomass time series fluctuated with a lower mean from 2007-2019. In 2023, the values have been increasing since 2019, with a slight decrease in 2024.

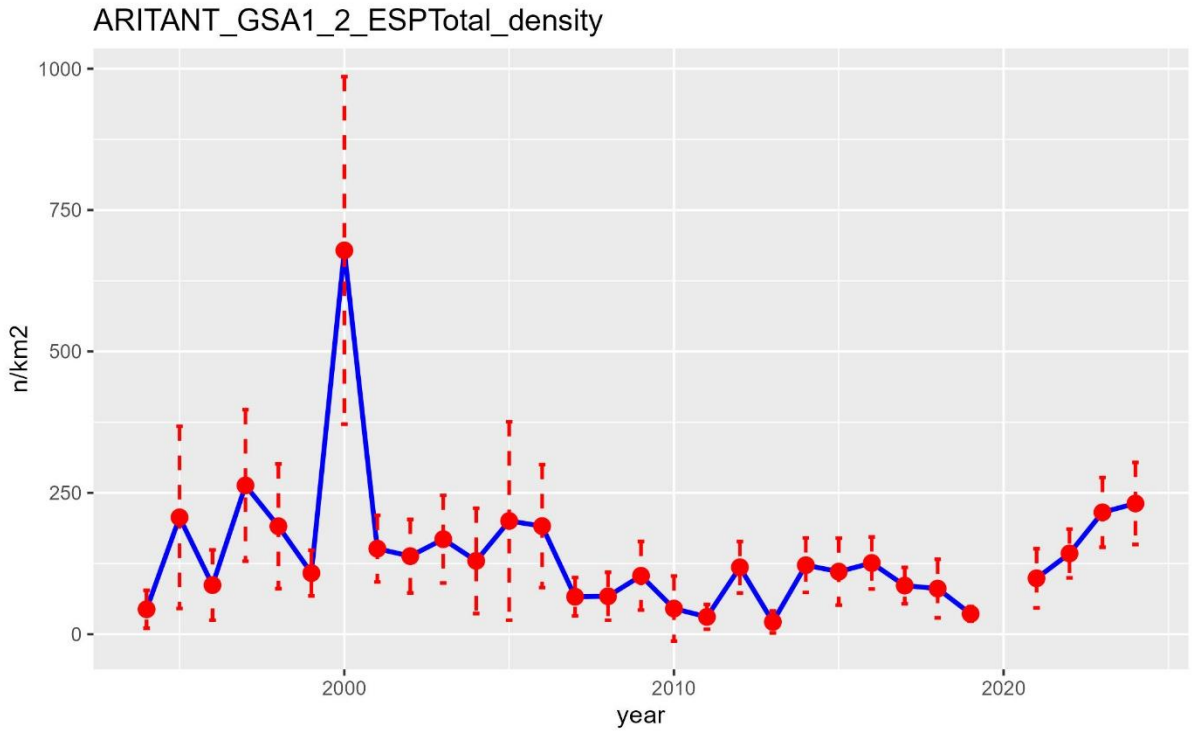


Figure 6.15.2.3.2. Blue and red shrimp in GSA 1 & 2. MEDITS survey abundance index (n/km^2) of blue and red shrimp in GSA 1 & 2 as reported by DCF. The survey is carried out from April to June.

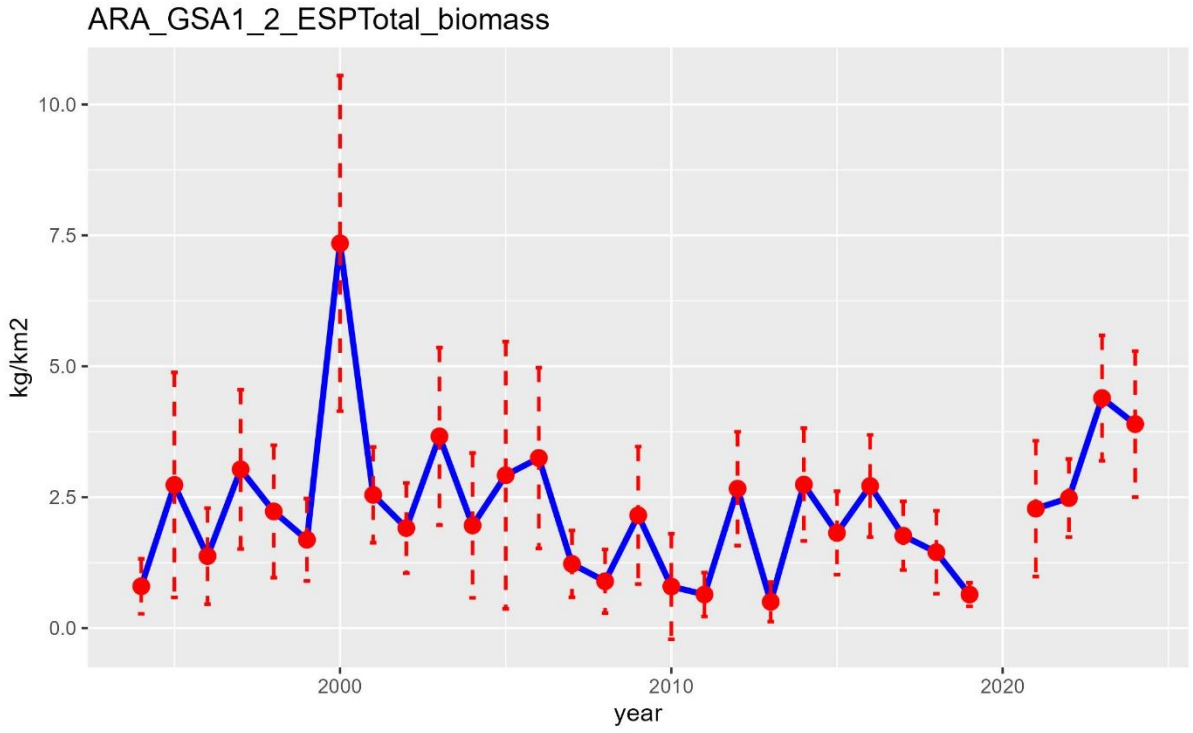


Figure 6.15.2.3.3. Blue and red shrimp in GSA 1 & 2. MEDITS survey biomass index (kg/km^2) of blue and red shrimp in GSA 1 & 2 as reported by DCF. The survey is carried out from April to June.

Trends in abundance by length (Figure 6.15.2.3.4) are shown below.

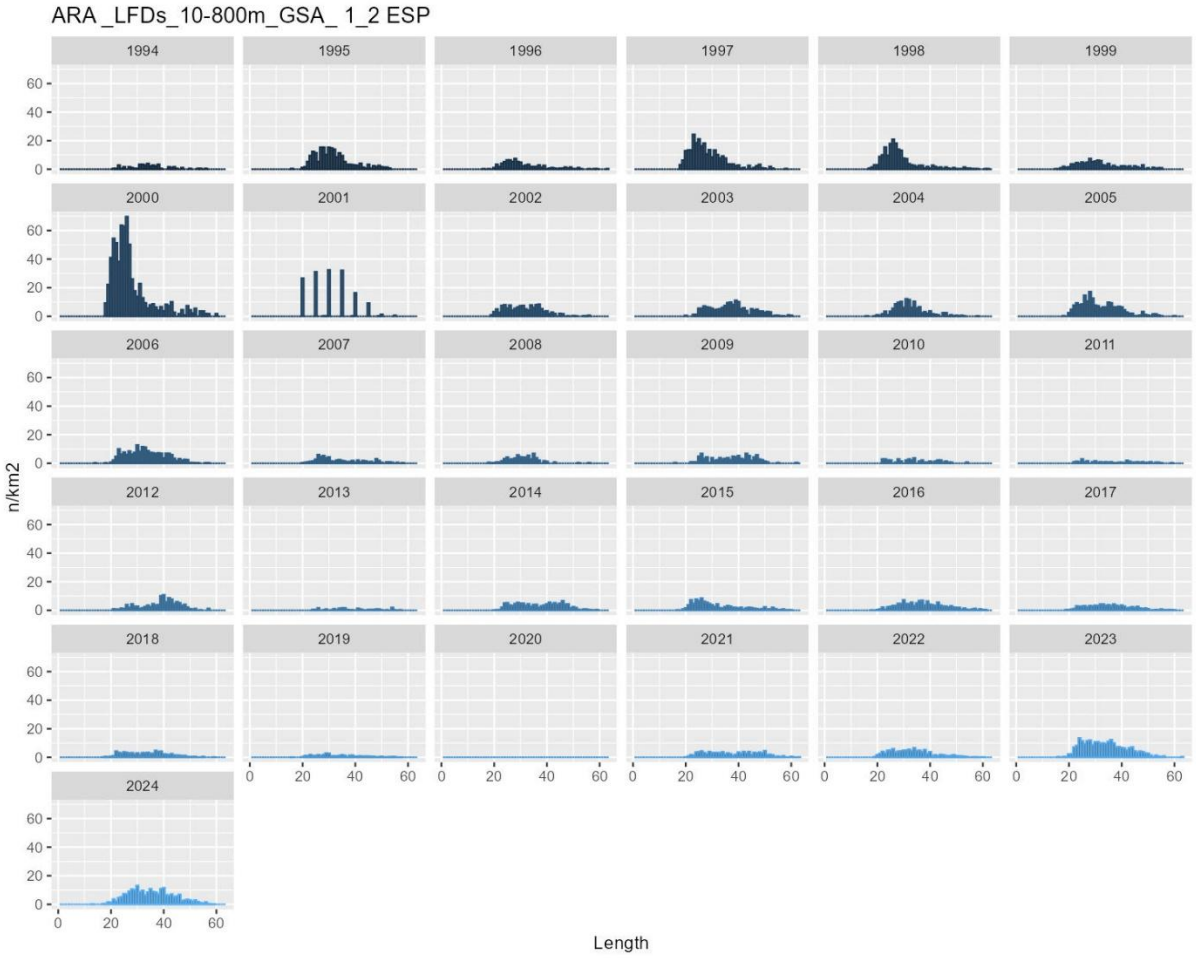


Figure 6.15.2.3.4. Blue and red shrimp in GSA 1 & 2. Length frequency distribution of the MEDITS survey abundance index (n/km^2) of blue and red shrimp in GSA 1 & 2 as reported by DCF. The survey is carried out from April to June.

6.15.3. STOCK ASSESSMENT

The present assessment used a statistical catch-at-age analysis (a4a). This year, new input data was used, as different growth parameters by sex were used, and the same were used for GSA 1 and 2. There's no survey data for 2020. Treatment of length to age that better aligns the the birthday to 1st of January for stocks with summer spawing resultys in different age structure which is considered to better reflect the observed growth.

Input data

As described above, the input growth parameters used were L_{inf} = 77 mm, k = 0.38 y^{-1}, t_0 = -0.082 for females and L_{inf} = 51 mm, k = 0.277 y^{-1}, t_0 = -0.582 for males. 0.5 was added to t_0 to align sizes appropriately with 1 January for length slicing.

The spawning of blue and red shrimp peaks during the summer, although continuous spawning throughout the year has been reported from some areas of the Mediterranean.

The proportion of mature individuals at age was not available for blue and red shrimp in GSA 1 & 2 and was taken from the previous assessment that was based on the DCF data for GSA 1 (Table 6.15.1.1). The maturity at age ogive was used for blue and red shrimp

assessment in GSA 1 & 2 as estimated from biological sampling based on length at first maturity and growth, giving 0.7 at age 1 (spawning in the first summer).

Natural mortality (M) was estimated using Chen-Watanabe (1989) model and is shown in Table 6.15.1.2. using the original growth parameters by sex (without adding 0.5 to t_0).

Sum of Products (SoP) correction was applied in catch numbers at age to match the total catch by year reported in the DCF (Table 6.15.3.1)

Table 6.15.3.1. Blue and red shrimp in GSA 1 & 2. Sum of Products (SoP) correction array.

Year	SOP
2002	1.00
2003	1.00
2004	1.00
2005	1.17
2006	0.90
2007	0.95
2008	1.03
2009	1.10
2010	1.01
2011	0.89
2012	0.89
2013	0.95
2014	1.00
2015	0.99
2016	1.05
2017	0.99
2018	1.03
2019	0.96
2020	1.37
2021	0.97
2022	0.97
2023	1.00
2024	0.77

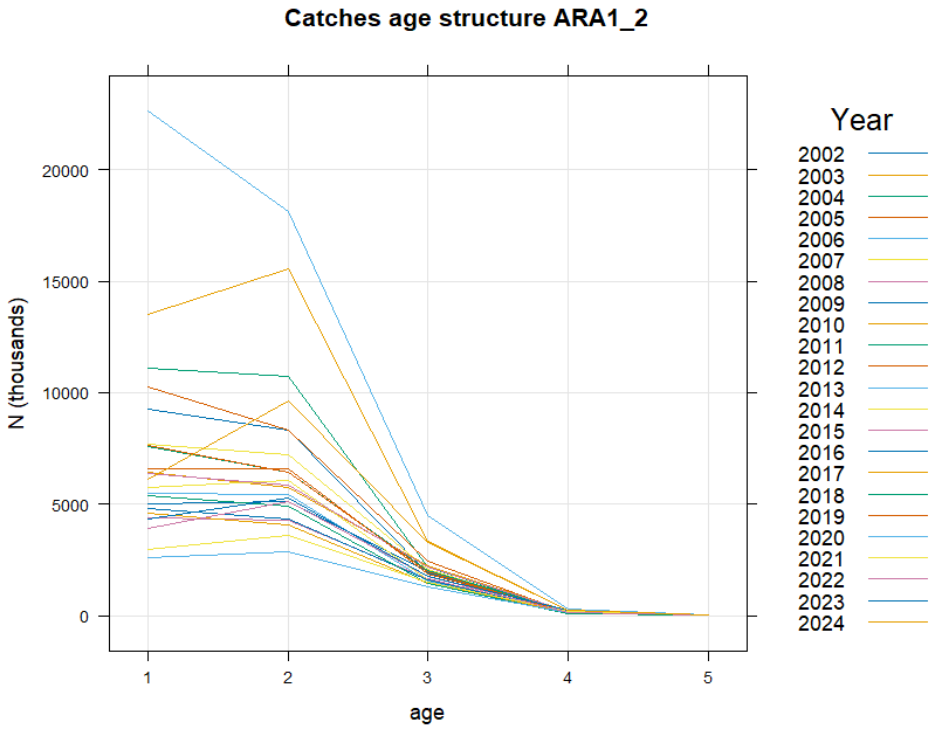


Figure 6.15.3.1. Blue and red shrimp in GSA 1 & 2: Catch-at-age data of blue and red shrimp in GSA 1 & 2 used in assessment.

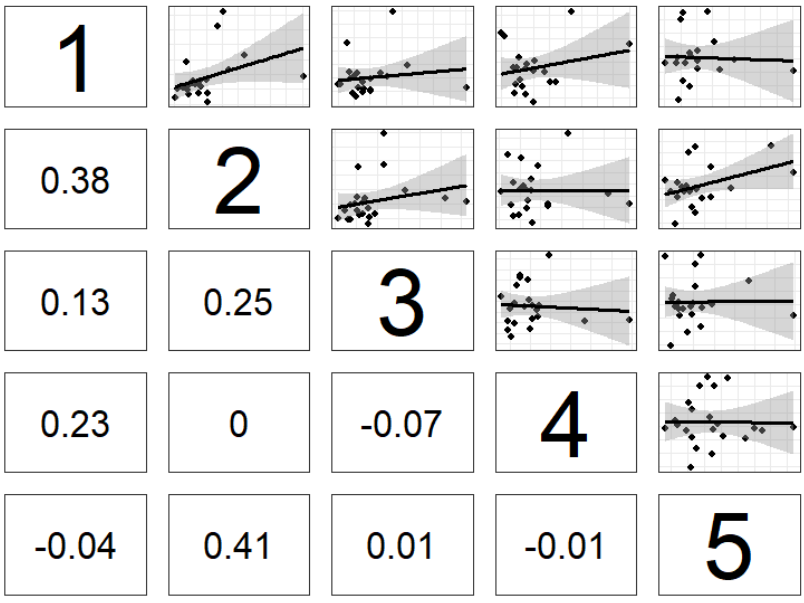


Figure 6.15.3.2. Blue and red shrimp in GSA 1 & 2. Cohort consistency of catches used in the assessment.

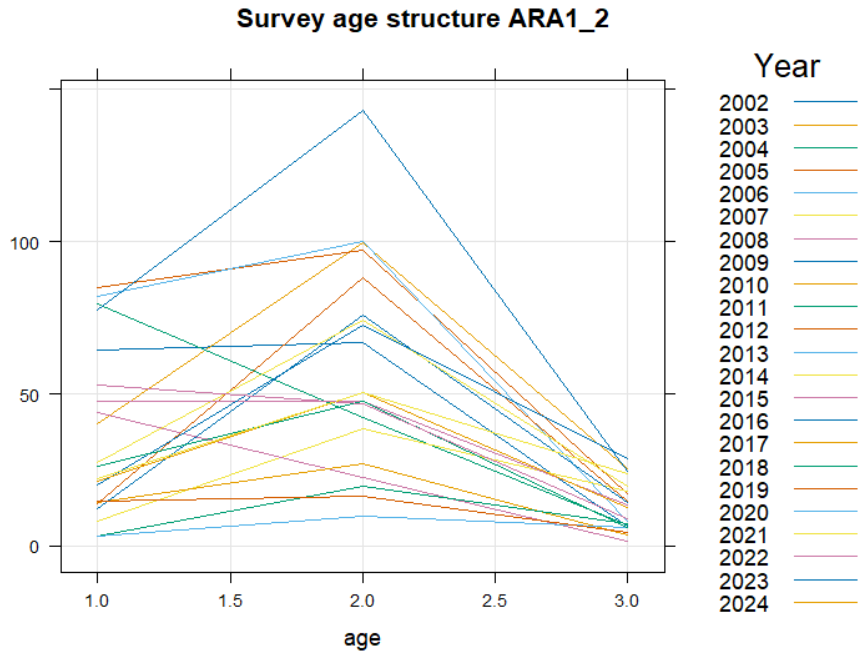


Figure 6.15.3.4. Blue and red shrimp in GSA 1 & 2: MEDITS indices describing density by age of blue and red shrimp in GSA 1 & 2 by year.

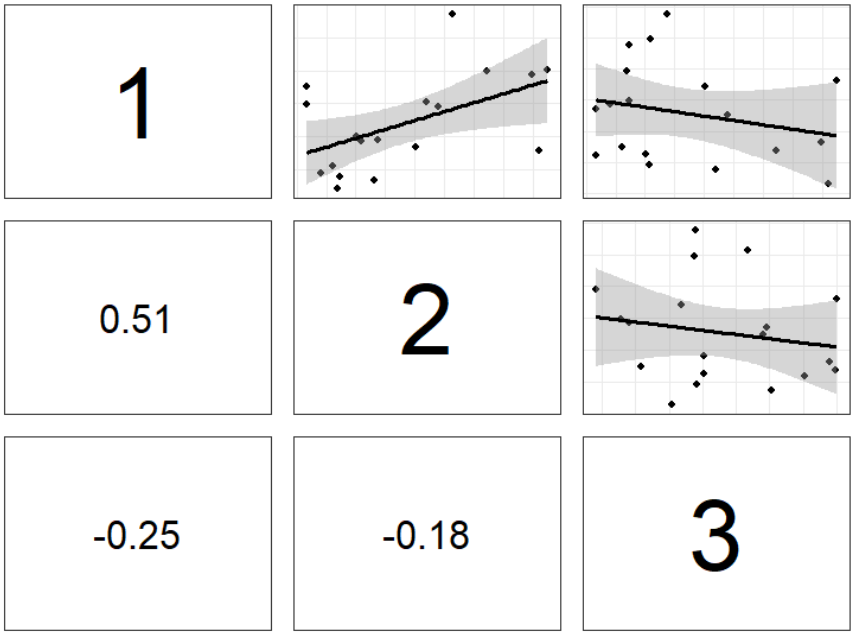


Figure 6.15.3.5. Blue and red shrimp in GSA 1 & 2: Cohort consistency of survey data used in the assessment.

Preliminary Results of the Assessment

EWG 24-10:

Different a4a models were investigated in terms of fishing mortality, catchability of the survey index and stock–recruitment relationship models (fmodel, qmodel, srmodel). The final scenarios were based on fmodel, trying different configurations regarding the use of split or as a factor on ages and also testing different k values for the year.

```
fmod1 <-  ~ factor(age) + s(year, k=8)
fmod2 <-  ~ factor(age) + s(year, k=12)
fmod3 <- ~ s(age,k=4)  + s(year, k=8)
fmod4 <- ~ s(age,k=4)  + s(year, k=12)

qmodel <- list(~ s(replace(age,age>3,3),k=3))
srmodel <- ~ factor(year)
```

Although the four scenarios reach good diagnostics, the model selected has the best retrospective analysis.

<u>UPDATE RY2024</u> -> Models applied and selected in EWG24-10:

```
fmodel <- ~ factor(age) + s(year, k=12)

qmodel <- list(~ s(replace(age,age>3,3),k=3))

srmodel <- ~factor(year)
```

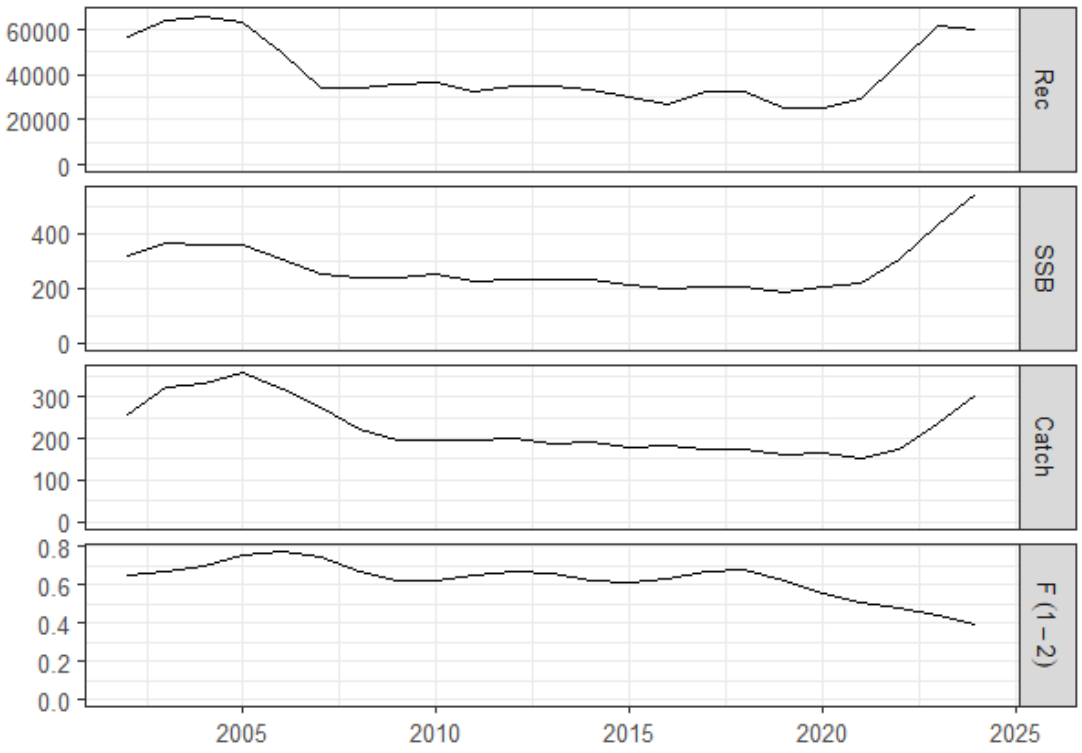
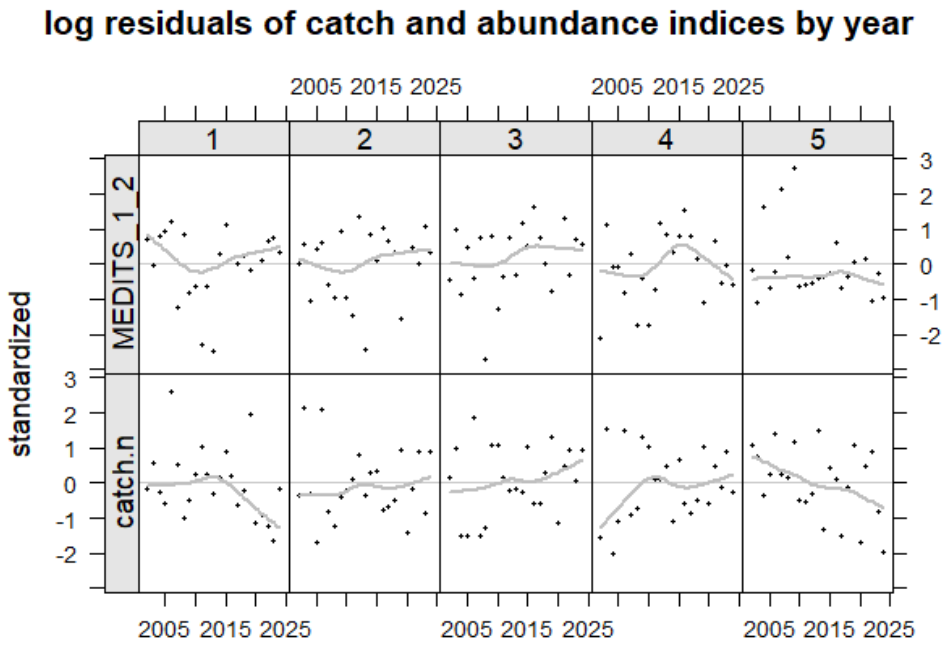


Figure 6.15.3.6. Blue and red shrimp in GSA 1 & 2: Stock summary from the final a4a model.



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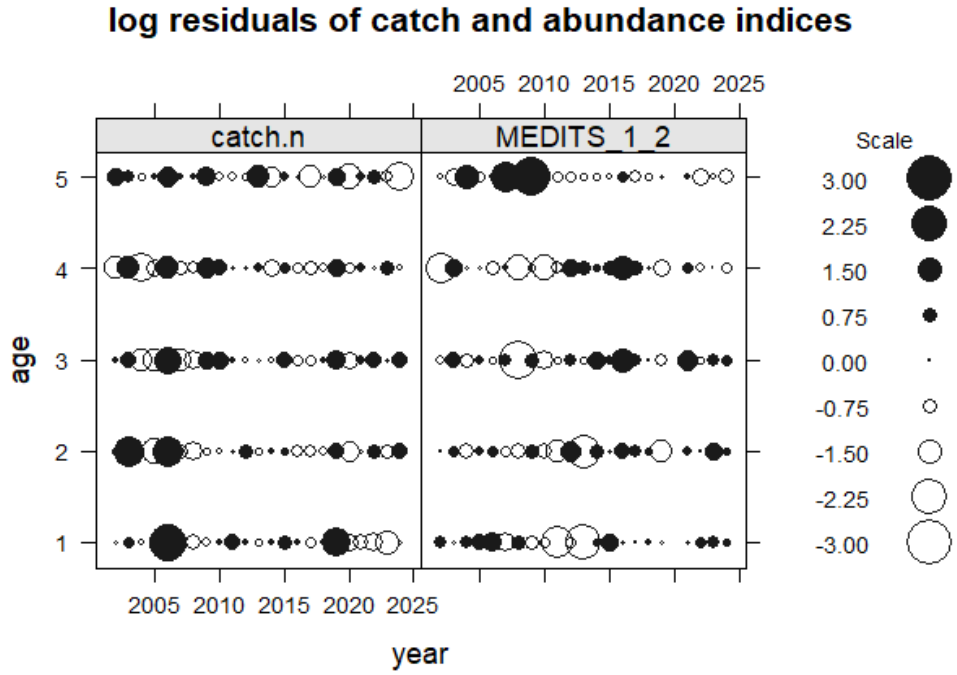


Figure 6.15.3.8. Blue and red shrimp in GSA 1 & 2: Standardized residuals for abundance indices and for catch numbers.

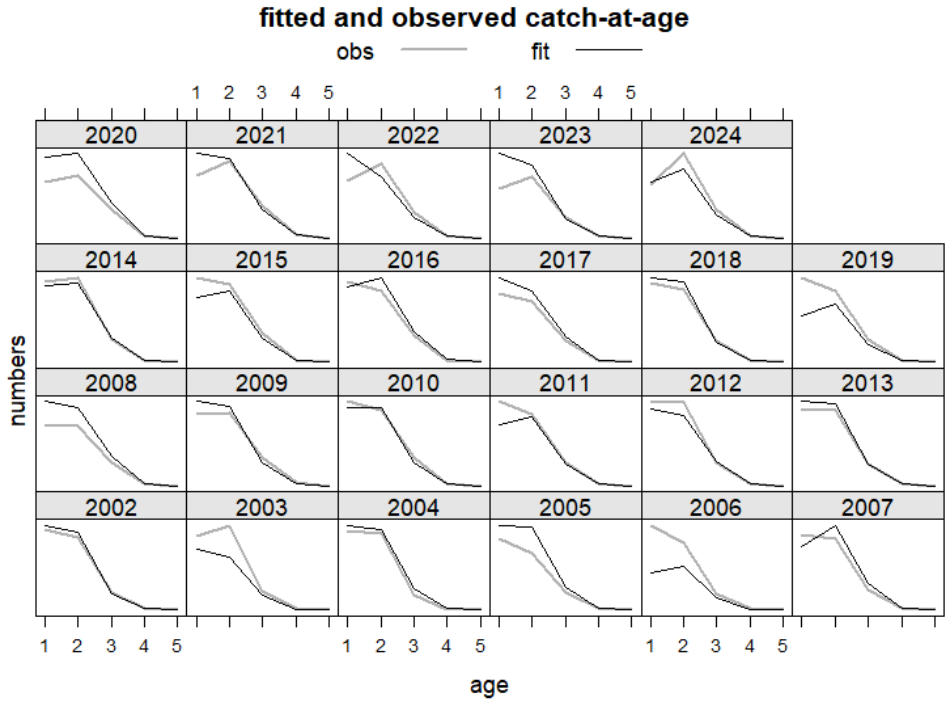


Figure 6.15.3.9. Blue and red shrimp in GSA 1 & 2: Fitted and observed catch at age.

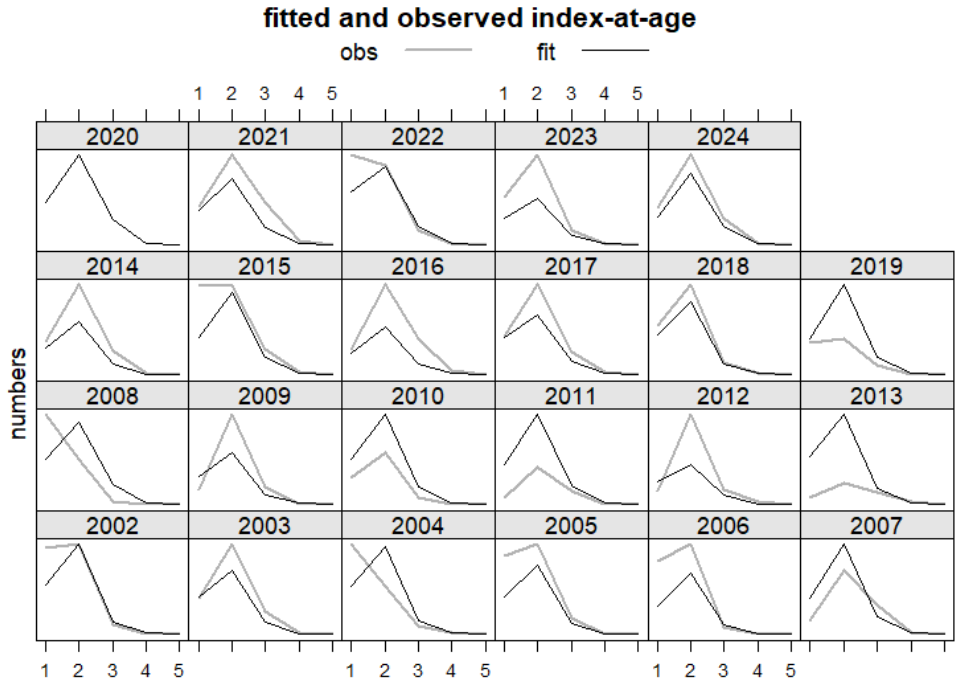


Figure 6.15.3.10. Blue and red shrimp in GSA 1 & 2: Fitted and observed index at age.

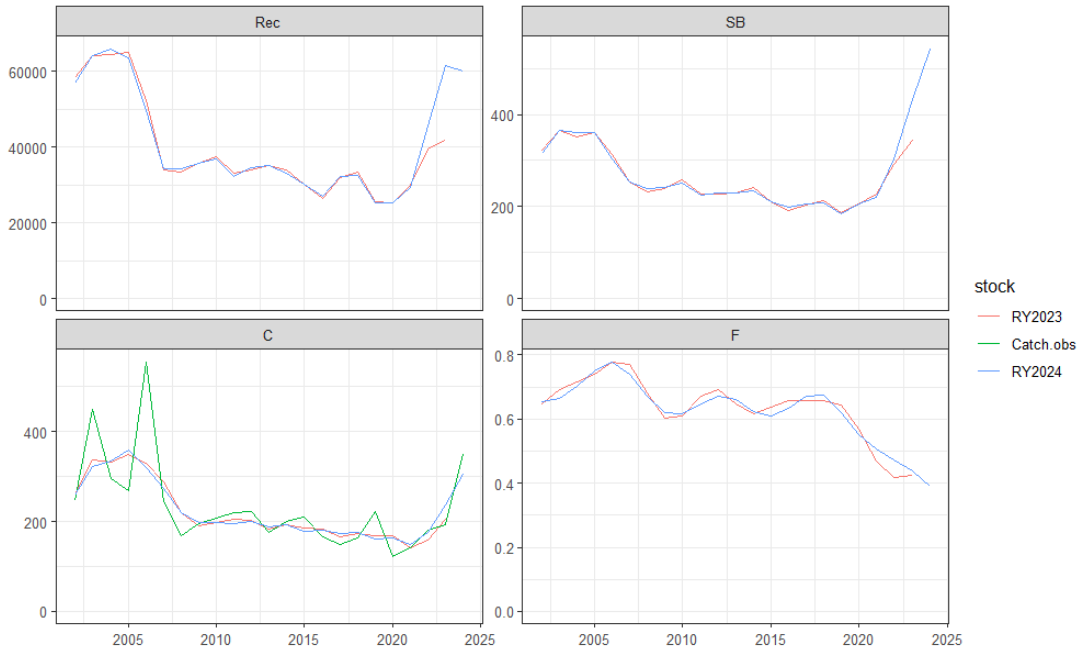


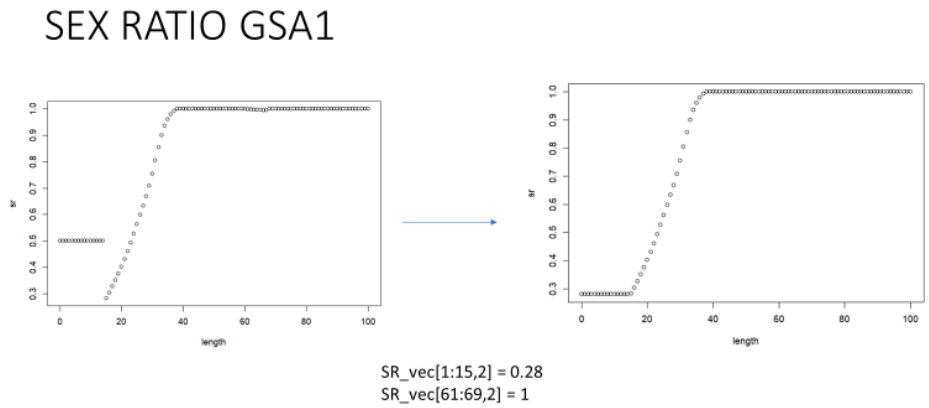
Fig X. First run with updated data RY2024

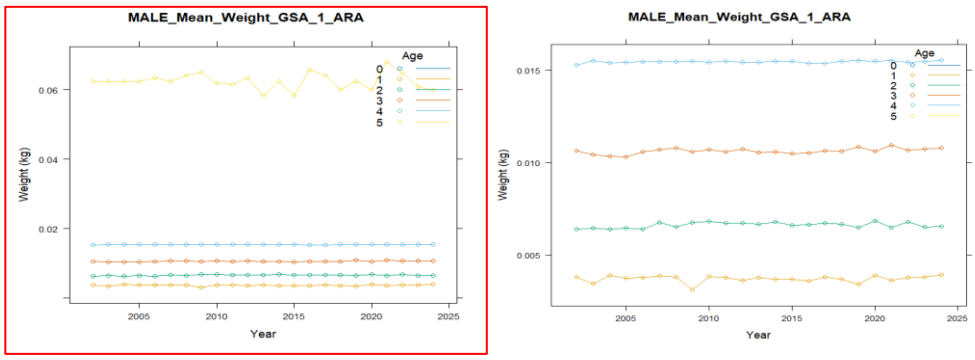
Quality of the assessment (FROM EWG 24-10)

A new a4a model configuration has been accepted during EWG 24-10, using growth parameters by sex after different tests. The configuration seems stable, but conducting a more thorough review of the data is crucial, as some problems were found (e.g., males aged 5 for GSA1). The issues encountered during EWG 23-09 regarding residuals in ages three and four are solved with the new model. All the diagnostics and retrospective analysis from the a4a assessment were acceptable. However, some new patterns need to be reviewed in detail. As this is a new assessment no reference points are calculated.

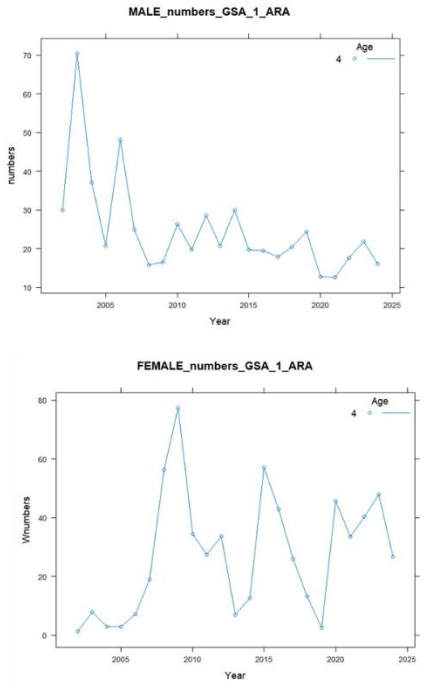
Other exploratory analysis to by discussed with the group:

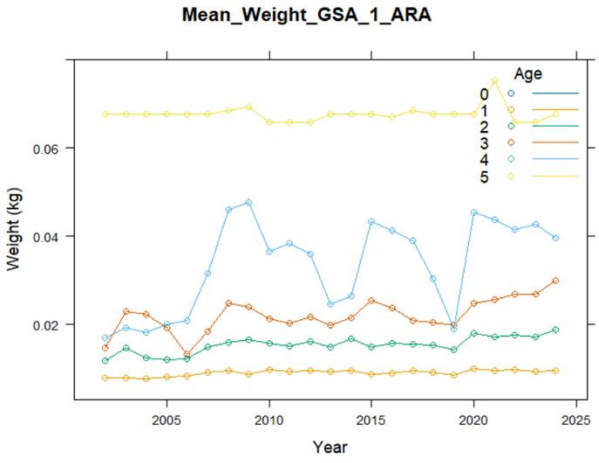
- Problems with wg at age in age 5 in GSA1 for males were solve fixing the values in the sex ratio:





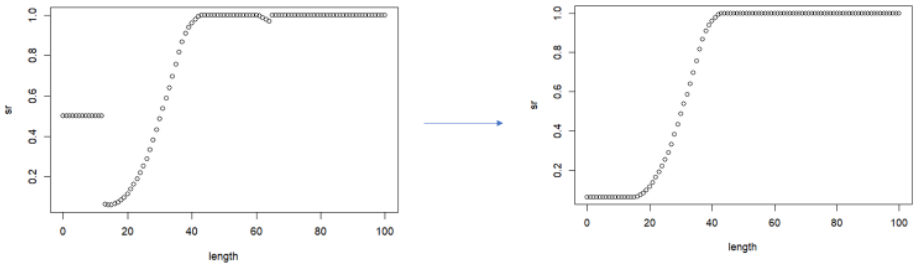
- Need to discuss: Numbers at age for females high influence in wg at age combined (GSA1)





- Sex ratio in GSA2 was also fixed:

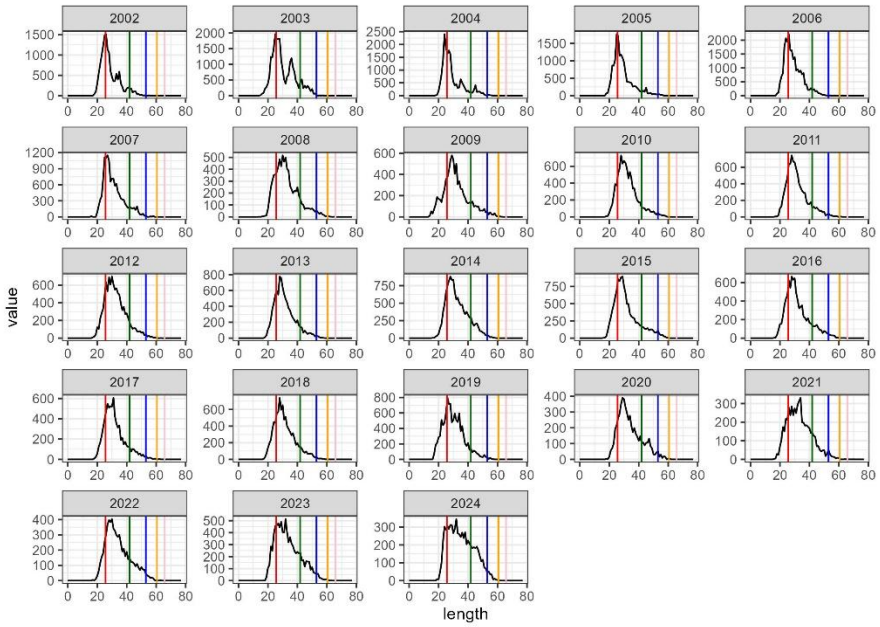
SEX RATIO GSA2



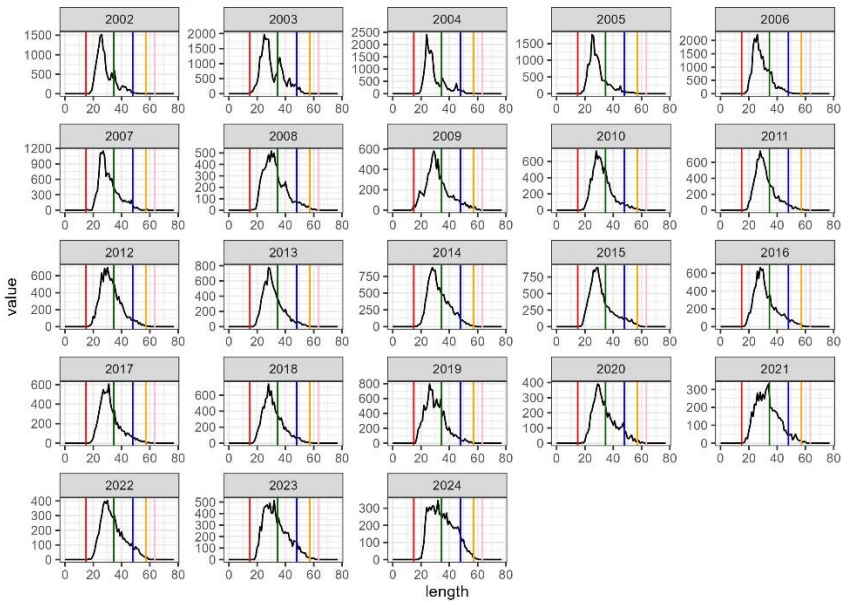
SR_vec[1:15,2] = 0.062
SR_vec[61:69,2] = 1

- Update with 2024 data -> PLOT t0 correction Commercial

LFDs without t0 correction



LFDs with t0 correction



- Update with 2024 data -> PLOT t0 correction Commercial and Medits by sex (to do list)
- New cohort consistency plot (to do list)