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Input data for the assessment of beaked redfish (*S. mentella and S. fasciatus*) in NAFO Division 3M

By

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Abstract

The management unit of the Flemish Cap beaked redfish is composed by two very similar species: *S. mentella* and *S. fasciatus*. The *S. mentella* and *S. fasciatus* populations have similar length growth, namely females up to 20 years old. On the assessment, an age length key based on the EU surveys data collection only from *S. mentella* was applied until 2018. Since 2018, the number of otoliths age readings for *S. mentella* has been decreasing; which resulted in lower length coverage and some gaps in the age length keys. To overcome those constraints and the possible impacts on the beaked stock assessment species combined (*S. mentella* and S. fasciatus) age length keys, was been applied. On this document evidence of the advantage of a species combined age length keys is highlighted. Due to age readings and a maturity ogive lack on data in 2023 EU Div. 3M survey, the hypothesis of using the 2022 data versus last 3-years combined data (2020, 2021 and 2022) to the 2023 stock assessment was presented here. There were no significant differences found between the two hypotheses. However, the inclusion of the 3-year combined age-length key led to an increased number of observations, enhancing the robustness of the final estimates based on stock abundance at age. As for the maturity ogive, no significant differences were evident when comparing the two options. The 3-year species combined age-length key and the maturity ogive will be applied in the 2024 Div. 3M beaked redfish stock assessment.

Introduction

The Div. 3M (Flemish Cap bank) redfish assessment is focused on beaked redfish, regarded as a management unit composed of two populations from two very similar species: *S. mentella* and *S. fasciatus*. Beaked redfish represents the majority of redfish biomass (average of 78%, according to the EU Flemish Cap survey series, 1988-2023) and the majority of the redfish commercial catch on the bank (Alpoim et al. 2024).

Flemish Cap beaked redfish are long living species with slow growth, slow maturation and a long recruitment processes to the bottom, extending to lengths up to 30-32cm. The S. mentella and S. fasciatus populations have similar length growth, namely females up to 20 years old (Saborido-Rey et al. 2004; Saborido-Rey, 2001). The age plus group considered on this stock is 19.

For the assessment purposes, the age composition of catches was obtained using the *S.mentella* age length keys from the 1990-2007 and 2009-2018 EU surveys. With the exception of 2008, when no age length key was available for *S.mentella* 2008, and a synthetic *S.mentella* age length key was applied both to commercial and survey length compositions. Since 2018, the number of otoliths age readings for *S. mentella* has been decreasing; which resulted in lower length coverage and some gaps in the age length

keys. To overcome those constraints on age length key for S. mentella the option was to apply a combined age length key with the data collected for *S. fasciatus*.

In 2023, the age readings and the maturity ogive from the EU survey for the beaked redfish were not available. Two age length keys options have been explored, to decide on how to use on the 2024 3M beaked redfish stock assessment: (1) 2022 species combined age length key; and (2) species combined age length key using the data from the last 3-years (2020, 2021 and 2022). A similar approach was tested to overcome the lack on 2023 maturity ogive data, the use of the one from 2022 (1) and the one resulting from the last 3-years (2020, 2021 and 2022) combined data (2).

Age length keys *S.mentella* versus species combined (*S. mentella* and *S. fasciatus*)

Previous studies have shown no significant differences between the growth of *S.mentella* and *S. fasciattus* (Saborido-Rey et al. 2004; Saborido-Rey, 2001). The comparison of von Bertallanfy growth model parameters (a and b) are shown in Figure 1.

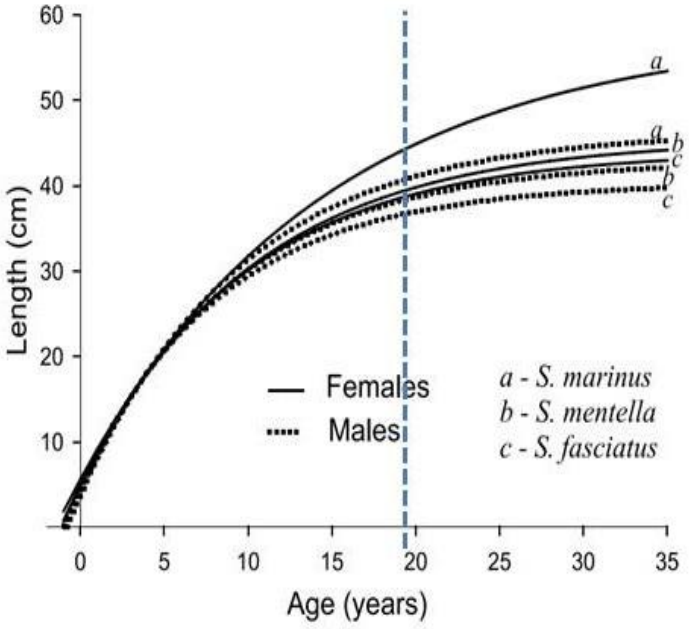

Figure 1. Von Bertalanffy growth curves for males and females of the three redfish species on the Flemish Cap from research vessel bottom-trawl surveys carried out during summer 1990 - 2000 for *S. marinus* and 1991 - 2000 for *S. mentella* and *S. fasciatus* (from Saborido-Rey et al. 2004). Blue line represents the plus age group for beaked redfish stock assessment.

The comparison of the age-length keys from using only the *S. mentella* age readings from the EU-surveys with the species combined (Sebastes spp: *S. mentella* and *S. fasciatus*) age readings data for the period 2018 until 2020 is presented in Figure 2a-c.

The figures (2a-c) show an increase in the number of observations on some of the age groups when using the species combined data. Non-significant differences have been observed in the age at length distribution from the two options.

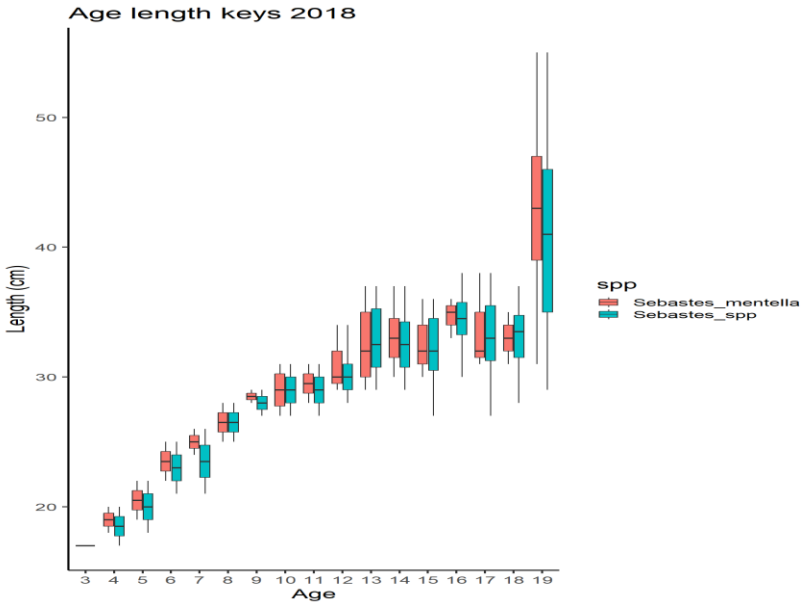

Figure 2a. 2018 age at length data for *Sebastes mentella* and Sebastes spp (*S. mentella* and *S. fasciatus*) from the EU survey age readings.

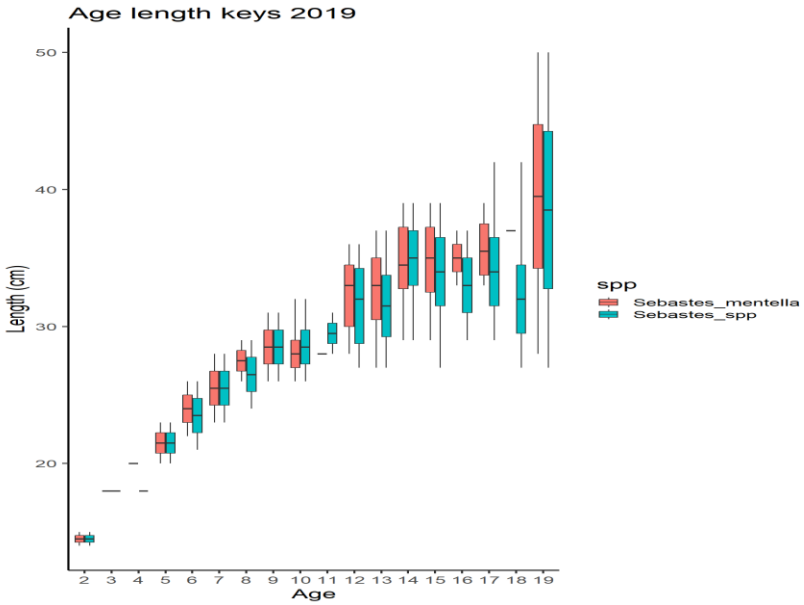

Figure 2b. 2019 age at length data for *Sebastes mentella* and Sebastes spp (*S. mentella* and *S. fasciatus*) from the EU survey age readings.

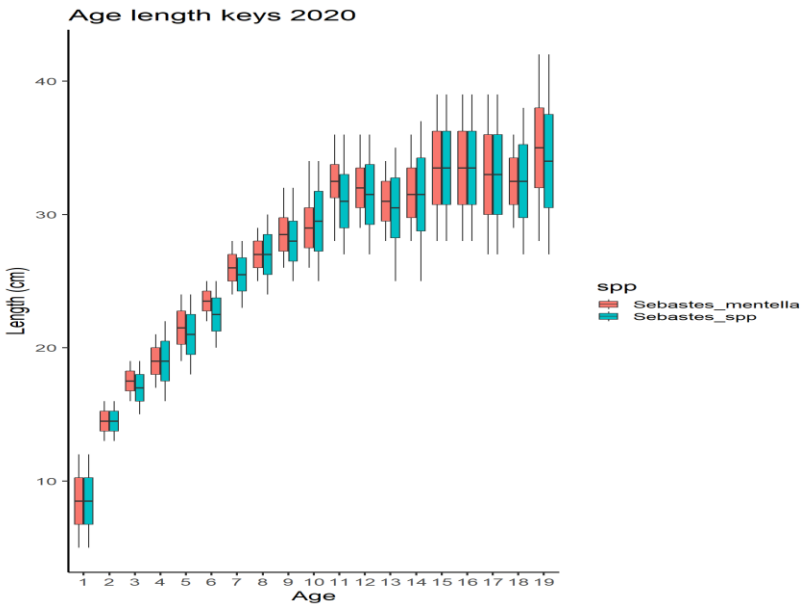

Figure 2c. 2020 age at length data for *Sebastes mentella* and Sebastes spp (*S. mentella* and *S. fasciatus*) from the EU survey age readings.

2022 age length key versus 3-years combined age length keys (2020, 2021 and 2022)

The age-length keys from 2020 until 2022 and the 3-years combined (2020, 2021 and 2022) are presented in figure 3 and figure 4.

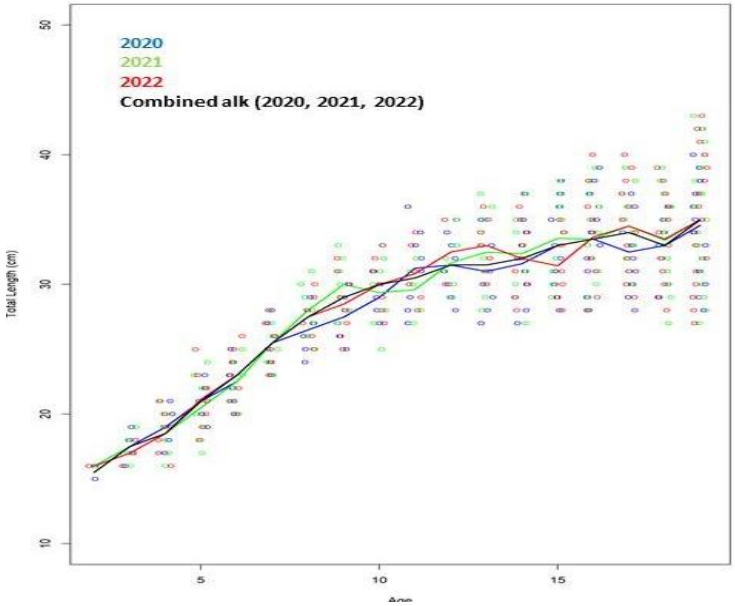

Figure 3. Age at length for Sebastes spp. from 2020 (blue), 2021 (green), 2022 (red) and the 3-years combined (black: 2020, 2021 and 2022).

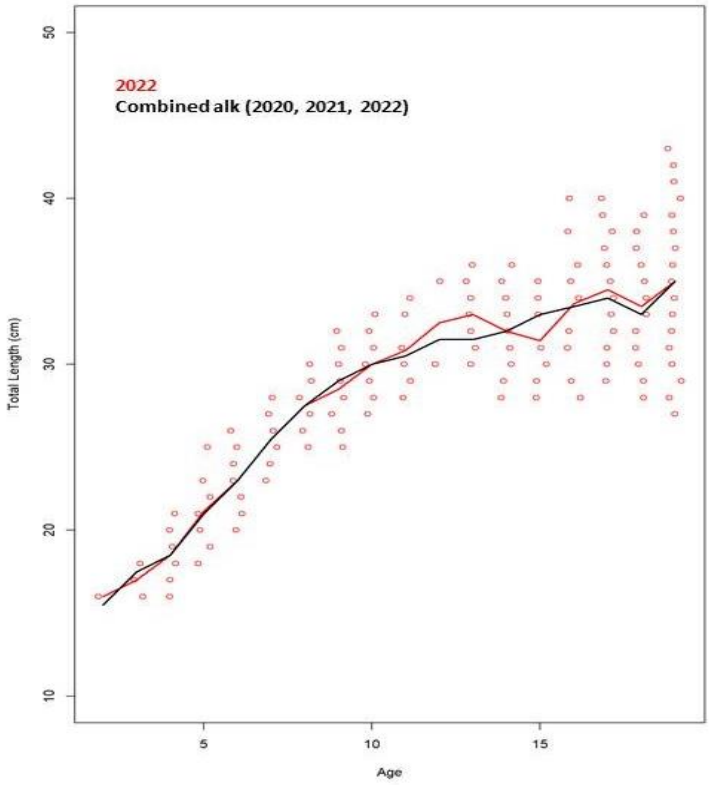

Figure 4. Age at length for Sebastes spp. from 2022 (red) and the 3-years combined (black: 2020, 2021 and 2022).

The adjusted curves from the main age length keys from the different years show no main differences (figures 3 and 4).

A Tukey HSD test has been applied to the age length keys from the all years to evaluate if there were significant differences between them. The data used to perform the analysis of the statistical test comparison was based on the mean length at age presented on Table 1.

Table 1. Mean, minimum, median, maximum length at age. Standard deviation (sd) and 1st quantile and 3rd quantile from the length at age distribution for the age length keys from 2020, 2021, 2022 and the 3-year combined (202122).

Age	Mean Lt	sd	Min Lt	Q1	Median Lt	Q3	Max Lt	Year
2	15.5	0.71	15	15.25	15.5	15.75	16	2020
3	17.5	1.29	16	16.75	17.5	18.25	19	2020
4	19	1.58	17	18	19	20	21	2020
5	21	1.58	19	20	21	22	23	2020
6	22.5	1.87	20	21.25	22.5	23.75	25	2020
7	25.5	1.87	23	24.25	25.5	26.75	28	2020
8	26.5	1.87	24	25.25	26.5	27.75	29	2020
9	27.5	1.87	25	26.25	27.5	28.75	30	2020
10	29	1.58	27	28	29	30	31	2020
11	31.25	3.11	27	28.75	31.5	33.25	36	2020
12	31.5	2.45	28	29.75	31.5	33.25	35	2020
13	31	2.74	27	29	31	33	35	2020

Age	Mean Lt	sd	Min Lt	Q1	Median Lt	Q3	Max Lt	Year
14	31.6	3.2	27	29.25	31.5	33.75	37	2020
15	33	3.32	28	30.5	33	35.5	38	2020
16	33.5	3.61	28	30.75	33.5	36.25	39	2020
17	32.5	3.03	28	30.25	32.5	34.75	37	2020
18	33	2.74	29	31	33	35	37	2020
19	34.57	4.31	28	31.25	34.5	37.75	42	2020
3	17.5	1.29	16	16.75	17.5	18.25	19	2021
4	18.5	1.87	16	17.25	18.5	19.75	21	2021
5	20.5	2.45	17	18.75	20.5	22.25	24	2021
6	22.5	1.87	20	21.25	22.5	23.75	25	2021
7	25.5	1.87	23	24.25	25.5	26.75	28	2021
8	28	2.16	25	26.5	28	29.5	31	2021
9	30	2.16	27	28.5	30	31.5	33	2021
10	29.38	2.67	25	27.75	29.5	31.25	33	2021
11	29.6	2.07	27	28	30	31	32	2021
12	31.67	2.16	29	30.25	31.5	32.75	35	2021
13	32.5	3.03	28	30.25	32.5	34.75	37	2021
14	32.38	3.11	27	30.75	32.5	34.25	37	2021
15	33.56	3.21	29	31	34	36	38	2021
16	33.5	3.61	28	30.75	33.5	36.25	39	2021
17	34.5	3.03	30	32.25	34.5	36.75	39	2021
18	33.42	3.75	27	30.75	33.5	36.25	39	2021
19	35	5.05	27	31	35	39	43	2021
3	17	1	16	16.5	17	17.5	18	2022
4	18.5	1.87	16	17.25	18.5	19.75	21	2022
5	21.14	2.41	18	19.5	21	22.5	25	2022
6	23	2.16	20	21.5	23	24.5	26	2022
7	25.5	1.87	23	24.25	25.5	26.75	28	2022
8	27.5	1.87	25	26.25	27.5	28.75	30	2022
9	28.5	2.45	25	26.75	28.5	30.25	32	2022
10	30	2.16	27	28.5	30	31.5	33	2022
11	30.83	2.32	28	29.25	30.5	32.5	34	2022
12	32.5	3.54	30	31.25	32.5	33.75	35	2022
13	33	2.16	30	31.5	33	34.5	36	2022
14	32	2.74	28	30	32	34	36	2022
15	31.43	2.64	28	29.5	31	33.5	35	2022
16	33.67	4.03	28	31	34	36	40	2022
17	34.5	3.61	29	31.75	34.5	37.25	40	2022
18	33.5	3.61	28	30.75	33.5	36.25	39	2022
19	35	5.05	27	31	35	39	43	2022
2	15.5	0.71	15	15.25	15.5	15.75	16	202122
3	17.5	1.29	16	16.75	17.5	18.25	19	202122
4	18.5	1.87	16	17.25	18.5	19.75	21	202122

Age	Mean Lt	sd	Min Lt	Q1	Median Lt	Q3	Max Lt	Year
5	21	2.16	18	19.5	21	22.5	24	202122
6	23	2.16	20	21.5	23	24.5	26	202122
7	25.5	1.87	23	24.25	25.5	26.75	28	202122
8	27.5	1.87	25	26.25	27.5	28.75	30	202122
9	29	2.74	25	27	29	31	33	202122
10	30	2.16	27	28.5	30	31.5	33	202122
11	30.5	2.45	27	28.75	30.5	32.25	34	202122
12	31.5	2.45	28	29.75	31.5	33.25	35	202122
13	31.5	3.03	27	29.25	31.5	33.75	36	202122
14	32	3.32	27	29.5	32	34.5	37	202122
15	33	3.32	28	30.5	33	35.5	38	202122
16	33.5	3.61	28	30.75	33.5	36.25	39	202122
17	34	3.32	29	31.5	34	36.5	39	202122
18	33	3.89	27	30	33	36	39	202122
19	35	5.05	27	31	35	39	43	202122

On figure 5 the result of the different age length keys based on the Tukey HSD diagnostics analysis is presented. No significant differences between the years different age length keys have been found.

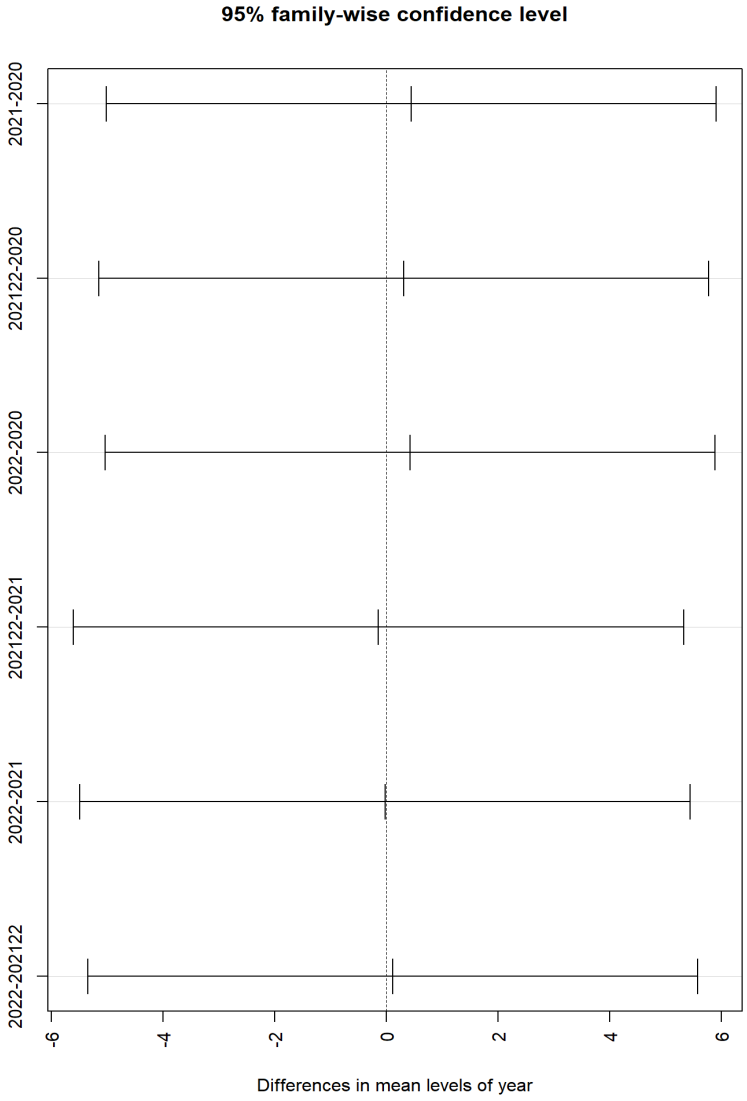

Figure 5. Tukey HSD diagnostic plot based on the differences on the mean length at age from the different year's age length keys comparison.

No-significant differences have been found between the age length key from 2022 and the 3-years combined. Notwithstanding, the two age length keys have been applied to catches (figure 6) and survey data (figure 7) to obtain the age distribution and the mean length, mean weight and the number of individuals estimated have been compared.

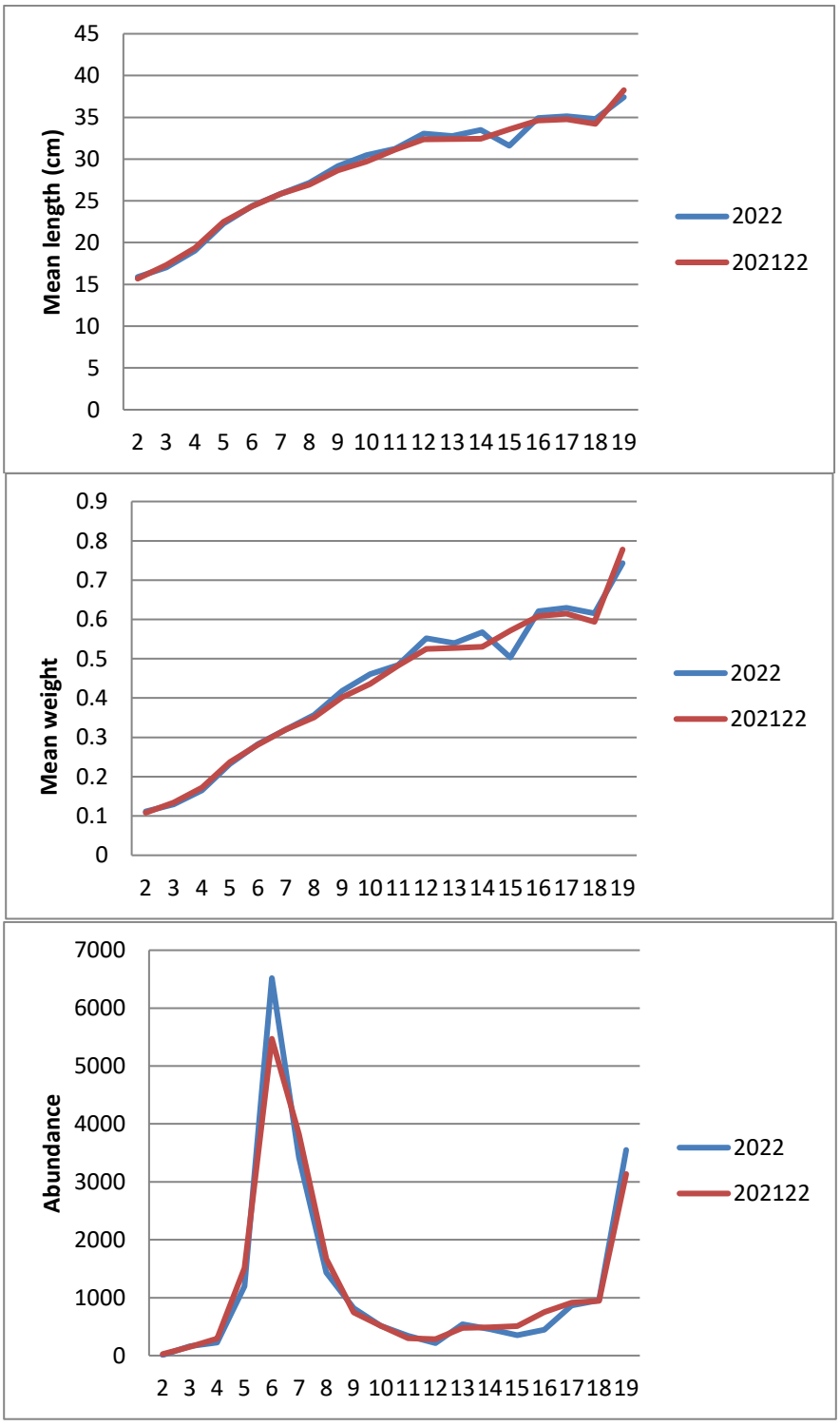

Figure 6. Mean length at age, mean length at age and abundance estimated for 2023 beaked redfish catch data comparing the use of the 2022 age length versus the 3-years combined (202122).

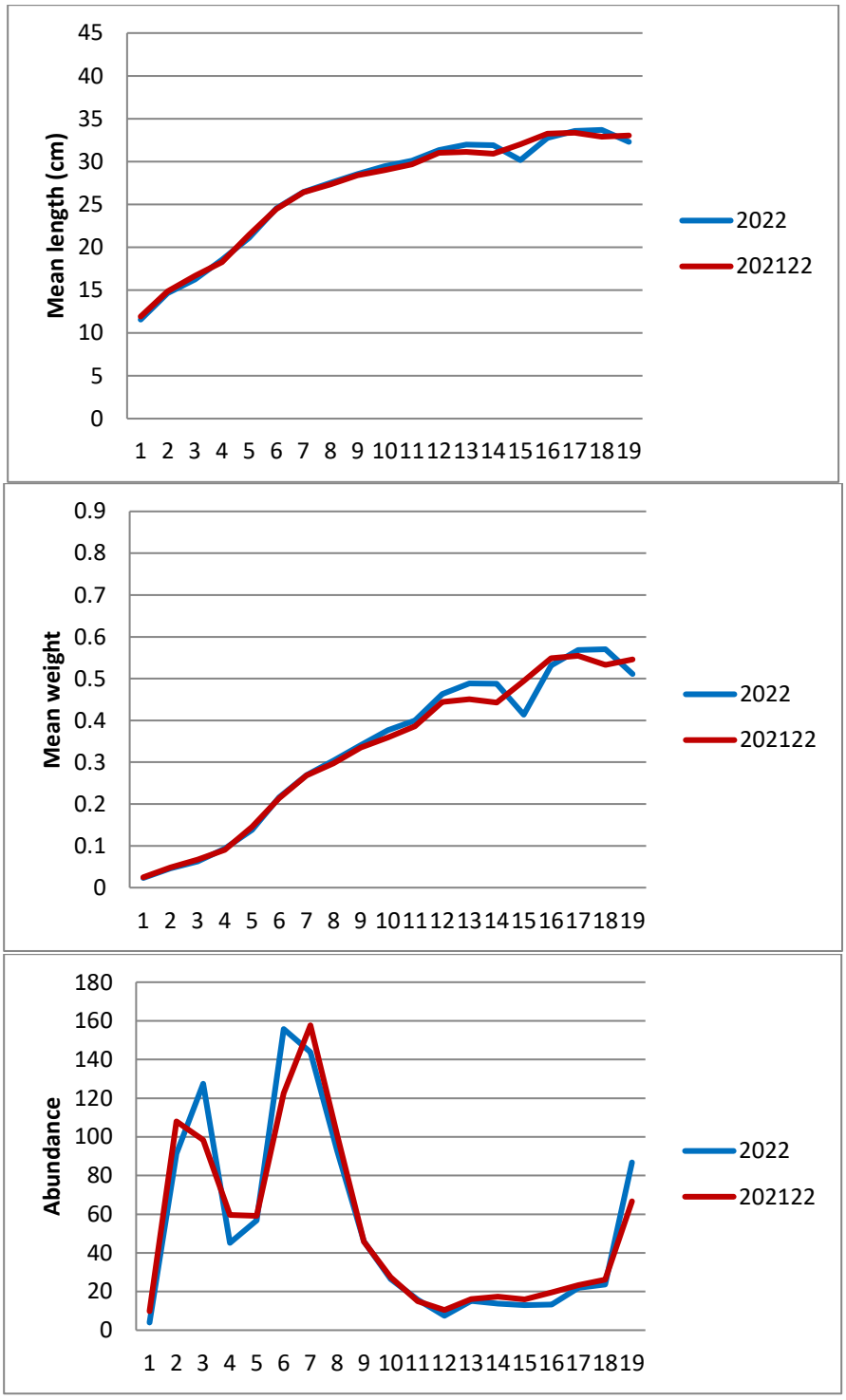

Figure 7. Mean length at age, mean length at age and abundance estimated for 2023 beaked redfish surveys data comparing the use of the 2022 age length versus the 3-years combined (202122).

The figures 6 and 7 show that for the catch and survey data the mean length, mean weight and abundance pattern from using the 2022 versus the 3-years combined age length key no present considerable differences. Although, the use of the 3-years combined data could give a more robust distribution, since in this case the number of observations by age class are increased.

The stock total abundance at age (figure 8) was estimated based on the two scenarios: (1) 2022 age length key (alk22); and (2) 3-year combined age length key (alk202122).

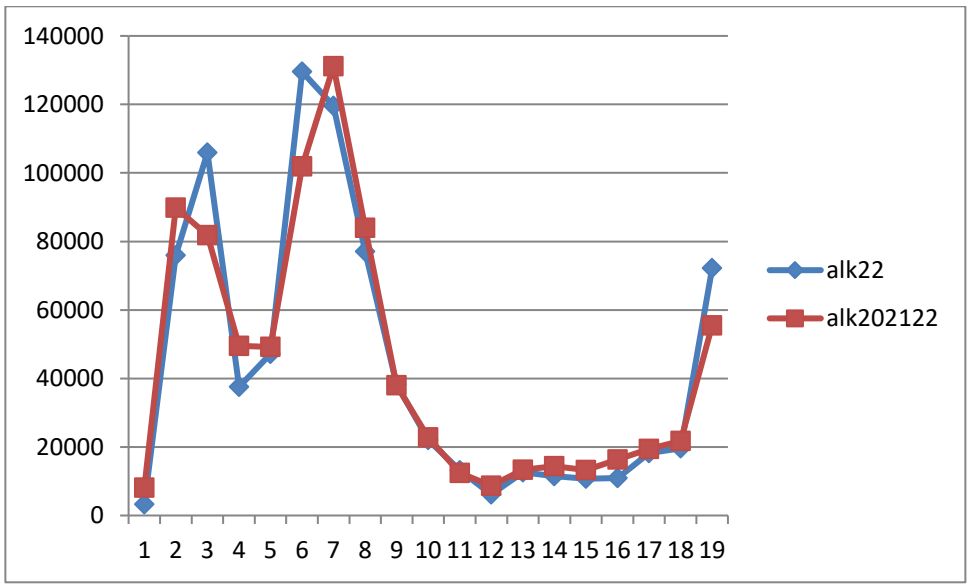

Figure 8. 2023 Total stock abundance at age estimated with: (1) 2022 age length key (alk22_mo22) (blue); (2) 3-year combined age length key (alk202122) (red).

The results estimated with the tested scenarios, presented in figure 8, seem to be very consistent for ages higher than 8. The only difference, even if small, on the stock abundance at age was obtained between the scenarios that use the single year data from 2022 on the age length key, compared with the 3-year combined approach.

The proportion of mature females at age (figure 9a-b) were estimated based on four different scenarios: (1) age length key and the maturity ogive from 2022 (alk22_mo22); (2) 2022 age length key and the 3-year combined maturity ogive (alk22_mo202122) (figure 9a); 3-year combined age length key and the 2022 maturity ogive (alk202122_mo22); and (4) age length key and the maturity ogive from the 3-years combined (alk202122_mo 202122) (figure 9b).

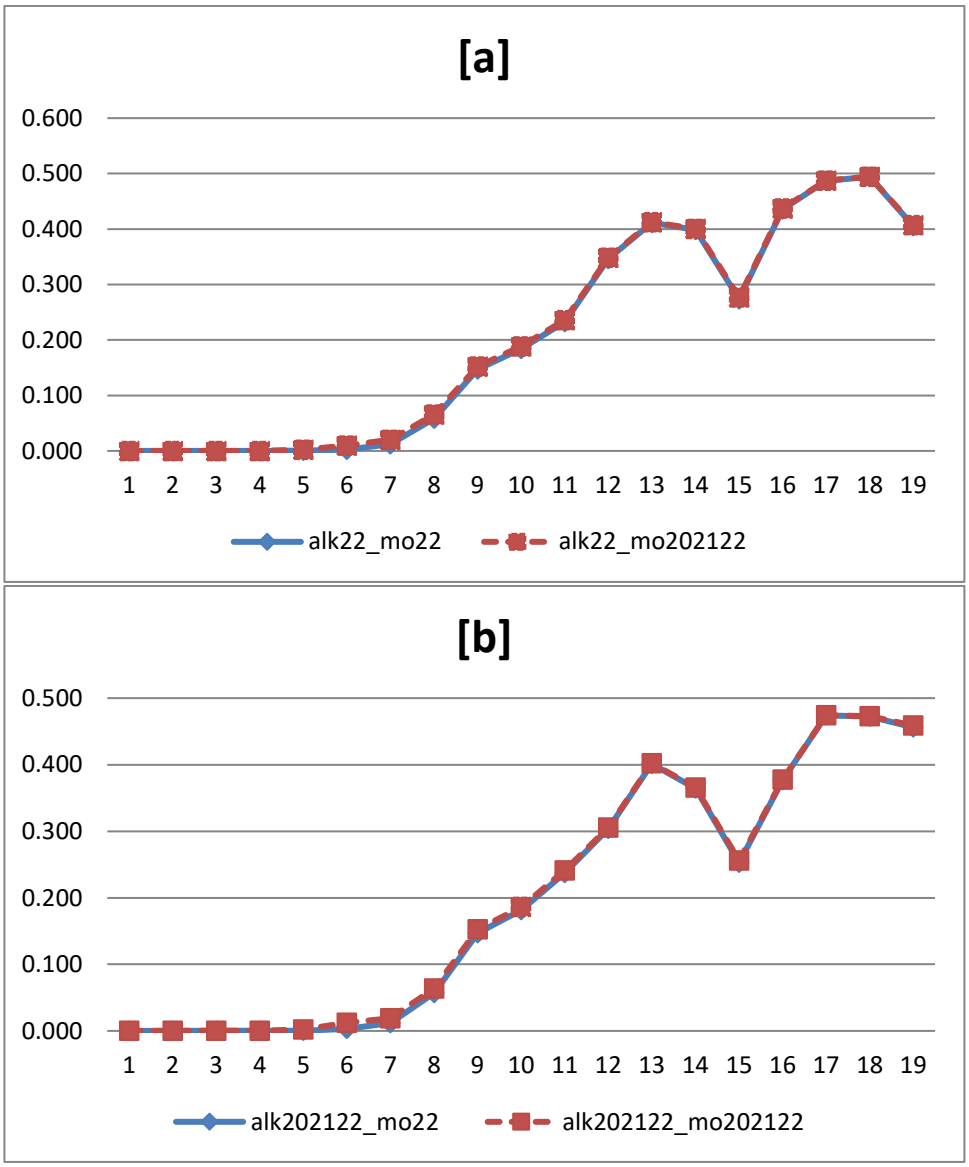

Figure 9. 2023 proportion of mature females at age estimated with: [a] (1) age length key and the maturity ogive from 2022 (alk22_mo22) (blue); (2) 2022 age length key and the 3-year combined maturity ogive (alk22_mo202122) (red); [b] (3) 3-year combined age length key and the 2022 maturity ogive (alk202122_mo22) (blue) ; and (4) age length key and the maturity ogive from the 3-years combined (alk202122_mo 202122) (red).

The results estimated with the tested scenarios, presented in figure 9, were very similar. Just small differences were noticed between the scenarios by using the 2022 age length key and the 3-year combined one.

The abundances from the EU survey by year and age are presented using the two different age length keys applied to the 2023 survey data: (1) 2022 (figure 10) and (2) 3-year combined (2020, 2021 and 2022 in figure 11).

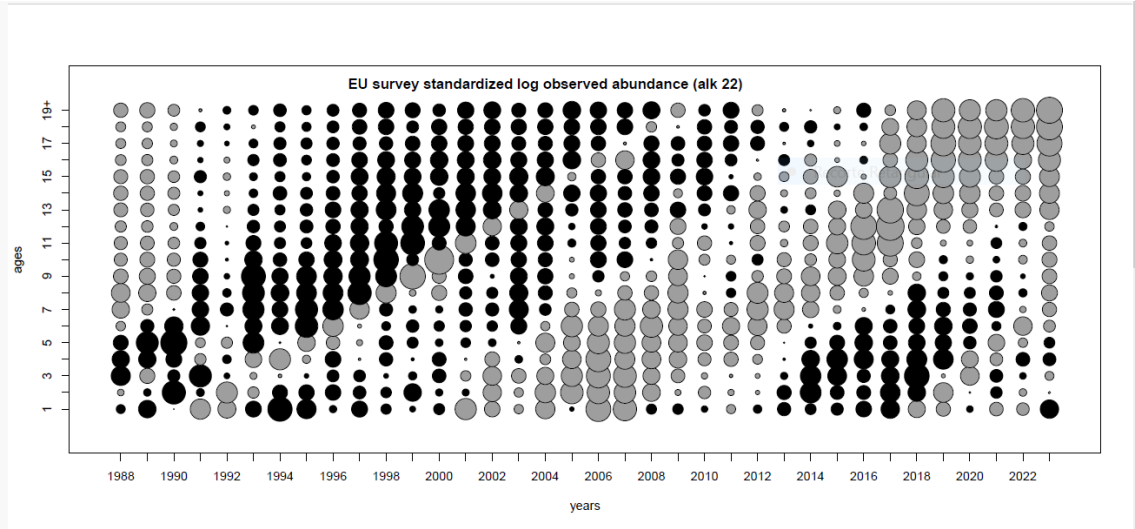

Figure 10. EU survey standardized log observed abundance by year (1988 – 2023) and age (1-19+) by applying the 2022 age length key to the 2023 survey data.

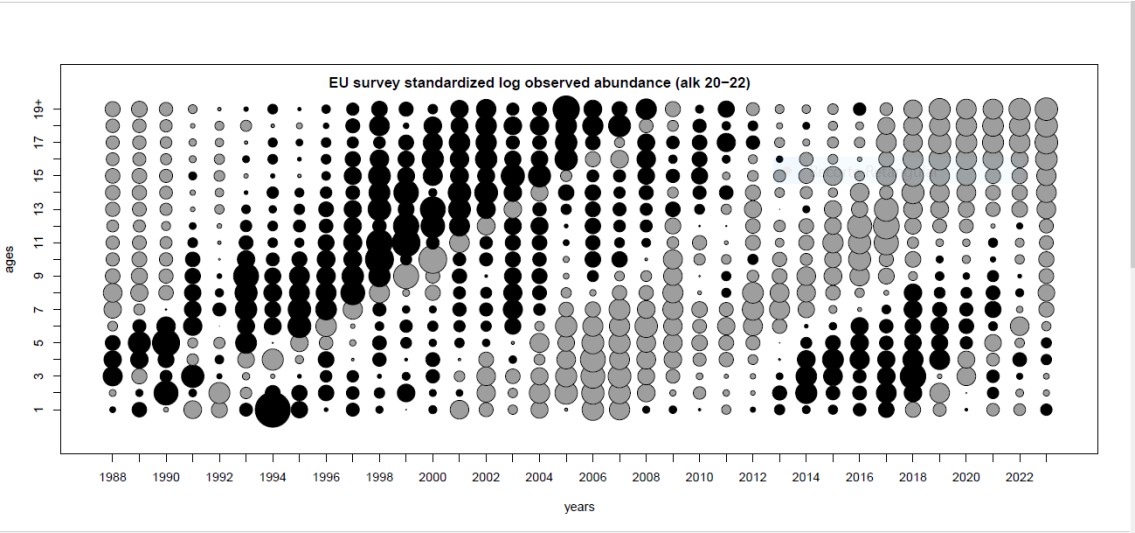

Figure 11. EU survey standardized log observed abundance by year (1988 – 2023) and age (1-19+) by applying the 3-year combined age length key (2020, 2021 and 2022) to the 2023 survey data.

The comparison of the 2023 EU survey standardized abundance with the two age length keys (figures 10 and 11) shows only small differences in the youngest age groups. However, there are no significant differences across in the age ranges over 4, and it is possible to track the strongest cohorts observed in previous years with the two different age length keys.

Conclusions

The absence of growth differences between the *S. mentella* and *S. fasciatus* together with the lower number of age readings on the former species, makes suitable the application of a species combined age length key for the Div. 3M beaked redfish assessment. The comparison analysis between the 2022 and the 3-years combined age length keys (2020, 2021 and 2022) show no considerable differences. Although, since the 3-year combined data increases the number of observations by length class, which results in an increased robustness of the data distribution based on the stock abundance at age. The decision was to apply the 3-years species combined age length key and also maturity ogive for the 2024 Div. 3M beaked redfish stock assessment.

Acknowledgements

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