Food and Agriculture Organization of the United Nations

General Fisheries Commission for the Mediterranean
Commission générale des pêches pour la Méditerranée

SCIENTIFIC ADVISORY COMMITTEE ON FISHERIES (SAC)

Working Group on Stock Assessment of Demersal Species (WGSAD)

Session on the assessment of deep-water red shrimp

Online, 8–11 February 2022

REPORT

EXECUTIVE SUMMARY

An additional session of the Working Group on Stock Assessment of Demersal Species (WGSAD)[1] dedicated to giant red shrimp (*Aristaeomorpha foliacea*; ARS) and blue and red shrimp (*Aristeus antennatus*; ARA) in the eastern–central Mediterranean was held online on 8–11 February 2022. The main objective of this meeting was to advance the assessment of these two species in the two subregions, towards the provision of advice.

Out of the seven assessments presented, two new assessments were validated as providing quantitative advice, while the other five were considered in need of further work or additional data collection. All three validated assessments indicated stocks either in overexploitation (ARA in geographical subareas (GSAs) 18–19) or overexploited and in overexploitation (ARS in GSAs 12–16 and 21). In addition, the assessment for ARS in GSA 18–19 validated by the WGSAD in January 2022 was presented for completeness.

OPENING OF THE SESSION OF THE WORKING GROUP ON STOCK ASSESSMENT OF DEMERSAL SPECIES (WGSAD) DEDICATED TO DEEP-WATER RED SHRIMP IN THE EASTERN–CENTRAL MEDITERRANEAN

1. Due to travel limitations resulting from the COVID-19 pandemic, the tasks of the session of the Working Group on Stock Assessment of Demersal Species (WGSAD) dedicated to giant red shrimp (*Aristaeomorpha foliacea*; ARS) and blue and red shrimp (*Aristeus antennatus*; ARA) in the eastern–central Mediterranean were accomplished by means of an online meeting held on 8–11 February 2022 and organized by the General Fisheries Commission for the Mediterranean (GFCM) of the Food and Agriculture Organization of the United Nations (FAO). The meeting was attended by a total of 54 participants from 12 Mediterranean riparian countries as well as from FAO, the Directorate-General for Maritime Affairs and Fisheries of the European Commission (DG MARE) and the Secretariat of the GFCM. The meeting agenda is provided in Appendix 1 and the list of participants in Appendix 2.

2. In response to the workplan drafted in 2019 and adopted by the twenty-first and twenty-second sessions of the Scientific Advisory Committee on Fisheries (SAC) (Appendix 3), the group progressed on

[1] This meeting was supported by the European Union under grant agreement SI2.839872

the assessment of ARS and ARA in the eastern–central Mediterranean geographical subareas (GSAs), from simpler to more complex models depending on the data available for each GSA as summarized below and in the table of advice provided in Appendix 4.

ASSESSMENT SUMMARY SHEETS

SUMMARY OF VALIDATED STOCK ASSESSMENTS BY SPECIES AND GSA

(Progressive numbers are referring to the table of advice provided in Appendix 4).

N: 1

Stock: Blue and red shrimp (*Aristeus antennatus*)

GSA: 18–19

Author(s): Pierucci A., Bitetto I., Zupa W., Carbonara P., Neglia C., Maiorano P., Carlucci R., Cipriano G., Lembo G. and Spedicato M.T.

Fishery: Blue and red shrimp (*Aristeus antennatus*)is one of the most important demersal species in the area, in terms both of landing and income. This resource is exploited by trawlers, targeting deep-water species (DWS) as well as mixed deep-water and demersal species (MDD).

Data and parameters This was the first assessment for this species in GSAs 18 and 19; the assessment was performed by joining the two GSAs.

The assessment was carried out using length–frequency distribution (LFD) abundance indices (N/km^2) for GSAs 18 and 19 (International Bottom Trawl Survey in the Mediterranean (MEDITS) data, available from 1994, used from 2008 to 2020); length structure of landings (discard negligible) by fishing segment and landing in weight from the Data Collection Framework (DCF) (2008–2020). The growth parameters were estimated within DCF, as well as length–weight relationship and maturity ogive. The vector of natural mortality by age was calculated applying the Chen and Watanabe method. The catch at age matrices (for landing and survey) were derived according to deterministic age slicing procedure. A sex separated growth parameter was also tested (Relini *et al*, 2013).

Assessment method: The assessment was carried out using two different assessment models: eXtended Survival Analysis (XSA) and Assessment for All (a4a) for both combined and sex separated age slicing. Despite the comparability of the results from the four assessments, the combined XSA assessment was preferred.

Model performance: The results showed a decrease in fishing mortality (F) in the last years. The spawning stock biomass (SSB) and recruitment also showed a recent decrease. The residuals showed some trends in the first years of the time series. The overall absolute values of residual were quite small. The retrospective analysis, on an overall basis, showed a consistent pattern.

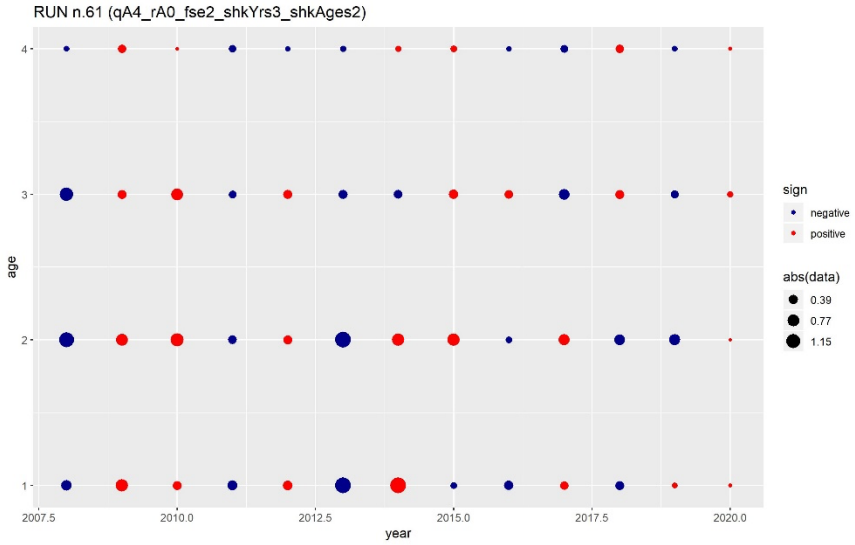
Results: Fishing mortality showed an average value of 0.50 ($F_{bar}(1–3)$) in 2018–2020. The estimated $F_{0.1}$ value was 0.23.

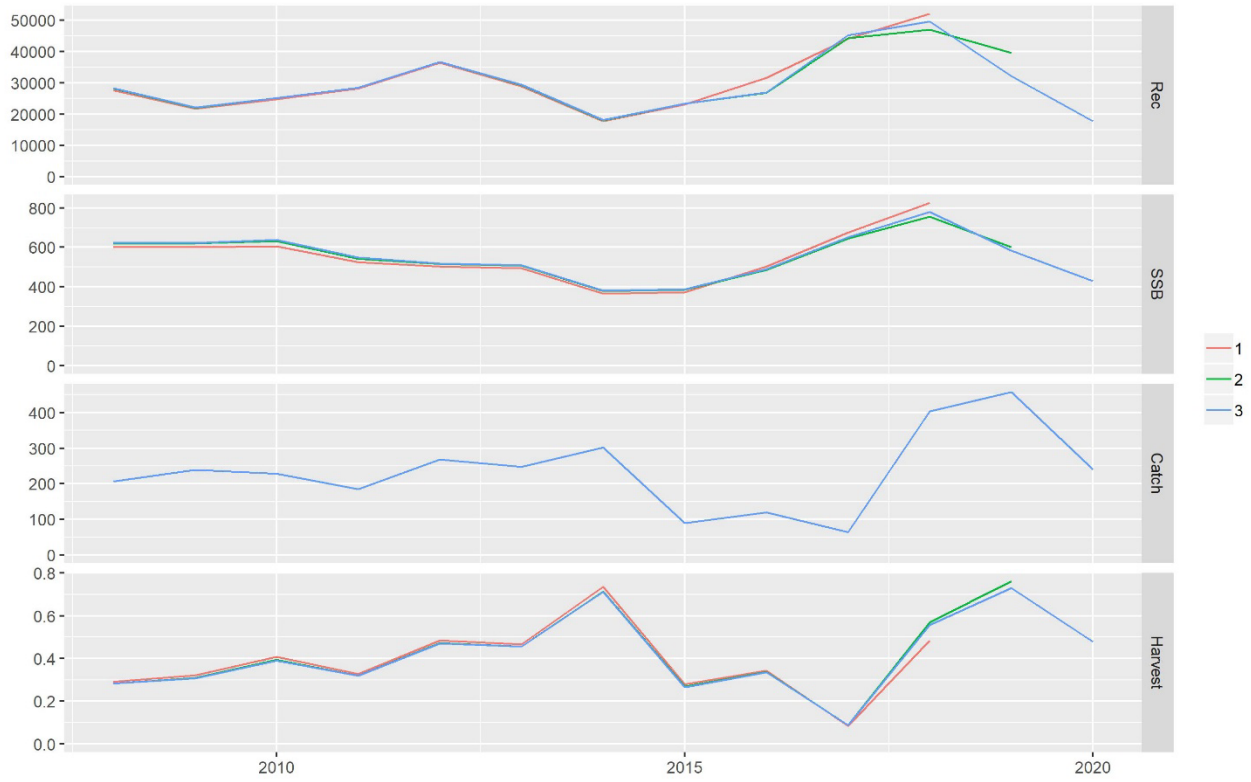
$F_{current}$ (2020)	0.50
F_{01}	023
$F_{current}/F_{01}$	2.51
B $_{current}$ (tonnes) (2020)	429.5
B 33rd percentile(tonnes)	488.98
B 66th percentile (tonnes)	518.19

Diagnosis of stock status:

- In overexploitation ($F_{current}$ > F0.1)
- Relative low biomass ($SSB_{current}$< SSB 33rd percentile)

Advice and recommendations: It is recommended to reduce the fishing mortality.





Retrospective analysis for the XSA sex combined assessment

References

Orsi Relini, L., Mannini, A., & Relini, G. 2013. Updating knowledge on growth, population dynamics, and ecology of the blue and red shrimp, Aristeus antennatus (Risso, 1816), on the basis of the study of its instars. *Marine Ecology*, *34*(1), 90–102

N: 2

Stock: Giant red shrimp (*Aristaeomorpha foliacea*)

GSA: 12–16, 21 (central–western sector)

Author(s): Scannella, D., Jarboui, O., Mifsud, J., Falsone, F., Rejeibi, O., Gambin, M., Gancitano, V., Albanozzo, M., Vitale, S., Ceriola, L. and Fiorentino, F.

Fishery: Giant red shrimp (*Aristaeomorpha foliacea*) is an important species for commercial deep-water demersal fisheries in the south–central Mediterranean Sea. It is fished exclusively by trawling on deep fishing grounds ranging from around 400 to 650 m.

In the south–central Mediterranean Sea, giant red shrimp is mainly fished by three fishing fleets: Italian trawlers, Tunisian trawlers and Maltese trawlers. Tunisian and Maltese fleets operate exclusively in the south–central Mediterranean. The Italian fleet operate in the central and eastern Mediterranean, therefore landings in GSA 16 include the capture production deriving both from the central and eastern Mediterranean Sea. To obtain the fraction of Italian landings deriving exclusively from the south-central Mediterranean, the capture production from the eastern Mediterranean was estimated and subtracted from the total landings. The eastern Mediterranean landings were estimated using three different data sources: official data of the trawl fleet registered in GSA 16, local ecological knowledge (LEK) and logbooks of

Mazara del Vallo's captains specialized in DWRS fisheries. Mean annual landings for 2017–2020 were about 1000 tonnes, 53 tonnes and 34 tonnes from Italian, Tunisian and Maltese trawlers, respectively.

Data and parameters: Fishery-dependent data used for the stock assessment are reported in the following table:

YEAR	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Italian fleet	568	918	1029	1113	911	1370	1401	1313	1430	1581	942	999	1071	1097	1172	990	847
Tunisian fleet						6	6	6	6	7	8	4	11	5	58	63	37
Maltese fleet		18	26	34	27	42	27	41	48	40	25	29	22	27	29	41	32
Total fleets	568	936	1055	1147	938	1418	1435	1361	1485	1628	975	1031	1105	1129	1260	1094	916

Stock abundance indices were derived from the MEDITS survey carried out in GSAs 16 and 15. Data on biomass index were available from 2003 to 2020. For assessment purposes, a combined biomass index was calculated by merging the two GSAs together using a weighted average in which the surface of each GSA was used as the weight.

The surplus production models used for the assessment required priors of the intrinsic rate of the population increase (r) and a parameter that described the state of the stock in terms of biomass on carrying capacity (B/K) at the beginning, middle and end of the time series. Prior r was derived from SeaLifeBase (Palomares and Pauly, 2019) and was set to 0.30–0.73. Priors B/K were chosen based on expert knowledge and set at medium depletion (0.2–0.6) both at the beginning of the time series and in an intermediate year (2012). The prior for the unfished biomass (K) was set to 10 000 tonnes as a mean and 0.3 as a coefficient variation (CV).

Assessment method: The assessment was performed through three different surplus production models: Abundance Maximum Sustainable Yield (AMSY), Catch Maximum Sustainable Yield (CMSY) and Just Another Bayesian Biomass Assessment (JABBA).

Results: The outputs of all models performed indicated that the stock is in overexploitation ($F/Fmsy > 1$) and overfished condition ($B/Bmsy < 1$). In addition, a sensitivity analysis was performed to test the influence of the choice of priors on the estimation of the stock status. All configurations tested confirmed the bad state of the stock.

Diagnosis of stock status: Taking into account the final results of the models, giant red shrimp in GSAs 12–16, 21 is in overexploitation and overexploited.

Advice and recommendations: The WGSAD validated the stock assessment of giant red shrimp in GSAs 12–16, 21 as qualitative. It is recommended to reduce fishing mortality. In addition, the WGSAD agreed that further data exploration and improvement of Italian catch reconstruction is needed to improve accuracy and move from qualitative to quantitative advice.

CONCLUSIONS AND RECOMMENDATIONS

3. A framework for the application of data-limited methodologies using the Stock Synthesis Data-Limited (SS-DL) tool for mimicking Length-based Integrated Mixed Effects (LIME), Length-Based Spawning Potential Ratio (LBSPR) and catch-only models was illustrated based on a demonstration dataset comprising data for ARS from GSAs 18 and 19 – among the most data rich GSAs in the eastern–central Mediterranean. It was agreed that the comparison foreseen under this framework would be completed for all assessment methods applied to ARS in GSAs 18–19, to be demonstrated in the future, and would be used to apply LBSPR to the data available for ARS and ARA in GSA 20 and ARS in GSA 25 (details below).

4. Two assessments were validated as providing qualitative, precautionary advice – ARS in GSAs 12–16 and 21, and ARA in GSAs 19–20 (Appendix 4; details below), significantly increasing the spatial coverage of assessments in the eastern–central Mediterranean.

5. The issue of better understanding the spatial dynamics of all fleets and incorporating into the assessments information on catches, and their length structure, from fleets fishing outside their GSA of origin was raised numerous times and identified as the most important next step towards truly informative and representative assessments. In this context, the group compiled a table of information summarizing all important shortages by GSA that should be addressed in the forthcoming interactions of the group in order to improve the quality of the assessments and expand the number of methods that can be used (Appendix 5). These gaps are of two origins: some concern existing data that have not been made available by the contracting parties and cooperating non-contracting parties (CPCs) while the others concern data that are not currently being collected owing to the lack of technical infrastructure in place to collect them.

6. The WGSAD agreed that a benchmark session on DWRS in the eastern–central Mediterranean was needed (2022–2023 intersession) to finalize the work.

7. Several assessments and data summaries were presented during the session, as follows:

ARS in GSAs 12–16, 21

- An assessment was presented for ARS in GSAs 12–16 and 21 using three production models: AMSY, Bayesian Schaefer Model (BSM) and JABBA. The assessments were based on all information available: Italian, Maltese and Tunisian catches as well as MEDITS surveys from GSAs 15 and 16. Of particular note was an important effort made to reconstruct the catches of the Italian fleet to isolate and exclude the portion of catches originating from the eastern Mediterranean GSAs, based on all available information including LEK studies, samples of DCF data and logbook data for select vessels. The three models provided consistent results, but the group was asked to further investigate some of the assumptions:
    - deriving the survey index jointly for GSAs 15 and 16, rather than combining them post-hoc; and
    - trialling the use of wider initial and intermediate priors to understand if the model follows the same trajectory when allowing the data to have more weight.
- Additional scenarios were run during the session in JABBA, including wider initial and intermediate productivity–susceptibility analysis (PSA) priors as well as increased uncertainty around the biomass index in specific years (2009) as well as around catches, to take into account the uncertainties related to the reconstruction of catches of the Italian fleet. The additional scenarios were compared to the best model selected from the initial assessment scenarios (base case). The different model configurations and assumptions did not reveal significant differences in the trajectory of F and SSB, consistently denoting a stock in overexploitation and overexploited and emphasizing the stability and robustness.
- The group agreed to validate this assessment as providing qualitative, precautionary advice based on the results of all three explored models and suggested further work should be done to improve the reconstruction of catches from the Italian fleet using the full extension of recordings from both the vessel monitoring system (VMS) and electronic reporting system (ERS) (Appendix 4).

ARS in GSAs 18–19

- The joint assessment of ARS in GSAs 18 and 19 using a4a that had been previously validated with quantitative advice by the WGSAD in January 2022 was presented for completeness; the results are summarised in Appendix 4

ARA in GSAs 18–19

- Assessments of ARA in GSAs 18 and 19 using a4a, Surplus Production Model in Continuous Time (SPiCT) and XSA were presented for the first time at the WGSAD in January 2022, when issues with the fits and diagnostics of the trialled configurations led the WGSAD to deem the assessments as not yet adequate for validation. Further work was performed in the weeks between this session and the previous meeting of the WGSAD, including at in-depth evaluation of the MEDITS survey in general and in the Montenegro area in particular. Additional assessment scenarios with all three models were presented, including combined-sex and separate-sex configurations using growth parameters from different sources. The group agreed, based on both the final model diagnostics and the need to be guided by the biological plausibility of the assumptions, to validate the XSA assessment using combined sexes for qualitative, precautionary advice (Appendix 4).
- The group suggested future work should concentrate on the further analysis of input data and biological assumptions used, such as growth parameters, in the context of a benchmark assessment.

ARS and ARA in GSA 20

- Data for ARS and ARA in GSA 20 were presented revealing the availability of limited time series of catch data (more so for ARA with two years of data than for ARS with six years of data) and various survey data with considerable gaps (1996–2022, with gaps). In order to improve the situation of survey data, an important effort was made towards combining all available surveys into a single, more informative time series.
- As a first, very preliminary attempt, an AMSY model was run for ARS to investigate the trajectories of F and biomass, filling survey gaps using a Kalman filter. The group suggested to run LBSPR based on the length structure from the survey data using the three most recent years, by sex. Despite the survey having a very different selectivity to the commercial fishery, which would not allow the WGSAD to draw conclusions on the spawning potential ratio (SPR), this exercise was deemed fit to provide useful corollary information on the F and natural mortality (M) ratio.
- Given that the fleet from GSA 18 has been exploiting the DWRS fishing grounds in GSA 20 over the years (probably more so in the past than at present) and exerting a greater fishing effort than the local fleet, the WGSAD discussed the value of including GSA 20 in the joint assessment of GSAs 18 and 19. Given the scanty information from GSA 20, the group agreed that a trial to join GSA 20 to GSAs 18 and 19 would be more worthy than reconstructing past catches from GSA 20. A preliminary attempt was made to include the GSA 20 MEDITS information from 2003 as biomass index, as well as the six years of catches, in the a4a assessment for ARS in GSAs 18 and 19. The outcomes of this new assessment were very similar to those obtained from the validated a4a assessment for GSAs 18 and 19 together, revealing that the contribution, especially of catches, from GSA 20 was minor. The group agreed that future work should further explore this avenue as a means to overcome the issues related to the effort exerted by GSA 18 vessels on GSA 20 grounds.

ARS in GSA 25

- Available data for ARS in GSA 25 were presented, including automatic identification system (AIS) and VMS information, effort, catches and the MEDITS survey index. The group noted that survey time series greatly fluctuated and agreed this was probably due to the fact that MEDITS stations were placed on the edges of the fishing grounds and the species hotspots, as had already been revealed by a previous analysis on the overlap between MEDITS stations and fishing grounds. Attempts were made to apply AMSY using the MEDITS biomass index; however, results of a state space evaluation of the timeseries showed unfavourably high root mean square error (RMSE) scores (well above 30) and evident residual patterns for some years, suggesting low reliability of the biomass index used. The use of the time series of survey data according to Category 3 International Council for the Exploration of the Sea (ICES) assessments was also investigated and proposed as an alternative tool.

- The group agreed that future work could concentrate on:
    - the use of LBSPR, borrowing growth parameters from other GSAs;
    - further exploration of AMSY;
    - standardisation of the survey index to account for the temporal shifts of the survey throughout the time series;
    - a possible increase of sampling effort in the area so as to include more commercial biological data;
    - a scientific survey at sea and/or expansion of existing ones covering the mapped fishing grounds;
    - further exploration into the quantity of catches in GSA 25 from vessels coming from other GSAs; in this respect, it is essential that the provision of Recommendation GFCM/42/2018/3 on a multiannual management plan for sustainable trawl fisheries targeting giant red shrimp and blue and red shrimp in the Levant Sea (geographical subareas 24, 25, 26 and 27) stating that vessels actively fishing in the Levant Sea declare all catches and bycatch of the key species is followed.

ARS and ARA in GSA 26

- Assessments were presented for ARS and ARA in GSA 26 based on VIT and LBSPR performed on one year of length–frequency data (2021) collected on a monthly basis, which consistently revealed both species to be in overexploitation.
- Additional analyses were performed during the session, using LBSPR, to test the sensitivity of the outcomes to the vector of M at age used and compared to the base-case which foresaw the use of Prodbiom. Thus the M at age vectors derived from Chen and Watanabe, Gislason and Charnov were tested for both species. For ARS, all four vectors yielded consistent results. For ARA, the use of Gislason and Charnov revealed a stock in sustainable exploitation, contrary to Prodbiom and Chen and Watanabe. The group agreed that the sensitivity should be explored with a full set of simulations in the future, also including the VIT assessments. This would allow for a further understanding into the effects of the assumptions on M on the results.
- The WGSAD acknowledged the meticulous work done to make the most of the limited amount of data available and discussed shortcomings as well as future actions to be undertaken for the improvement of the future assessments. In particular, an absence of larger individuals in the catches was noted, as was the effect this had on the estimation of growth parameters from the same catch data, which resulted in low values of Linf especially for females, not consistent with the known biology of the species. It was noted that the absence of larger individuals could be due to one of two factors: i) a resource in overexploitation, or ii) fishing dynamics that do not cover the entire distribution of species – larger animals are known to reside around 500–600 m and greater depth and this spatial segregation in size may not be adequately captured by the fleet. The group suggested efforts be made towards the future improvement of data and the collection of additional indicators from the fleet, as follows:
    - Establish a survey at sea to gain a fishery-independent perspective of the stocks, covering their whole distribution range.
    - Collect indicators of change in production and catch per unit effort (CPUE) over the history of the fishery and into the future, through LEK studies, to understand the perception of the fishers regarding the status of the population in the area.

Appendix 1

Meeting agenda

8–10 February 2022 14.30–17.00 (Rome time)	• Overview of the roadmap (GFCM Secretariat) • Summary of work done to date on data rich data in GSA 18–19 (Ricardo Amoroso) • Presentation of assessments performed at the WGSAD-C-E-AS: • Presentation of available data for other GSAs according to the workplan: • Plan for the week • Time to work
11 February 2022 14.30–17.00 (Rome time)	• Final results and conclusions • Workplan

Appendix 2

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Appendix 3

Work plan for the assessment of stock status and the determination of fishing grounds for deep-water red shrimp stock and fisheries in the eastern–central Mediterranean

1. Work plan for stock assessment

Following from the recommendations of the data preparation meeting held in Rome in October 2019, the following steps will be taken towards the assessment of giant red shrimp and blue and red shrimp:

- Assessments will be performed in each geographical subarea (GSA) with the aim of starting with the simpler methods and progressing towards more complex models in GSAs with enough data to do so. A minimum plan for the future is provided in Table 1, noting that these methods should be trialled, as far as possible, in each GSA in order for assessments to be presented at the WGSAD in November/December 2021. Thus each GSA will perform, to the extent permitted by their data, catch curves, Length-based Spawning Potential Ratio (LBSPR) and Length-based Integrated Mixed Effects (LIME). The work will be carried out step-by-step starting from catch curves, then addressing LBSPR and finally LIME. Where possible outcomes between methods will be compared in terms of the ratios of fishing mortality (F) to natural mortality (M). Data-rich GSAs may also explore more complex models if deemed useful, such as Surplus Production Model in Continuous Time (SPiCT), eXtended Survivor Analysis (XSA) and Assessment for All (a4a). In this respect, a number of critical issues by method should be borne in mind:
    - Catch curves: how years are pooled and sensitivity on the time series considered
    - LBSPR: LBSPR is very sensitive to the value of Linf used so in the cases where catch cannot be split by sex, care should be taken with respect to the growth parameters used. In this regard, the group agreed to explore two options: i) use female parameters and treat the outcomes as a worst-case scenario; and ii) calculate a new set of combined-sex parameters
    - LIME: the assumed variability of recruitment (sigmaR) is extremely important. The group agreed to calculate it from the MEDITS time series for recruits. GSAs with no surveys can borrow sigmaR from adjacent GSAs if it makes sense
- In order to provide adequate technical assistance in the assessments, a standard capacity-building module for these methods will be developed, using SS-DL for LIME and LBSPR and data from GSAs 18 and 19 as a demo. The module will be illustrated and rolled-out with a workshop which will be followed with bilateral assistance if needed.
- In order to maximize the quality of the results of these data-limited approaches, information on biological parameters should be improved and standardized protocols for data collection across GSAs should be ensured.
- The work towards assessing stocks will proceed step-by-step, starting from the GSA-level (i.e. from the basic unit of data availability), and maintain the prerogative to unify them whenever and if needed, also by performing sensitivity analyses. Overarching this, the concept of keeping all GSAs in the eastern–central Mediterranean together should be maintained as the null hypothesis to be challenged.

Table 1. Summary of available data and possible assessment methods by GSA

GSA	Available data	Possible assessment methods
15	MEDITS abundance index	Catch curves
	MEDITS biomass index	LIME
	MEDITS LFD by sex	LBSPR
	Catch	LBB
	Catch LFD (combined sexes)	AMSY
		SpiCT
		VPA-type
16	MEDITS abundance index	Catch curves
	MEDITS biomass index	LIME
	MEDITS LFD by sex	LBSPR
	Catch	LBB
	Catch LFD (combined sexes)	AMSY
	Catch LFD by GSA of origin for selected years (combined sexes)	SpiCT
		VPA-type
18	MEDITS abundance index	Catch curves
	MEDITS biomass index	LIME
	MEDITS LFD by sex	LBSPR
	Catch	LBB
	Catch LFD (combined sexes)	AMSY
		SpiCT
		VPA-type
19	MEDITS abundance index	Catch curves
	MEDITS biomass index	LIME
	MEDITS LFD by sex	LBSPR
	Catch	LBB
	Catch LFD (combined sexes)	AMSY
		SpiCT
		VPA-type
		SCAA

GSA	Available data	Possible assessment methods
20	Survey abundance index	Catch curves
	Survey biomass index	LIME
	Survey LFD by sex	LBSPR
		LBB
		AMSY
24	Survey abundance index (monthly)	Catch curves
	Survey biomass index (monthly)	LIME
	Survey LFD (monthly)	LBSPR
		LBB
		AMSY
25*	MEDITS abundance index	Catch curves
	MEDITS biomass index	LIME
	MEDITS LFD by sex	LBSPR
	Catch (issues)	LBB
	Catch LFD (combined sexes) (issues)	AMSY
26	LFD commercial (2016/2017)	Catch curves
		LIME
		LBSPR
		LBB
		AMSY

*When overlaying the survey positions onto the hypothetical fishing grounds there was no correspondence so it is not advisable to assume that the LFDs of the survey may include the catch LFDs

2. Work plan for the use of composite models for the estimation of fishing grounds for deep-water red shrimp (using AIS, survey data and other methods)

Following from the recommendations of the data preparation meeting held in Rome in October 2019, the steps outlined in Table 2 and Figure 1 will be taken to estimate fishing grounds for deep-water red shrimp (DWRS):

Table 2. Actions towards the estimation of fishing grounds for deep-water red shrimp in the eastern–central Mediterranean

WHAT TO DO	WHO	RESOURCES NEEDED	TIMEFRAME
Fishing grounds + survey locations	Lorenzo D'Andrea		DONE
Fishing grounds + AIS (2015–2018) Assess future possibilities acc. results	Nora Tassetti Carmen Ferrá Vega	Assess evolution of the fleet	DONE
MCDA (in GSA 24, 25, 26)	Irida Maina + help	Info needs: • Environmental data + fleet characteristics (DCRF?) • Local knowledge • Legislation (FRAs+national measures?) Minimum dataset	DONE
Biomass/abundance data (species distribution modelling) vs LEK (info available)	Lorenzo D'Andrea Tommaso Russo	Info needs: • Survey data	DONE
Overlap analysis	Lorenzo D'Andrea, Tommaso Russo, Irida Maina, Nora Tassetti, Carmen Ferrá Vega	Info needs: • All info available from analyses above	To be finalized

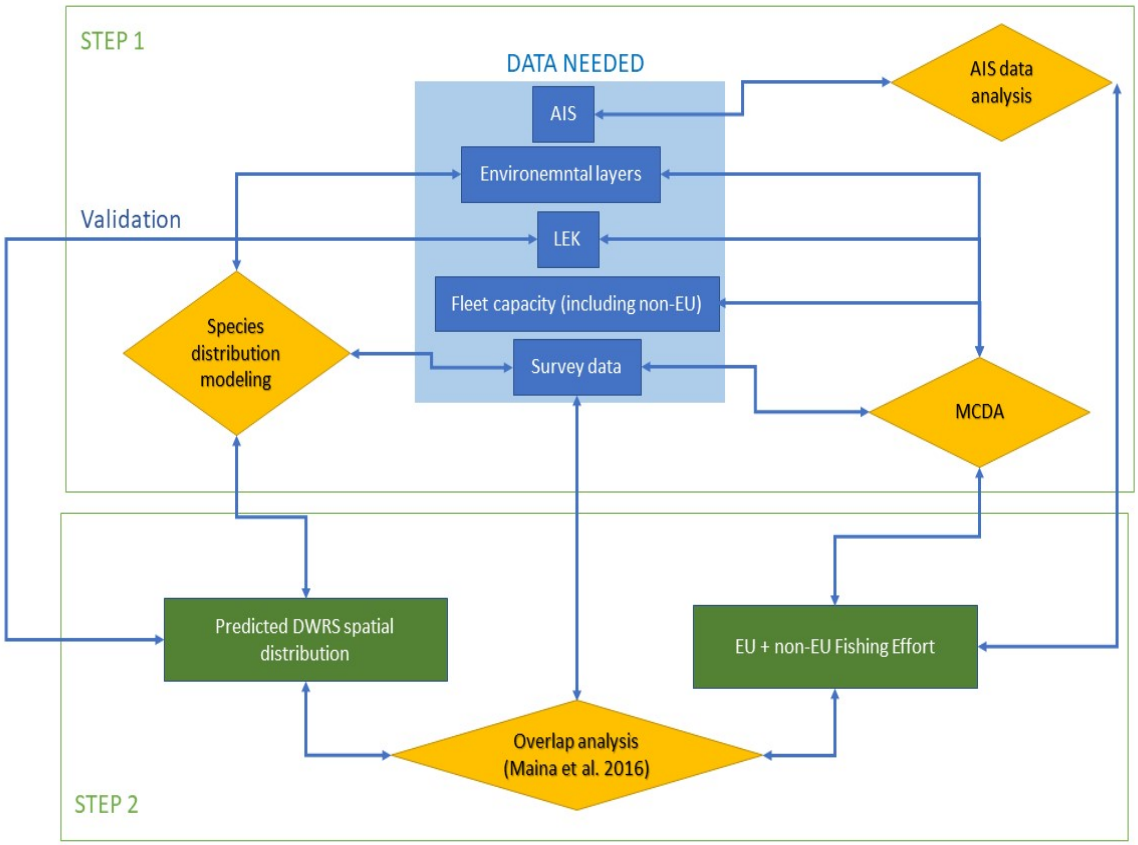

Figure 1. Schematic representation of the actions towards the estimation of fishing grounds for deep-water red shrimp in the eastern–central Mediterranean

Appendix 4

Scientific advice on the status of the stocks assessed, including WGSAD comments

No	GSA	Species	Method	Current levels	Reference points	Quantitative status	Stock status	Scientific advice	WG comments
1	18,19	*Aristeus antennatus*	XSA*, a4a, SPiCT				In overexploitation	Reduce fishing mortality	New assessment Validated providing qualitative advice based on XSA (sexes combined) Benchmark session suggested to further explore input data and modelling approaches
2	12–16, 21	*Aristaeomorpha foliacea*	AMSY, BSM, JABBA				In overexploitation and overexploited	Reduce fishing mortality	New assessment validated providing qualitative advice based on all three methods Improvement of catch reconstruction for the Italian fleet Benchmark session suggested to further explore input data and modelling approaches

	18,19	*Aristaeomorpha foliacea*	a4a	$F_c = 0.62$, $B_c = 285$	$F_{0.1} = 0.45$	$F/F_{target} = 1.38$	In overexploitation, with relatively intermediate biomass	Reduce fishing mortality	**Previously validated by the WGSAD in January 2022; presented for the sake of completeness** Revised assessment Previously validated by the WGSAD in January 2022

Appendix 5

Summary of additional information useful for making assessments more informative, by GSA

GSA	Additional information
12	
13	
14	
15	
16	Catches by GSA of origin – to check DCRF submissions Georeferenced catches
18	Georeferenced catches Logbook information
19	
20	Surveys at sea to improve information on the abundance fluctuations of the species.
21	
24	
25	Increase commercial sampling effort Surveys at sea Provision of catches of Italian vessels fishing in GSA25 and/or use of the availability of information on catches from other CPCs in GSA25
26	Surveys at sea Complementary indicators of productivity/CPUE from LEK