Food and Agriculture Organization of the United Nations

TECHNICAL DOCUMENT 51

REPORT OF THE JOINT COPEMED - GFCM DATA PREPARATION MEETING ON BLACKSPOT SEABREAM (PAGELLUS BOGARAVEO) IN THE STRAIT OF GIBRALTAR COMMITTEE

19-21 March 2019
Cadiz, Spain

The conclusions and recommendations given in this document and in other documents in the *Co-ordination to Support Fisheries Management in the Western and Central Mediterranean* CopeMed IIProject series are those considered appropriate at the time of preparation. They may be modified in the light of further knowledge gained in subsequent stages of the Project. The designation employed and the presentation of material in this publication do not imply the expression of any opinion on the part of Food and Agriculture Organization of the United Nations, FAO, the Government of Spain or the Commission of the European Union concerning the legal status of any country, territory, city or area, or concerning the determination of its frontiers or boundaries. This document has been financed bythe European Union and the Government of Spain. The views expressed herein can in no way be taken to reflect the official opinion of the European Union or the Government of Spain.

Preface

The CopeMed II Project on *Co-ordination to Support Fisheries Management in the Western and Central Mediterranean* is executed by the Food and Agriculture Organization of the United Nations (FAO) and funded by the Government of Spain, represented by the Secretaría General de Pesca (Mº de Agricultura, Pesca y Alimentación, MAPAMA), and the European Union, represented by the European Commission (EC).The premises of the project at the Subdelegación del Gobierno in Málaga (Spain) are part of the Spanish contribution included in the agreement with the FAO.

The objective of the project is to maintain the sustainability of the marine fisheries in the central and western Mediterranean Sea and its ecosystem, taking into consideration environmental, biological, economic, social and institutional issues. In addition, the project will continue to reinforce the collaboration among the participating countries of the sub-region by facilitating their participation in the activities of the Scientific Advisory Committee (SAC) and in the General Fisheries Commission for the Mediterranean (GFCM).

Regions covered by CopeMed II are the western and central sub-regions of the Mediterranean. Participating countries are Algeria, France, Italy, Libya, Malta, Morocco, Tunisia and Spain. The main beneficiaries are the fishery policy-makers, managers and fishery administrations in the western and central Mediterranean countries. The project is also contributing to the strengthening of regional collaboration by supporting the participation of the countries in relevant regional scientific organizations, such as the FAO's General Fisheries Commission for the Mediterranean (GFCM). Secondary beneficiaries include the national research institutes, fishers and fishers' associations, and industrial organizations.

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CopeMed II (GCP/INT/028/SPA – GCP/INT/006/EC) Publications

CopeMed II project publications are issued in the CopeMed Technical Documents series and are related to meetings, missions and research organized or conducted within the framework of the CopeMed II Project.

Comments on this document would be welcomed and should be sent to the Project premises:

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Preparation of this document

This document is the final version the Report of the Joint COPEMED II – GFCM data preparation meeting on Blackspot seabream *(Pagellusbogaraveo)* in the Strait of Gibraltar. Cádiz (Spain), 19-21 March 2019.

Acknowledgements

CopeMed II acknowledges the participation and valuable contributions of all experts from INRH (Morocco) and IEO (Spain) in the Report of the Joint COPEMED II – GFCM data preparation meeting on Blackspot seabream (*Pagellus bogaraveo*) in the Strait of Gibraltar Cádiz (Spain), 19-21 March 2019

ABSTRACT

In response to the requirement of the twentieth session of SAC and the forty-second session of the Commission to carry out benchmark assessment sessions for priority species in the Mediterranean and Black Sea, CopeMed II project in collaboration with GFCM organized this "data preparation meeting" to ensure all input data are adequately analysed and compiled in advance of the benchmark assessment. Historical data series on catches, effort and size distribution since1983 until 2018 were pulled together. The experts identified and discussed the historical trends providing possible reasons for the observed trajectories. The fleet of the two countries exhibit similar technical characteristics but cannot be considered a single fleet. The group concluded with the establishment of three different fleet segments operating over the same stock. CPUE indices were split in three according to this segmentation and GLM were used to standardize these indices for the purpose of assessing the status of the stock. Biological parameters such as growth, mortality and maturity were also discussed, and new values were obtained based on a recent biological sampling carried out in Morocco during the months of July 2018 to November 2019. These values can be considered preliminary and would be treated in comparison with older values obtained in the Spanish coast and other areas until a complete year of sampling is available.

Report of the Joint COPEMED II – GFCM data preparation meeting on Blackspot seabream (*Pagellus bogaraveo*) in the Strait of Gibraltar

Cádiz (Spain), 19-21 March 2019

INTRODUCTION

In response to the requirement of the twentieth session of SAC and the forty-second session of the Commission to carry out benchmark assessment sessions for priority species in the Mediterranean and Black Sea, CopeMed II project in collaboration with GFCM organized this "data preparation meeting" to ensure all input data are adequately analysed and compiled in advance. As a step towards the benchmark assessment, the data preparation meeting provided a forum to discuss and agree on all assumptions associated to input data, allowing the benchmark session itself to concentrate on running models, discussing assumptions related to the models and providing advice.

The meeting was kindly organized by the IEO at the University of Cádiz premises in Cádiz, Spain. The agenda was accepted as presented in Appendix I. The meeting was attended by experts from Morocco (INRH), Spain (IEO) and the CopeMed staff. The list of participants is in Appendix II.

1. OBJECTIVES OF THE MEETING

Ms Pilar Hernández, CopeMed II fishery expert welcomed the participants of the two institutions and introduced the objectives and expected results of the meeting. She introduced the background by stating that in response to the recommendation GFCM/2017/41/2 and the Pending proposal on the establishment of a minimum conservation reference size in the Mediterranean, CPCs are called to provide a mechanism for adequate monitoring of fisheries and catches so as to allow the SAC to establish the reference size and to assess the status of the stock by 2019, including a benchmark session at the SRC-WM.

She also recalled research recommendations emanating from previous meetings of the CopeMed Working groups on blackspot seabream (2010– 2018) and from the GFCM working groups on stock assessment on demersal species, being the most relevant actions:

- Standardize effort between countries
- Obtain a standardized index of CPUE
- Continue the current monitoring on landings and length frequency
- Start biological sampling in both countries (Morocco and Spain);
- Conduct a study on stock boundaries;
- Keep exploring analytical tools such as GADGET to assess the stock;
- Launch a survey to obtain a fishery-independent index;

She commented on the progress achieved in all points, and that the current meeting will serve to discuss and to agree up on relevant items for the application of stock assessment models during the upcoming benchmark session (1-4 April 2019).

The expected outputs for these three days ahead were defined as:

- Standardize CPUEs. Discussion on effort assumptions.
- Update databases on catch, effort and size distribution.
- Obtain growth parameters from the analysis of length distributions and from the new biological data collected recently by Morocco.
- Agree on a value or vector for Natural Mortality
- Obtain and compare Sex ratios and Maturity Ogives.

2. CPUE STANDARDIZATION

Experts presented the data prepared for these procedures as it had been agreed in the previous meeting of October. They discussed on the methods to be used and agreed that two methods were going to be applied: General Linear Models and, alternatively, if data so allows a test will be carried out also with Boost Regression Trees.

Before starting the process of standardization, by either the two models, two crucial questions needed to be discussed and were agreed upon.

1. Analyze differences between vessel characteristics and fishing methods between countries and gears to establish the number of "métiers" to be considered for CPUE standardization purposes, *i.e*, can the three groups of vessels operating in the area (Moroccan longliners, Moroccan small-scale vessels and Spanish handliners), be considered as one single fleet? or are there evidences to consider them as different operating fleet segments?
2. Define an effort unit to estimate nominal CPUEs taking into account that no explicit measure of nominal effort is available (*i.e*., number of hooks or fishing hours) and the decisions taken about point 1.

The group analyzed different measures of fishing power of the vessels and the gears which are summarized in the table 1. They represent fleet characteristics according to official data and experts' knowledge. In addition, differences between the two main fleets, Spanish and Moroccan "voraceras", are represented in Figure 1 according to some of these characteristics.

The gear used by Spain and Morocco is named "voracera" in both countries and is very similar but, with some minor differences, mainly on the size and on the way it is set. In Morocco, the gear is left from the vessel that can go and set another gear in the nearby area and then go back to recover one by one after some 2-3 hours. The Spanish gear is always attached to the vessel. They can throw three lines at the same time, then they remain on the site for a couple of hours and recover the three lines before moving to another area.

Spanish "voracera": a local mechanized hook line usually baited with sardine. Fishing is carried out taking advantage of the turnover of the tides in bottoms from 350 to 750 m. Every boat can use a maximum of 30 lines (three lines simultaneously up to 10 times per day). Each line has a maximum legal length of 120 m and can hold a maximum of 100 hooks (usually ±70). The legal dimensions of the hooks are a minimum length of 3.95 ± 0.39 cm and a minimum width of 1.4 ± 0.14 cm. Number of boats has decreased over the last years and its mean technical characteristics are: Length= 9.80 meters, GRT= 6.36 and HP= 47.23. The gear itself is composed of a main line ("arriaera") with about 2.000 meters length rolled into a hauling machine. The end of this line is engaged to one of the tips of the "voracera" line and to a plummet. Plummet choice (large or

small) depends on of the strength of the tides. If the tide coefficient is high, a large plummet is used so currents does not raise excessively the “voracera” line. On the opposite, if the tide coefficient is low, they use a small plummet trying to avoid that the hooks goes too close to the sea bottom. The “voracera” line (about 100-120 meters length) has several legs separated every ± 1.10 meters with a hook baited (usually) with sardine. The end tip of the “voracera” line is linked to a concrete stone (about 15 k weight), which carry the whole fishing gear to the bottom. The stone at one tip and the plummet at the other tip maintains the “voracera” line fully extended parallell to the sea bottom. To raise the “voracera” at the end of the fishing operation, the link with the stone breaks and the line is released to be raised.

Spanish “voracera” fishery takes place during the daylight, taking advantage of the turnover of the tides (commonly in the change from low to high tide). So, every fishing trip a variable number of “voraceras” could be deployed, depending on the tides, weather conditions, number of hauling machines (maximum of 3 per boat). The skipper asks to recover the gear when he guess, by “listening” to the fish, that there are fishes hooked to the “voracera”. Hauling/recovering time of a “voracera” line rarely exceed half an hour.

Moroccan “voracera”: The blackspot seabream fishery is carried out at 150-700 m depth during the daylight. The gears used in Morocco also consists on the ‘‘voracera’’ also named locally “voracera” that is used both by the longliners and artisanal fleet. This longline is attached by buoys that ensure its flotation and does not remain tied to the boat as the Spanish handlines.

The longliners are based at the port of Tanger and the artisanal fleet along the Strait of Gibraltar. In the past years, the number of longliners was more or less stable (78 to 101 vessels) with an increasing trend for artisanal fleet since 2008. The number of longliners in 2018 was approximately 73 and 45 artisanal boats. The hook category targeting the blackspot seabream is between N°8 and N°12 and it is baited usually with sardine. The artificial bait is less common.

The mean technical characteristics of the longliners are: Length= 14 meters, GRT= 23 and HP= 181 with depth range 200-700 m. Each vessel can use a maximum of 20 lines up to 2 times per day depending on weather conditions. Each line has a length of 150-200 m and can hold a maximum of 50 hooks per line (one hook every 3-4 meters). Each vessel can hold a total between 200 and 2000 hooks.

The Moroccan artisanal fleet operate at depth range between 150 and 300 m. The technical characteristics of this fleet are: Length= 4-6 meters, GRT < 2 and HP= 15. Each vessel usually uses 15 lines targeting the blackspot seabream (with a minimum of 4 lines and maximum of 25 lines), each line has a length of 150-200 m. The fishermen may target other species (*Pagrus pagrus, Pagrus caeruleostictus, Thunnus thynnus)* using other types of longlines at the same trip. The main characteristics of the three groups of vessels to be considered three fleets are presented in table 1.

The second question about the unit of effort was the object of discussion by the group. They all agreed that ideal unit would be the number of hooks, but unfortunately, due to the particular features of this fishery and that this information is not requested in the current data obligations, (nor logbook, neither sales sheets) another nominal unit should be defined. As the fishing trips are mainly of one day of duration, the number of vessels operating each day is a measure of the activity of the fleets representing a global quantity of effort for each fleet each day, but not an individual daily vessel effort unit. Exploratory analysis of number of vessels per day were done but due to differences in

the number of observations between Moroccan and Spanish fleets, this measure of effort does not provide standardized indices with a balanced representation of both fleets at day basis. Hence, a second approach was conducted to solve the problem of the lack of nominal effort. For monthly aggregated data, CPUE was defined as:

$$CPUE_{m,v} = \frac{C_{m,v}}{Fishing\_days_{v,m}}$$

where *m* is the month. At month level, the number of fishing days is equivalent to the number of fishing trips and is calculated as the sum of fishing trips per month for each vessel. This approach provides a new data set for standardization with information at month basis much more balanced regarding the number of observations of both fleets.

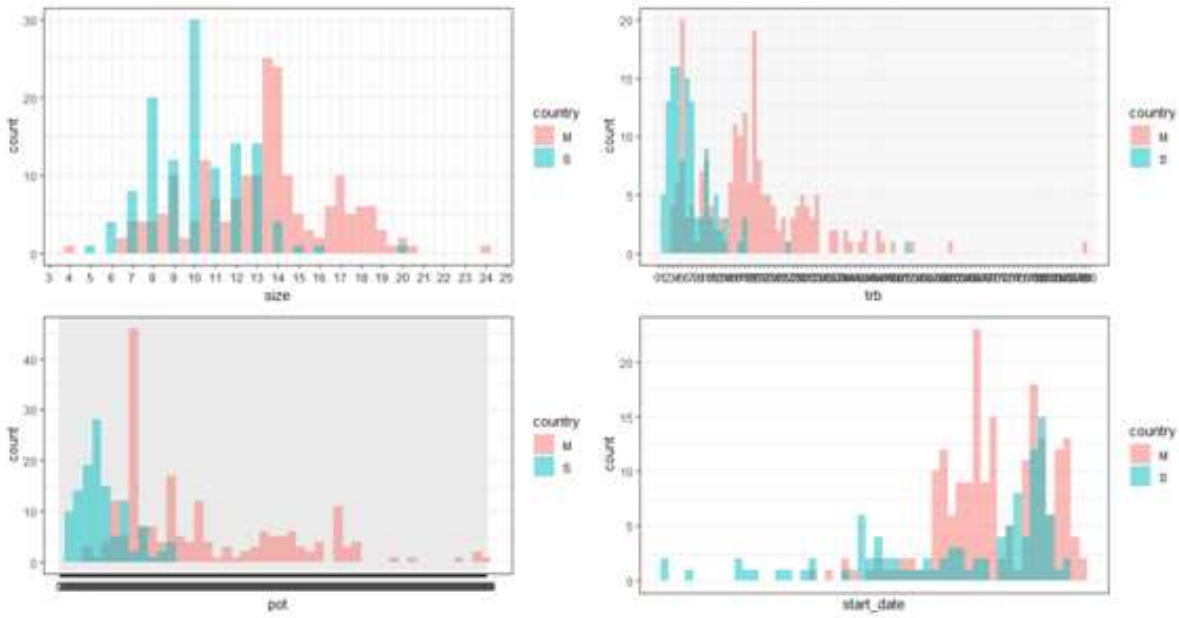

Figure 1. Plots of the two fleets according to four technical characteristics: from top-left to bottom-right: LOA, GRT, HP and year of construction.

As the time during the three days meeting was limited, the group decided to charge the experts on standardization to do some trials with the different units discussed, during the coming days after the meeting and it was agreed that a final discussion on the best index of CPUE will be held during the benchmark on the 1-4 April 2019 in Sète. Preliminary tests are presented in Appendix III.

Table 1 Main vessels characteristics.

Country/ Fleet	N. boats 2017	LOA (average)	GRT (average)	HP (average)	Depth range	Number of lines per day per boat	Dimension of lines (m)	Number of hooks per line	Number of hooks per boat	Dimension of hooks	Target species P. bogaraveo	Number of fishing hours (Average)
Moroccan longlines	94	14	23	181	200-700	40	150-200	50 hooks per line, (1 hook every 4 meters)	80-500 hooks per vessel	n.8-11	2	to be investigated
Moroccan artisanal	145	4-6	<2T	15	150-300	15	150-200	150-200 (1 hook per meter)	to be investigated	n.9,11,12	2	7
Spanish handline fleet	50	9,8	6,36	47,23	350-700	30	120 max legal	120 (1 hook per meter)	to be investigated	3,95+-0,39, large 1,4+-0,14	1	to be investigated

3. TRENDS IN CATCHES AND EFFORT IN THE TWO COUNTRIES

The group discussed about the trends in catches and effort in the last 10 years looking at the figures 1 and 2. Catches have been decreasing in general terms since 2009.

In Morocco there was a slight increase in catches due to the increase in effort after the ban of the driftnets in 2012. But the values registered during the last three years are not very positive for the fishery. Spanish vessels were registering less and less catches and consequently their effort was derived to other species that they may find more profitable with less risk under bad weather conditions, as the fishing grounds of blackspot seabream is far from the Spanish coast. The confirmed recovery of blue fin tuna populations may have contributed to this possible change of fishing strategy. Moroccan and Spanish fleets are always operating in the same fishing grounds, in the last year, the Moroccan fleet is following a similar trend than the Spanish one.

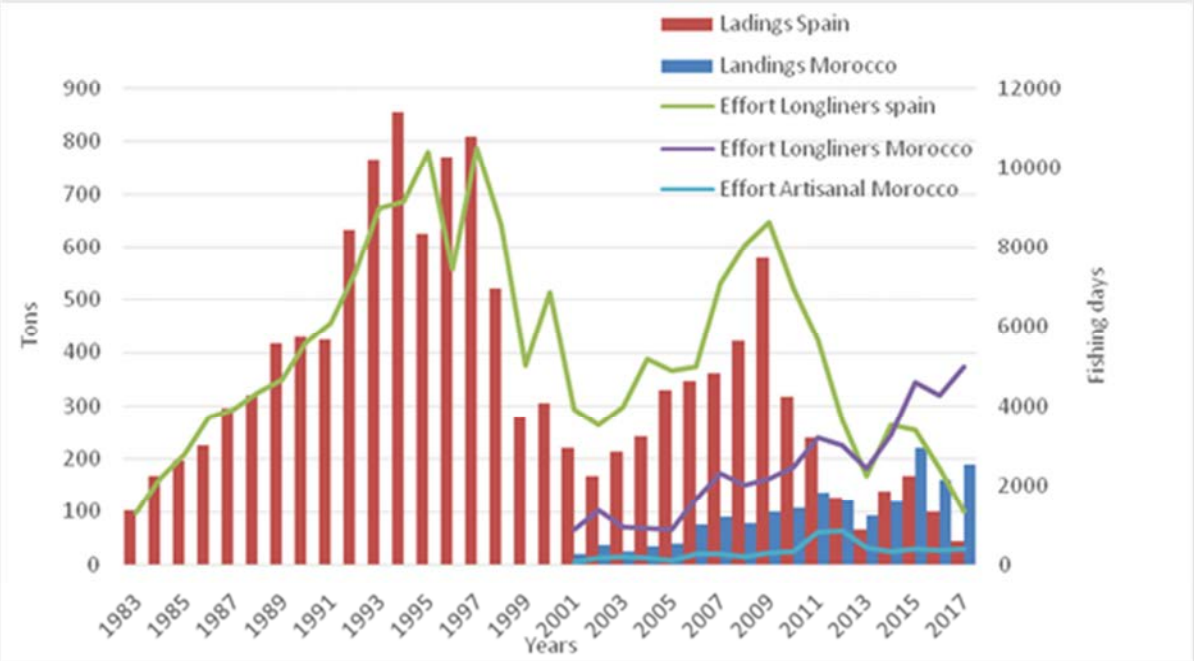

Figure 2. Landings and effort in Spain and Morocco (1983-2017)

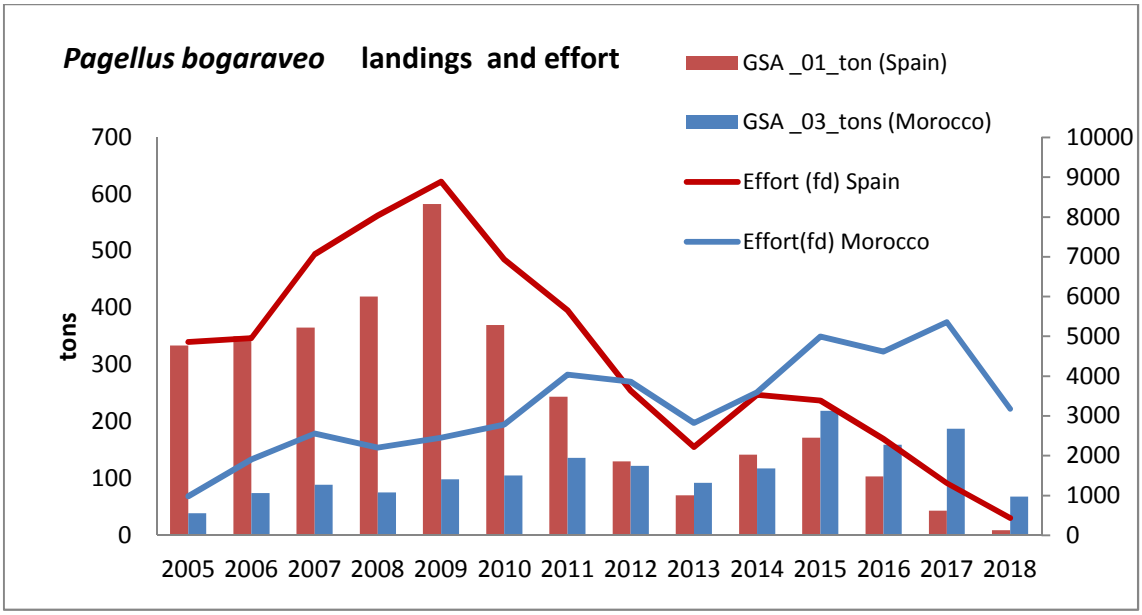

Figure 3. Landings and effort in Spain and Morocco (2005-2018)

4. LENGTH COMPOSITION OF CATCHES AND GROWTH PARAMETERS.

The length composition of catches was available from Spain (1997-2018) and from Morocco (2005-2018). As otoliths readings to produce and age-length key were only available from Spain back in 2006, the group decided to use two different methods to estimate L∞, K and t0based only in length distributions: FISAT and LFDA.

Using these estimated growth curves, further analysis allows estimation of total mortality rates from a length converted catch curve and two other methods, and estimation of age frequency distributions based on "age slicing".

Table 2. Values of growth parameters estimated form length frequencies and old values from previous studies

	FISAT	**LFDA**	**Old (from maximum length in catches, and from mark-recapture experiments).**
L∞	66,78	72,6	62
K	0,44	0,51	0.14
t_0	-0,59	-0,25	-0.34

The values obtained with the two methods were assessed as too high compared with old data and also in comparison with values form other areas and years presented in table 3.

Table 3. References from other areas and years.

Reference	**Area**	**Sex**	**L ∞**	**K (y^{-1})**	**t_0**
Orsi-Relini& Fida, 1992	Ligurian Sea	M+H	52	0.18	0.16
Papaconstantinou*et al.* 1994	Greece	M+H	25.1	0.19	-2.72
Krug *et al.*, 1998	Azores	M+H	54.9	0.127	-1.83

Krug, 1989	Azores	M+H	57.45	0.102	-1.13
Krug & Marques, 1988	Azores	M+H			
Sobrino & Gil, 2001a	Gibraltar Strait	M+H	58.00	0.169	-0.67
Sánchez, 1983	Cantabric Sea	M+H	51.56	0.209	-0.53
Coull*et al.*, 1989	Shetlands	M+H	45.9	0.21	-0.53

A decision could not be taken given the strong differences observed, but all existing data were put at disposal of experts to attempt other methods during the benchmark assessment.

Parameters for the length-weight relationship were also obtained (Table 4)

Table 4 Parameters a and b from the length/weight relationship and natural Mortality, estimated and previous studies.

References	**Area**	**Sex**	**a**	**b**	**M**
Present work	Morocco biological sampling (2018-19)	**M+F**	0,0133	3,017	
Previous IEO	Spanish biological sampling (2003-2015)	**M+F**	0,0087	3,14	0.2
MEDITS ES, 1997	Spain	**M**	0.02335	2.821	
MEDITS ES, 1997	Spain	**F**	0.01942	2.890	
MEDITS ES, 1997	Spain	**M+F**	0.01466	2.959	
Krug, 1989	Azores	**M+F**	0.0124	3.137	
Sánchez, 1983	Cantábrico	**M+F**	0.011	3.079	
Coull*et al.*, 1989	Shetlands	**M+F**	0.0078	3.212	
Krug & Marques, 1988	Azores	**M+F**			0.3

The natural mortality M was estimated by using the equation of Taylor (1960):

$$M = \frac{2.996\,K}{(2.996 + (Kt_0))}$$

And Alagaraja method (1984): M = -Ln(0.01)/Tm

Tm = longevity.

5. SEX RATIO AND MATURITY STAGES

The experts presented the results of last analysis performed on the biology of the species. In particular in Morocco an intensive eight-months sampling period supported by CopeMed II has allowed the country to obtain monthly data on length, sex, maturity stage, sex ratios, weight, IGS and otoliths extraction. The work is ongoing to fulfill a complete annual cycle.

On the Spanish side, unfortunately, biological sampling has not taken place in the last three years, but data are available since 2003-2015 which were presented and discussed by the group. Summary graphs are included in Appendix IV.

Discussion on the way each maturity stage is named and how they are organized in the database were held. Hermaphrodites has to be assigned a functional sex if one of the gonads is more developed than the other one. Once all data have been standardized to this nomenclature, sex ratio has been obtained for the 8 months sampled in Morocco and the average of previous year in Spain during the same 8 months period.

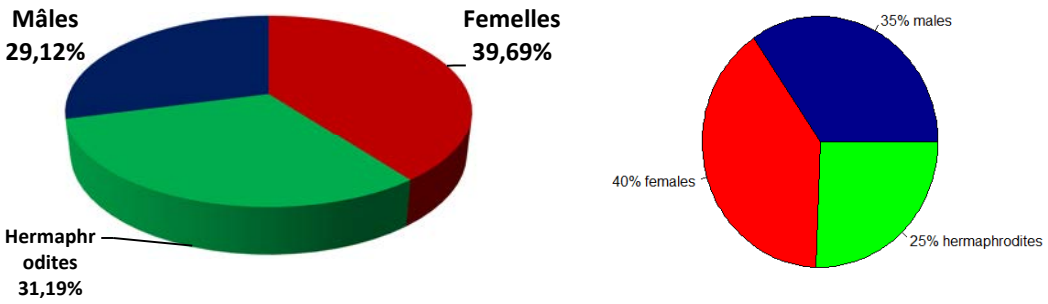

Figure 4. Proportion of the three sexual states in Morocco (left) and Spain (right) during the months July-February.

The difference is relevant only in the proportion of hermaphrodites. This can be explained because the data in the Spanish graph is an average of 12 years (2003-2015), whilst in Morocco they come from a single 8 months period (July 2018-february 2019). This last year, a remarkable decrease in mean length of catches has been detected. This effect is shown in figure 5. These minor average lengths may have an effect on the higher proportion of hermaphrodites. To confirm this difference, a similar historical series should be needed in both countries.

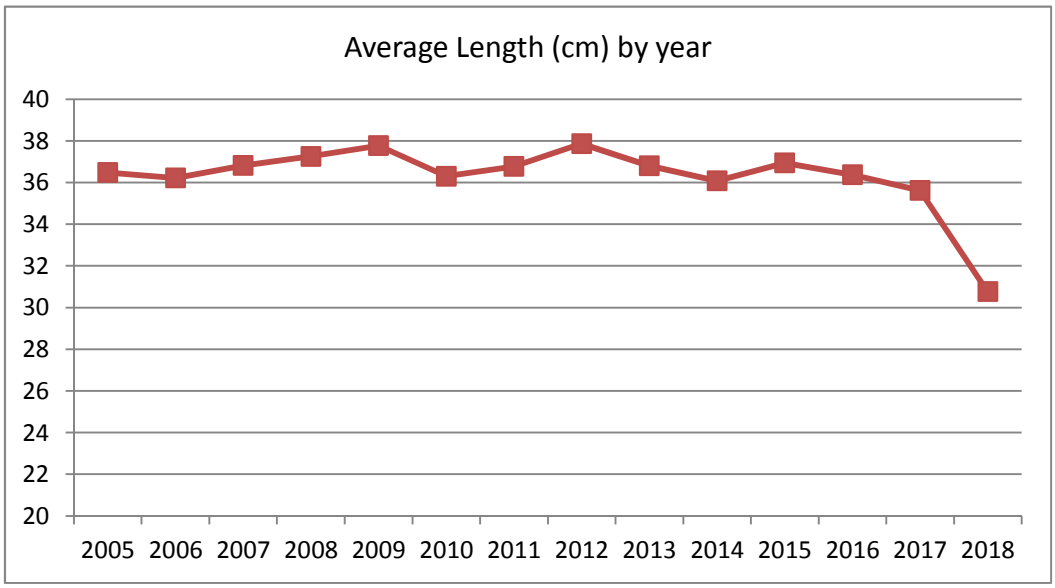

Figure 5. Mean length in landings for the two countries pooled together in 2005-2018.

In addition, **average size of sex inversion** has been obtained by analyzing the Spanish data on 12 years (not consecutive, since there are some wholes between 2003 and 2015). This analysis is reproduced in Appendix V.

The value obtained for sexual inversion from males to females is 34,6 cm (0,9 sd)

Length at maturity

Previous studies in the Spanish side had obtained $\mathbf{L_{50}}$ values of **30 cm for males and 35 for females**. The new biological data collected in Morocco in 2018-19 has been used to estimate new values: **30,97 cm for males and 31,74 for females.** These values need to be taken with caution as the sampling period (July to February) does not cover the spawning period of the species which is considered to be in February-March.

The maturity ogive and values obtained are presented in Appendix VI.

6. CONCLUSIONS

The group adopted the main conclusions drawn from the discussions as follows:

- The fleets and gears have been characterized in both countries with remarkable differences in number of boats, size, and power found. Furthermore, in Morocco the gear is set in the sea, while in Spain is always attached to the boat.
- The biological data are available in Morocco in 2018-19. The INRH is planning to start otoliths reading in 2019.
- With the existing data on length frequencies attempts were made to obtain growth parameters but the values are very different from the previous available estimates. The group decided to double-check the data and methods with the collaboration of some other expert in the field before concluding the growth analysis.
- The catches and CPUES have observed a strong decline from 2017 to 2018, followed by a drop in the mean length.
- Length at first maturity estimated from Moroccan data cannot be used until a full year, sampling covering the reproductive period (February-March) will be completed. Up to now, the values obtained from old data in Spain can be considered i.e.: 30 cm for males and 35 for females.
- A size for sexual inversion has been obtained from historical Spanish data 34,6 cm (0,9 sd).
- The standardization of CPUEs is still in progress as the data needed for the standardization was not made available in time for the meeting.
- The compilation of data to re-run the models has been completed and will be made available to the benchmark.

Appendix I

Joint COPEMED II – GFCM data preparation meeting
Blackspot seabream *(Pagellusbogaraveo*) in the Strait of Gibraltar
Cádiz (Spain), 19-21 March 2019
AGENDA

19 – 21 MARCH 2019
Morning Session, 9:00-13:00
Afternoon Session, 14:30-17:30

1. Opening and arrangements of the meeting

COPEMED II and the GFCM Secretariat will very briefly introduce the session's background, objectives and expected outcomes, taking into account the outcomes of the COPEMED II data preparation meeting held in October 2018

2. Scope

In response to the requirement of the twentieth SAC and the forty-second session of the Commission to carry out benchmark assessment sessions for priority species in the Mediterranean and Black Sea, there is a need to ensure all input data are adequately analysed and compiled in advance. This data preparation meeting, organized jointly by COPEMED II and the GFCM, will therefore be an integrated part of the benchmark session providing the forum to discuss and agree on all assumptions associated to input data, allowing the benchmark session itself to concentrate on running models, discussing assumptions related to the models and providing advice.

3. Preparation of stock assessment input data

3.1 CPUE standardization

The work carried out within the COPEMED II data preparation meeting held in October 2018 will be continued towards producing standardized time series of CPUE, taking advantage of the expertise of Ms Maria Soto. Obtaining this ambitious goal will be heavily reliant on all data regarding explanatory variables for the standardization being available for both Moroccan and Spanish fleets. Assumptions on effort will be discussed.

3.2 Length composition of catches

New biological data collected recently by Morocco will be presented and analysed towards determining the growth parameters. These data will be compared with recent and historical length composition of Spanish catches towards agreeing on set(s) of growth parameters to be used in the benchmark assessment.

3.3 Natural mortality

Agreement will be reached on the natural mortality assumptions to be made in the benchmark session

3.4 Sex and maturity

Agreement will be reached on the assumptions to be made regarding sex and maturity in light of the extra complications presented by the hermaphroditism of the species.

4. Conclusions and collation of data

The agreed assumptions will be detailed and data collated in preparation for the benchmark.

Appendix II

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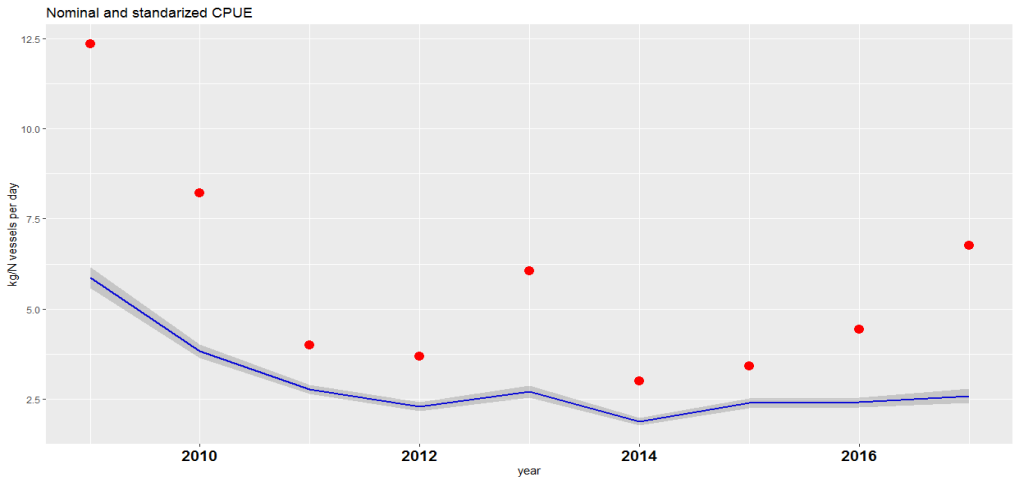
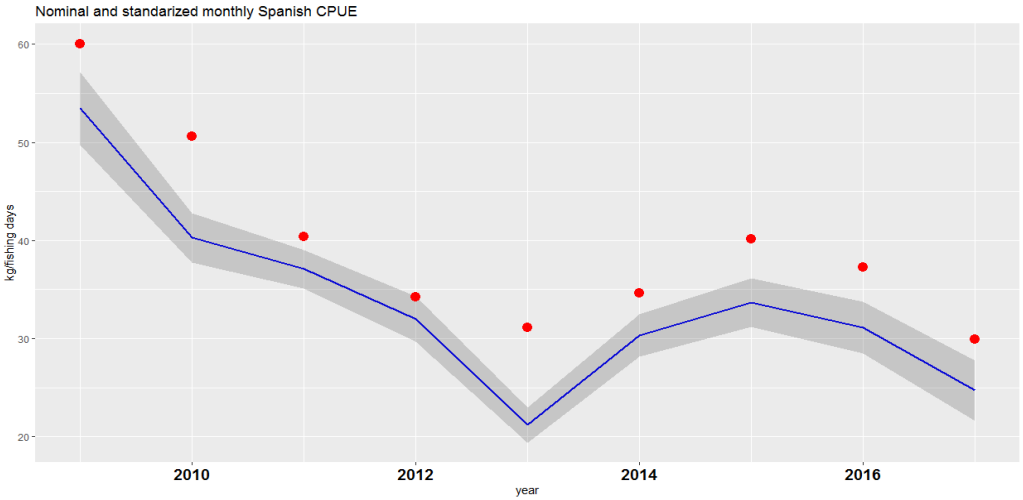
Preliminary test for standardization of CPUEs by Generalized Linear Model (GLM) . **Appendix III**



Nominal (points) and standardized CPUE (line) with confidence intervals of lognormal model GLM for both countries daily (top) and for Spain, monthly (bottom)



Preliminary test for standardization of CPUEs by Boosted Regression Trees (BRT)

Data source

The catch data by fishing vessel and by daily sales of each species landed were used to estimate the fishing effort (number of days at sea). First, the commercial data (ONP) of longliners by their corresponding port were compiled with catches by species (in kg), registration numbers, and date of landing for the period 2009 to 2018. The daily sales of each species for one trip were added together by vessel and by port. Then, the data matrix was built with daily sales, registration number, port, date and catch per species as variables. According to the survey conducted in each port, generally a sale of the catch landed by one vessel corresponds to one trip.

Selecting of explanatory variables and trips for the standardization of CPUEs

Analysis of Moroccan fleet dynamic and identification of fishing tactics is particularly important for standardizing CPUE. This approach helps to select a sample of the fleet to be used for CPUE standardization and to remove all fishing trips that are directed to other species. Given that fishing tactics can be described by a combination of many characteristics variables, the approach is to extract all fishing trips that contributed to the constitution of each fishing tactics and use its significant characteristics variables as explanatory variables in the model to standardized CPUE. This approach allowed us to select the following explanatory variables to construct a full model: species, year, power, trb, month and length. Species, power and trb and and length were log(x+1) transformed for use in the final statistical model using Boosted Regression Trees (BRT).

Statistical Models

Final statistical model

Fishing tactics: **Blackspot seabream**

Data points: 36886

Response Variable: LN(Blackspot seabream+1)

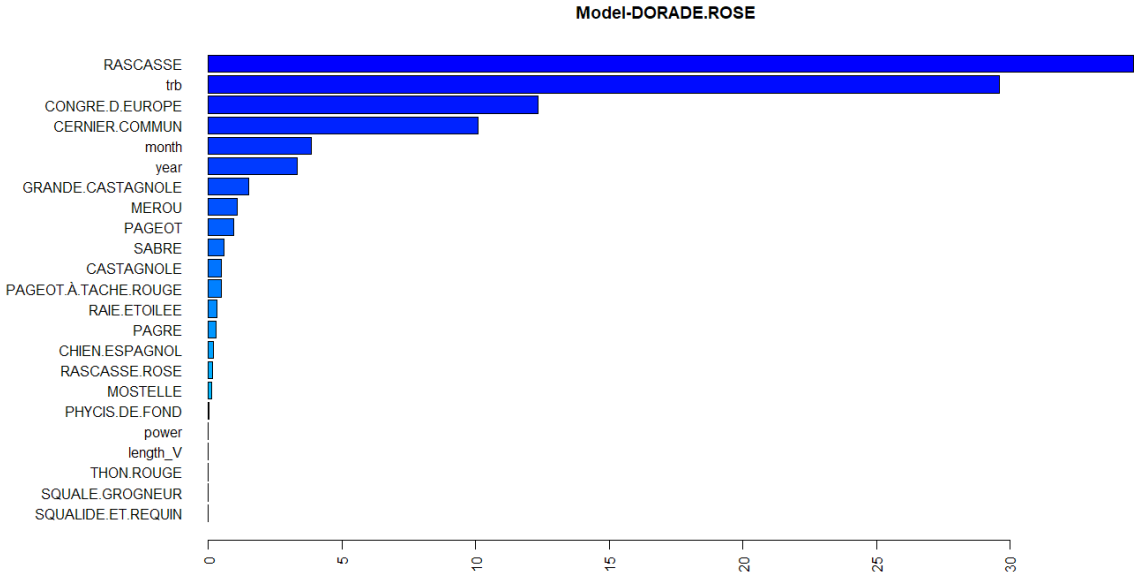
Explanatory variables:

year+month+LN(length_V+1)+LN(trb+1)+LN(power+1)+LN(RASCASSE+1)+LN(SABRE+1)+LN(CONGRE.D.EUROPE+1)+LN(CERNIER.COMMUN+1)+LN(MEROU+1)+LN(CASTAGNOLE+1)+LN(MOSTELLE+1)+LN(CHIEN.ESPAGNOL+1)+LN(PHYCIS.DE.FOND+1)+LN(THON.ROUGE+1)+LN(PAGEOT.À.TACHE.ROUGE+1)+LN(SQUALE.GROGNEUR+1)+LN(GRANDE.CASTAGNOLE+1)+LN(RAIE.ETOILEE+1)+LN(RASCASSE.ROSE+1)+LN(SQUALIDE.ET.REQUIN+1)+LN(PAGEOT+1)+LN(PAGRE+1)+LN(RAIE+1)+LN(SQUALIDE+1)

Brief model summary statistics: Model 1-Blackspot seabream-tc2-BRT-Two-way Interactions

Model-DORADE.ROSE	fitting final gbm model with a fixed number of 1150 trees for DORADE.ROSE
	mean total deviance = 1.767
	mean residual deviance = 0.839
	estimated cv deviance = 1.163 ; se = 0.022
	training data correlation = 0.73
	cv correlation = 0.588 ; se = 0.009
Percentage of explained deviance	**53%**
RMSE	1.035553

Model-Blackspot seabream-tc2-BRT-Two-way Interaction : Relative influence of model terms calculated by the contribution of each term in reducing overall model deviance.

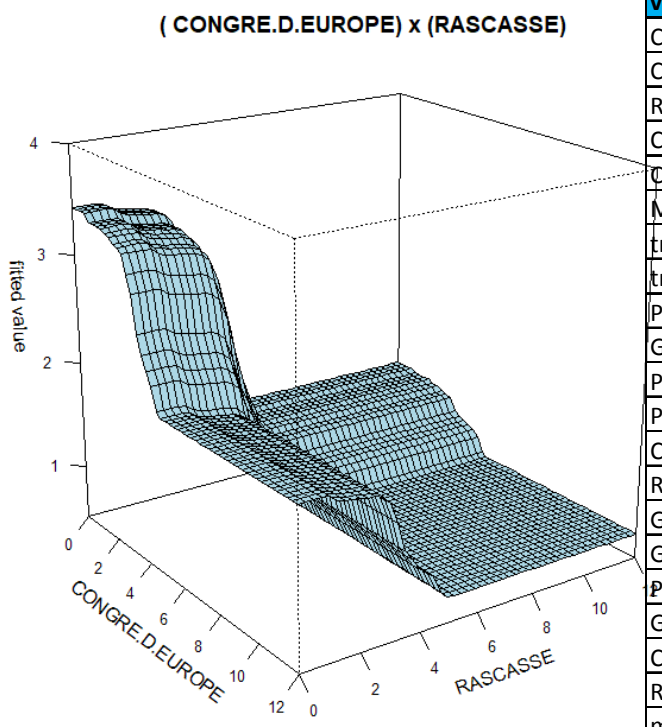


var	rel.inf
RASCASSE	34.61305176
trb	29.61422377
CONGRE.D.EUROPE	12.32346234
CERNIER.COMMUN	10.09187186
month	3.862690068
year	3.338540448
GRANDE.CASTAGNOLE	1.500298381
MEROU	1.072978453
PAGEOT	0.938875446
SABRE	0.587108042
CASTAGNOLE	0.489344075
PAGEOT.À.TACHE.ROUGE	0.481884638
RAIE.ETOILEE	0.304113317
PAGRE	0.283198749
CHIEN.ESPAGNOL	0.196239667
RASCASSE.ROSE	0.149333435
MOSTELLE	0.12984912
PHYCIS.DE.FOND	0.020249191
power	0.002687234
length_V	0
THON.ROUGE	0
SQUALE.GROGNEUR	0
SQUALIDE.ET.REQUIN	0

The interaction analysis of the explanatory variables shows that there is interaction between pairs of factors in model fitting: (conger Europe, rascasse), (cernier commun, rascasse), (rascasse, trb), (cornier commun, trb), (conger Europe, trb) and (merou, trb)

These changes in patterns and interaction analysis indicates that further research and analysis are necessarily to understand the contribution of each explanatory variables. (see the slide below)

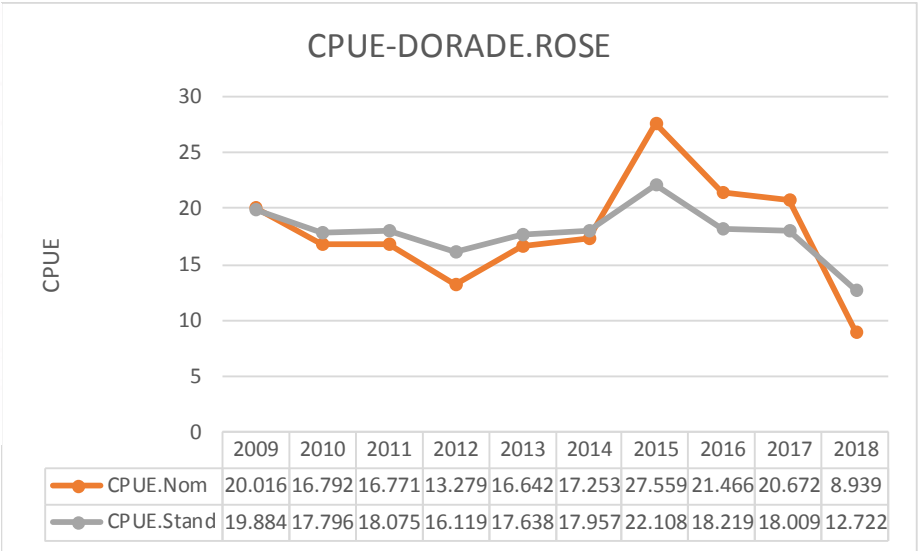
Blackspot seabream-tc2-BRT-Two-way Interaction: Ranked interaction sizes of the most important pair-wise interactions using global data



variable1	variable2	Interaction.size
CONGRE.D.EUROPE	RASCASSE	38.72
CERNIER.COMMUN	RASCASSE	10.93
RASCASSE	trb	10.75
CERNIER.COMMUN	trb	9.39
CONGRE.D.EUROPE	trb	6.27
MEROU	trb	5.47
trb	month	3.38
trb	year	1.13
PAGEOT.À.TACHE.ROUGE	trb	1
GRANDE.CASTAGNOLE	RASCASSE	0.55
PAGEOT	CASTAGNOLE	0.16
PAGEOT	MEROU	0.15
CASTAGNOLE	SABRE	0.12
RAIE.ETOILEE	trb	0.11
GRANDE.CASTAGNOLE	year	0.1
GRANDE.CASTAGNOLE	trb	0.09
PAGEOT	trb	0.06
GRANDE.CASTAGNOLE	CERNIER.COMMUN	0.05
CASTAGNOLE	trb	0.05
RASCASSE.ROSE	trb	0.04
month	year	0.04
PAGEOT	PAGEOT.À.TACHE.ROUGE	0.02
PAGEOT	RASCASSE	0.02
PAGEOT.À.TACHE.ROUGE	CASTAGNOLE	0.02
MEROU	year	0.02
RASCASSE	year	0.02

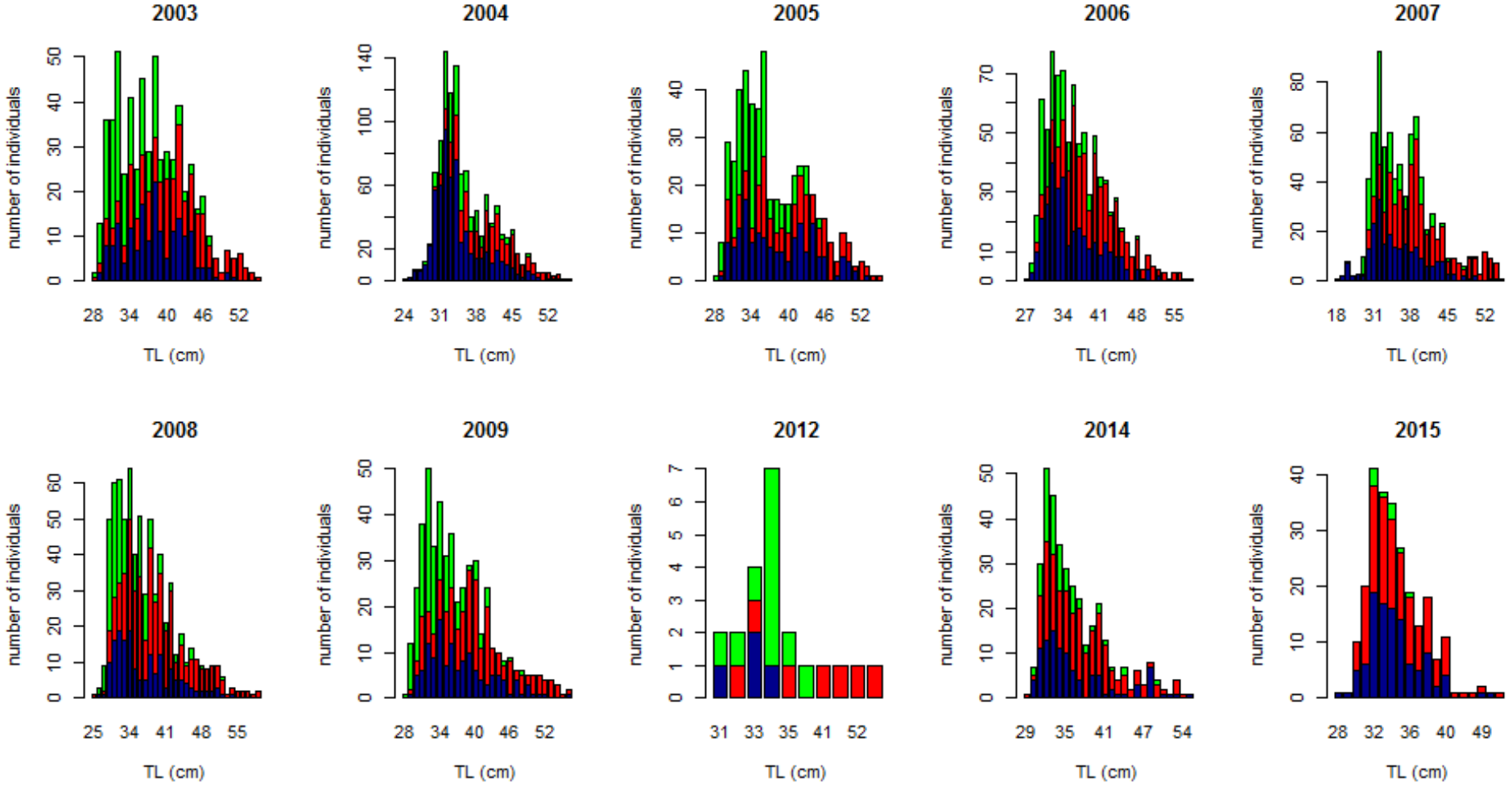
Comparisons of the standardized and nominal index of Blackspot seabream

year.effect	CPUE.Nom	CPUE.Stand
2009	20	20
2010	17	18
2011	17	18
2012	13	16
2013	17	18
2014	17	18
2015	28	22
2016	21	18
2017	21	18
2018	9	13

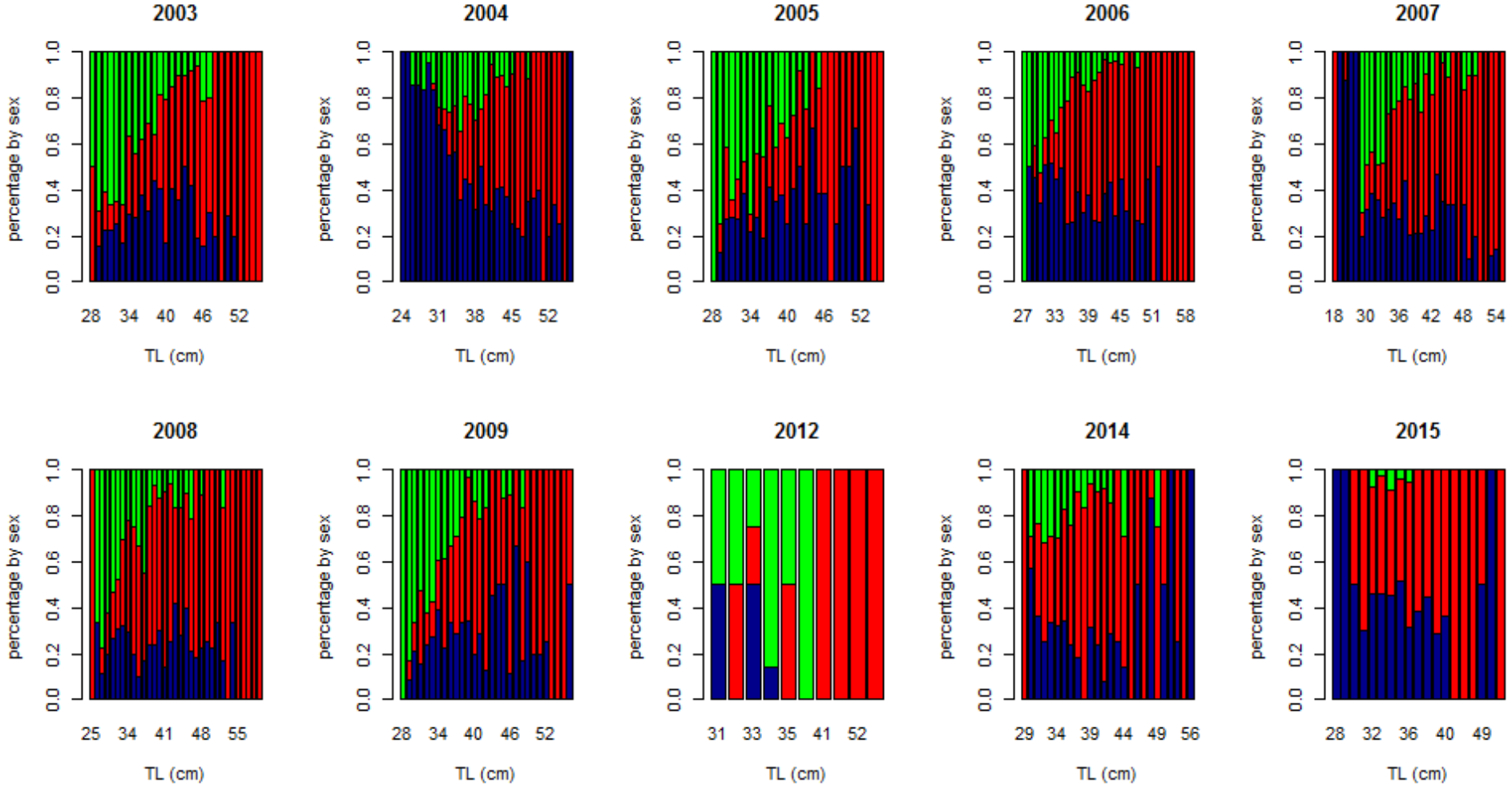


Appendix IV

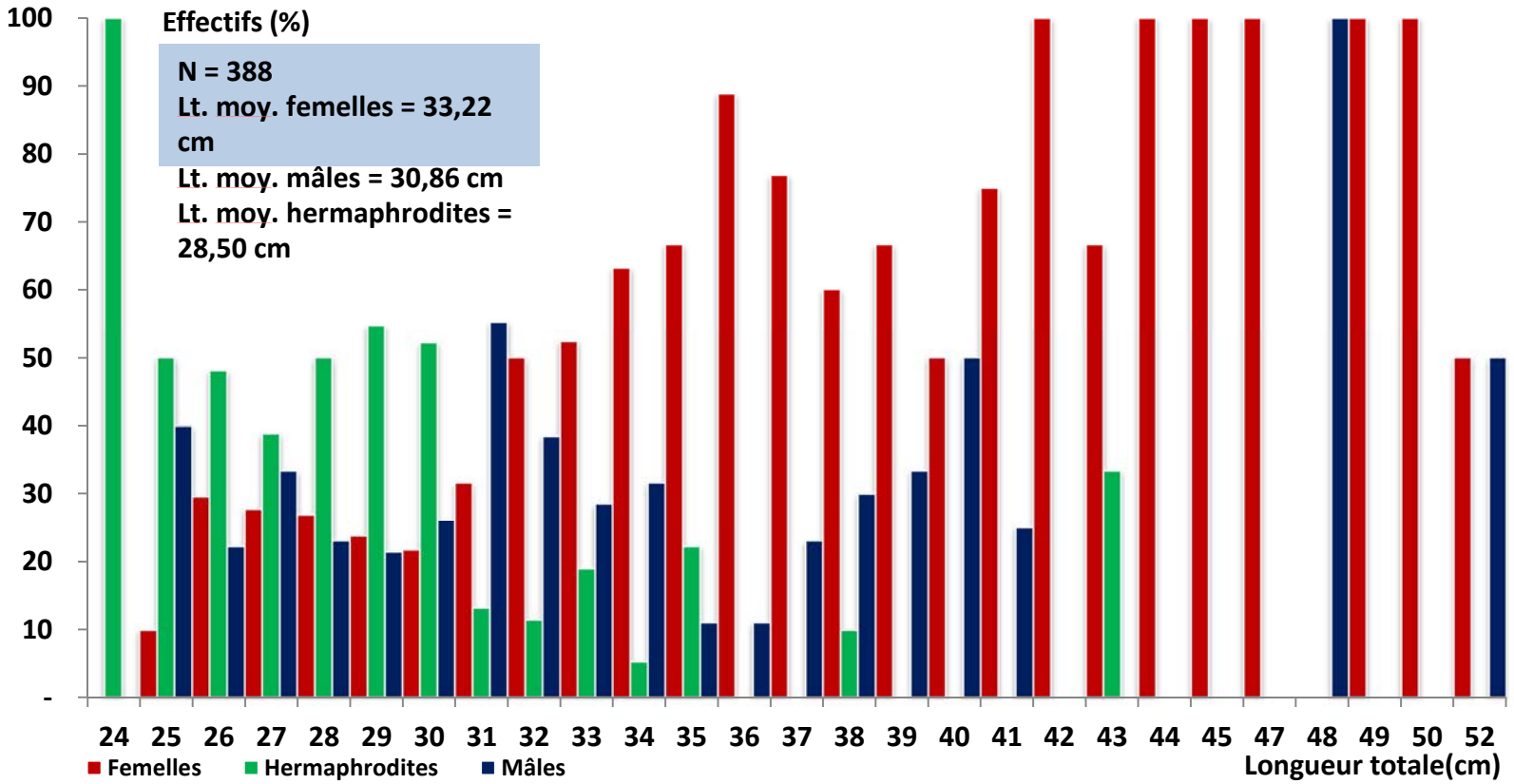
Number of individuals (counts) by sex and TL Per year (Spain)
Blue (1): male; Red (2): female; green (3): hermaphrodite



Percentage by sex and TLPer year (Spain)
Blue (1): male; Red (2): female; green (3): hermaphrodite



Number of individuals (counts) by sex and TL. MOROCCO
July 2018 to February 2019 (Out of spawning season)
Blue (1): male; Red (2): female; green (3): hermaphrodite



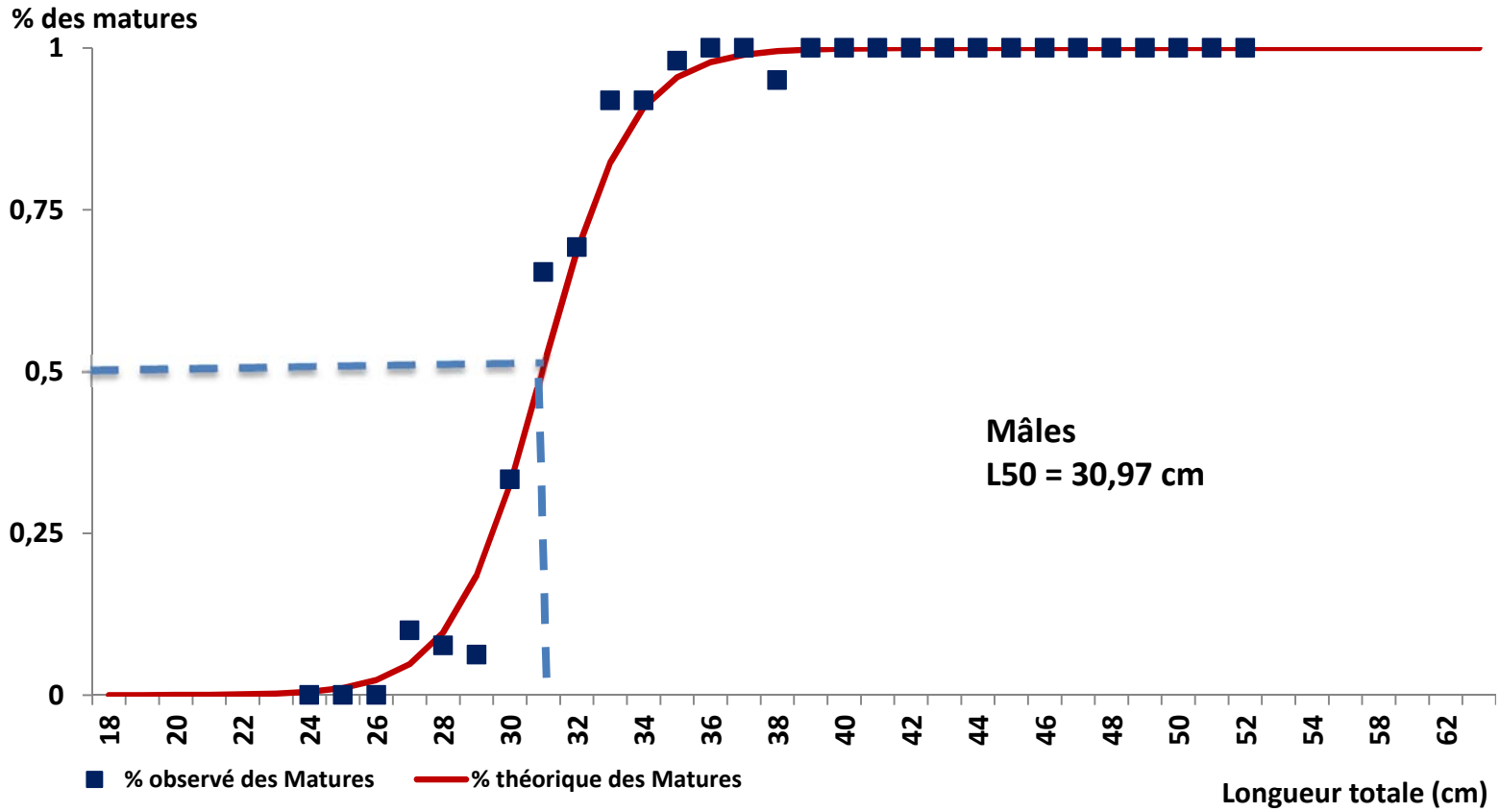
Appendix V

Length at sexual inversion
Estimated as the median of the Total length range (Spain data)

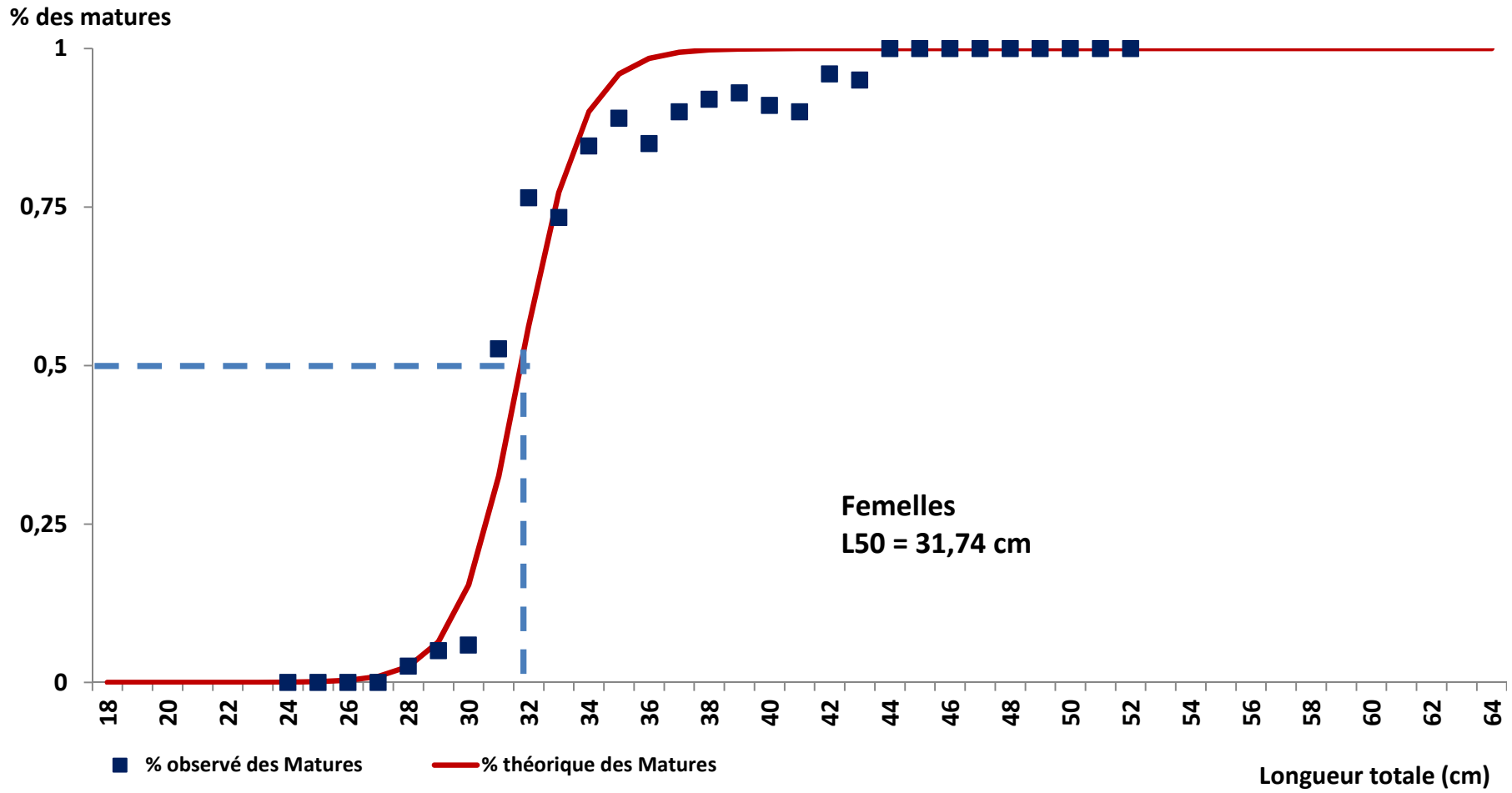
year	number of samples	length sexual inversion (mm) specific range per year	TL range_chosen per_year	length sexual inversion (mm) range 290-400 for all years	percentage of data with TL between 290 and 400
2003	391	390	290 -510	360	0,55
2004	930	350	300-540	332	0,7
2005	310	389,5	290-530	349	0,53
2006	678	368	290-520	346	0,67
2007	584	376	290-540	349	0,68
2008	509	375	290-540	346	0,65
2009	325	385	290-560	357	0,65
2012	11				
2014	285	353	300-520	340	0,76
2015	238	340	300-490	336	0,93
		Mean= 369,61		Mean= 346,11	
		SD= 18,23		SD= 9,13	

Appendix VI

Maturity Ogive for males.
Data from July 2018- February 2019 Morocco



Maturity Ogive for females.
Data from July 2018- February 2019 Morocco



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