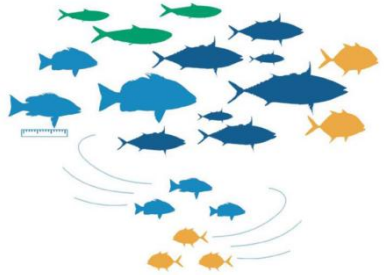
Stock identification: advancing in the knowledge of stock structure as a requirement for stock assessment





3-5 April 2023 | Abuja, Nigeria

Eva García-Isarch, Montse Pérez, Blanca Partida *et al*.

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Jorge Landa, Ivone Czerwinski, Carolina Acosta, Eli Muñoz, Carolina Johnstone, Javier Rey, Eva M. Hernández, Alba Jurado-Ruzafa, José F. González, Adriana Pérez, Pilar Rioja, Álvaro Pita, Jenifer Ramón, Gemma Rico, Iria Seijas

Beyah Meissa, Beyih Mohamed, Sid'Ahmed Khattry, Omar Bocar Mbodj, Wagne Amadou Ciré

Modou Thiaw, Aboubacar Gueye, Dame Ndiaye, Séga Ndao, Idrissa Cissokho, Papa Samba Sow

Momodou S. Jallow, Momodou Sidibeh, Peter K. Mendy, Mam Jarra Jarju

Assana Camara, Neidimar dos Santos, Iça Barri

Ibrahima Diallo, Ousmane II Camara, Diafodé Traore, Mamadou Sadjo Diallo

Ernest Ansong, Julius Afetorgbor, Patrick Tawiah, Ato Ekuban

Coulibaly Bakari, Joanny Tapé, N'gotta Bi Ramsès

Jerome Guitton

STRUCTURE OF THE PRESENTATION

1. Introduction
2. Methods
3. Life history traits: data analysis and preliminary results
4. Morphometry: data analysis and preliminary results
5. Genetics: data analysis and preliminary results
6. Conclusions

1- INTRODUCTION

1- INTRODUCTION

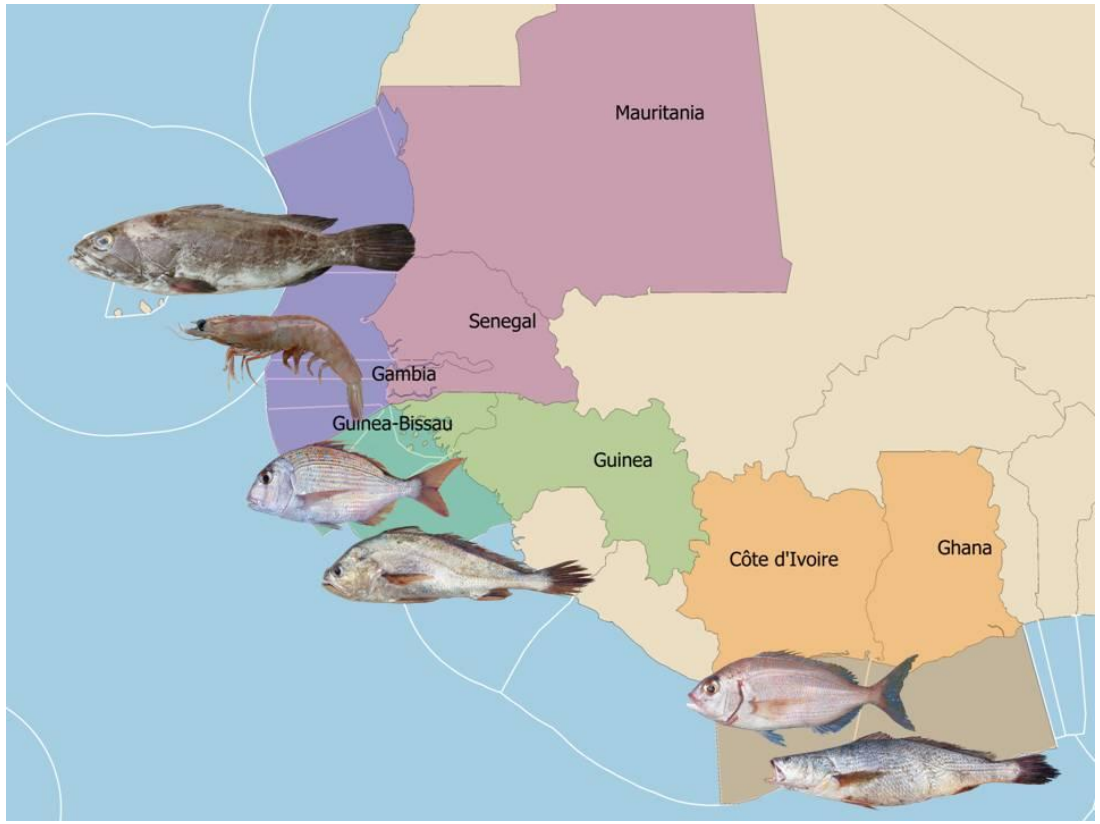
DEMERSTEM- Objectives of WP 1:

- Improve the knowledge on the selected demersal stocks with a particular effort to solve the problems of stock identification and improvement of the quality of the data used for the assessment.
- This follows the recommendations regularly made by CECAF.

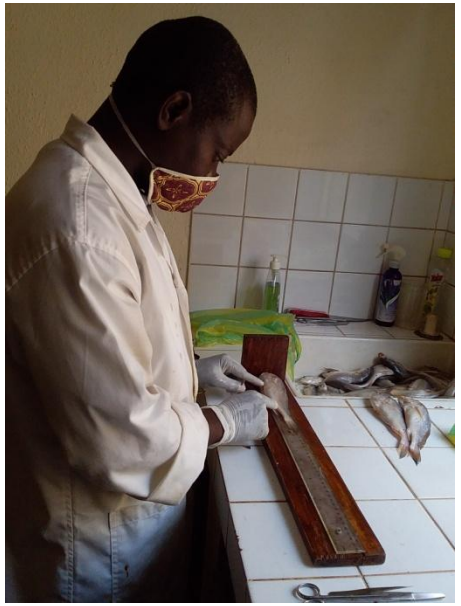
STOCK IDENTIFICATION

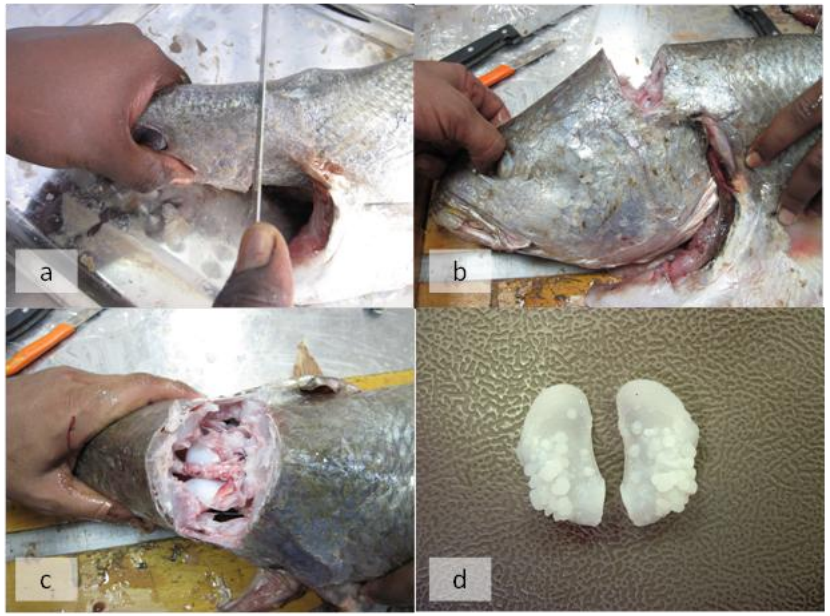
The selected stocks match one or more of the following criteria:

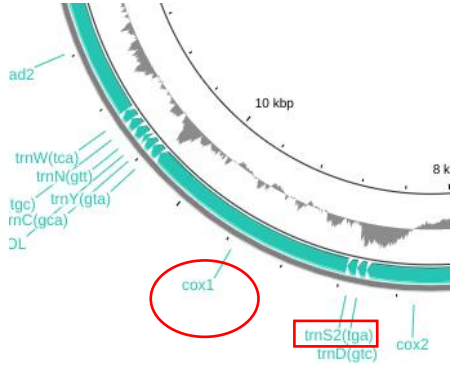
- Shared stock
- Commercially important species
- Emblematic species for artisanal fisheries
- Species of importance to EU fleets
- Species with coastal nurseries (link with WP2)



2- METHODS




a
b
c
d

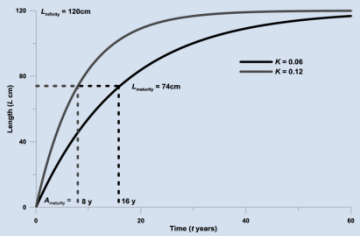

ad2
10 kbp
trnW(tca)
trnN(gtt)
trnY(gta)
cox1
trnS2(tga)
trnD(gtc)
cox2

2- METHODS

STOCK IDENTIFICATION- HOLISTIC APPROACH

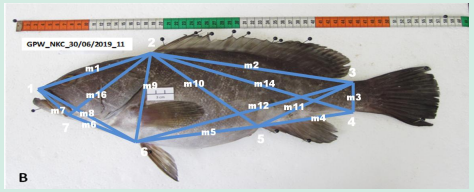
Life History Traits

- Weight parameters, reproduction, etc



Morphometry

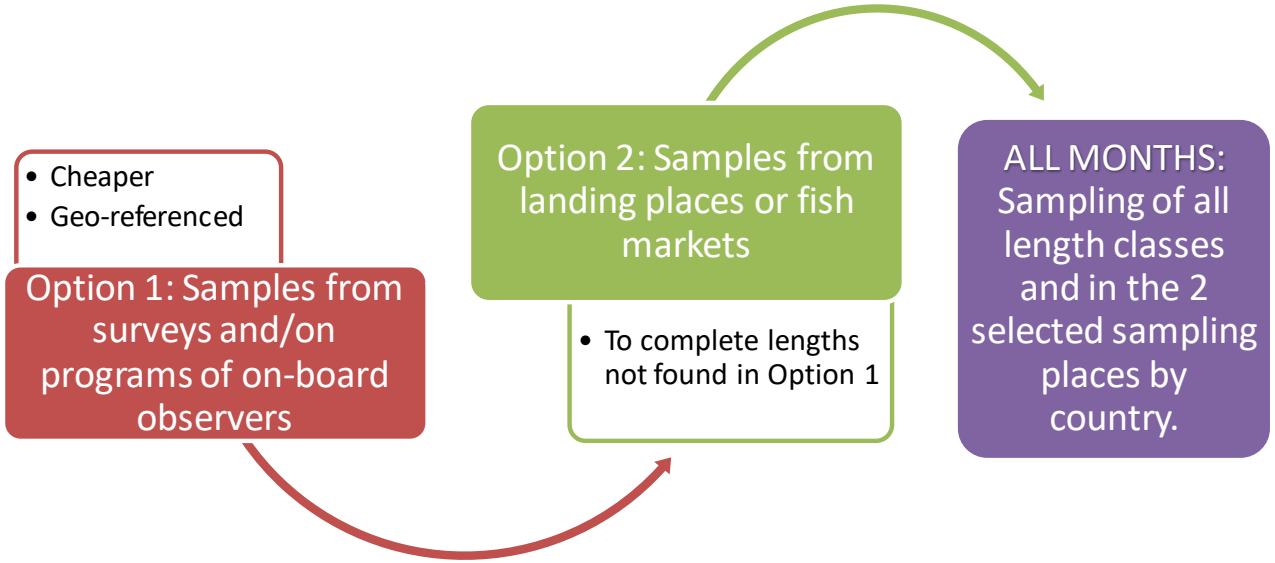
- Study based on morphometric measurements of the species.



Genetics

- Study of the genetic structure of the populations to identify the geographical limits of stocks using microsatellite markers.

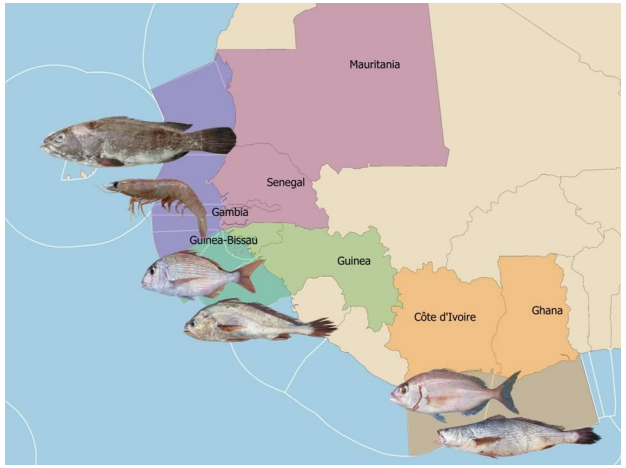
Sample sources



Sampling period

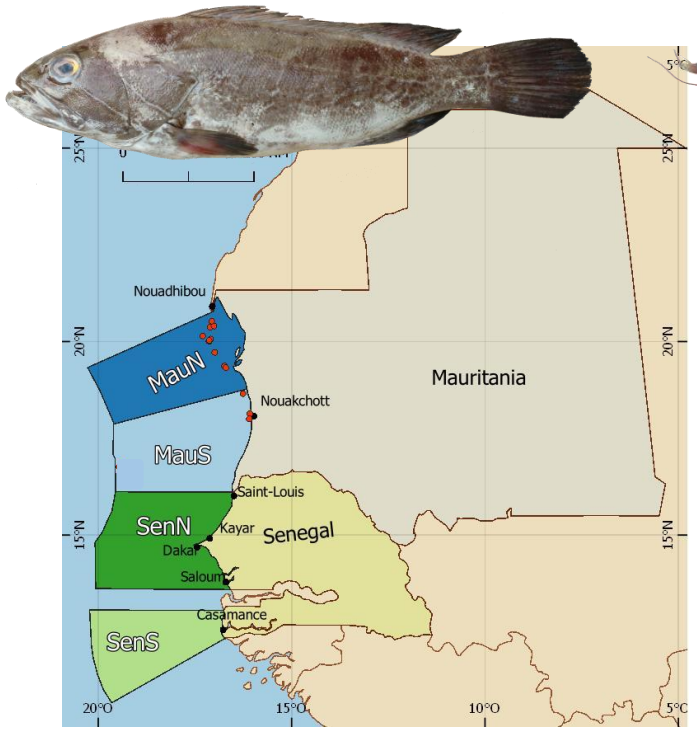
PAYS	Zone/ Mois	Mar 20	Avr 20	Mai 20	Juin 20	Juill 20	Août 20	Sep 20	Oct 20	Nov 20	Déc 20	Jan 21	Fév 21
MAURITANIA	North	T BIO-MOR-GEN	T BIO	T BIO	T BIO	T BIO	T BIO	T BIO-MOR-GEN	T BIO	T BIO	T BIO	T BIO	T BIO
	South	T BIO-MOR-GEN	T BIO	T BIO	T BIO	T BIO	T BIO	T BIO-MOR-GEN	T BIO	T BIO	T BIO	T BIO	T BIO
SENEGAL-GAMBIE	Saint Louis	T BIO-MOR-GEN	T BIO	T BIO	T BIO	T BIO	T BIO	T BIO-MOR-GEN	T BIO	T BIO	T BIO	T BIO	T BIO
	Saloum	T BIO-MOR-GEN	T BIO	T BIO	T BIO	T BIO	T BIO	T BIO-MOR-GEN	T BIO	T BIO	T BIO	T BIO	T BIO
	Gambie	T BIO-MOR-GEN	T BIO	T BIO	T BIO	T BIO	T BIO	T BIO-MOR-GEN	T BIO	T BIO	T BIO	T BIO	T BIO
GUINEA-BISSAU	Cacheu	T BIO-MOR-GEN	T BIO	T BIO	T BIO	T BIO	T BIO	T BIO-MOR-GEN	T BIO	T BIO	T BIO	T BIO	T BIO

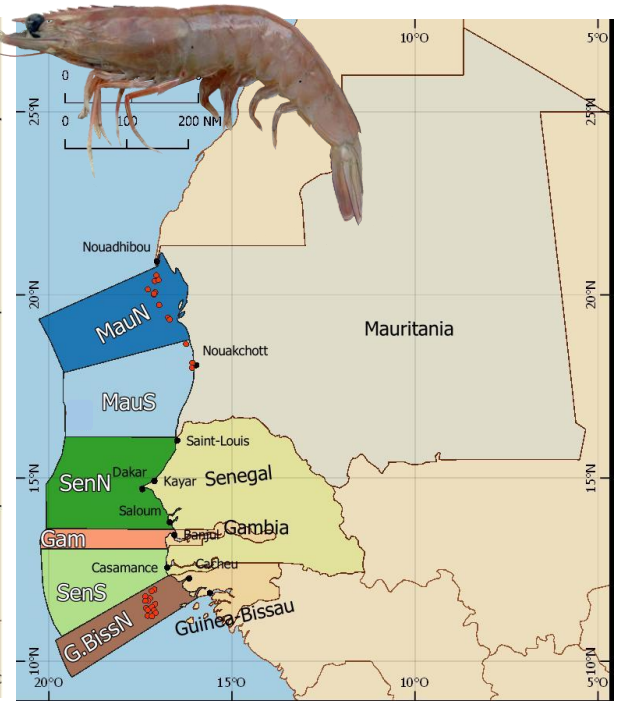
Sampling places

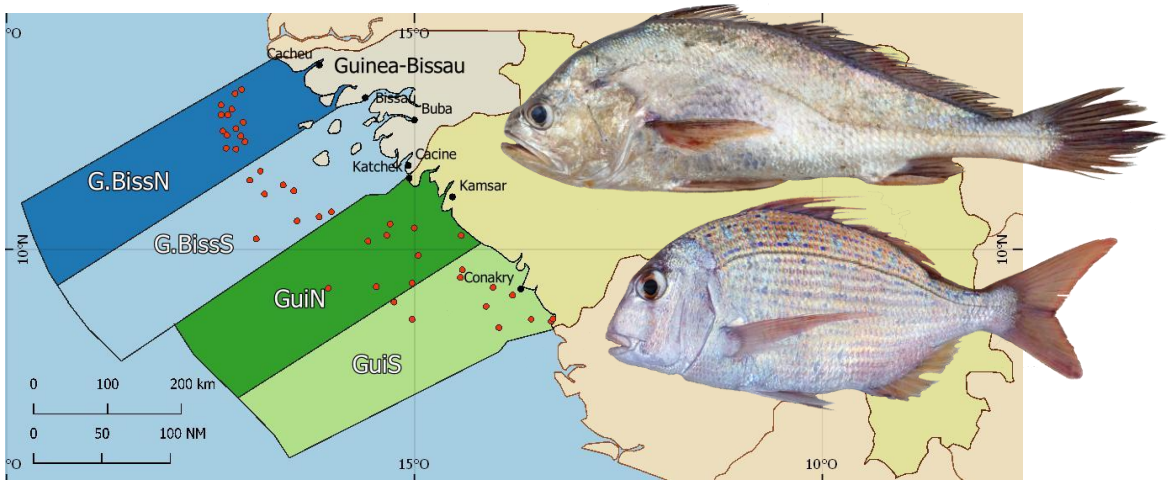


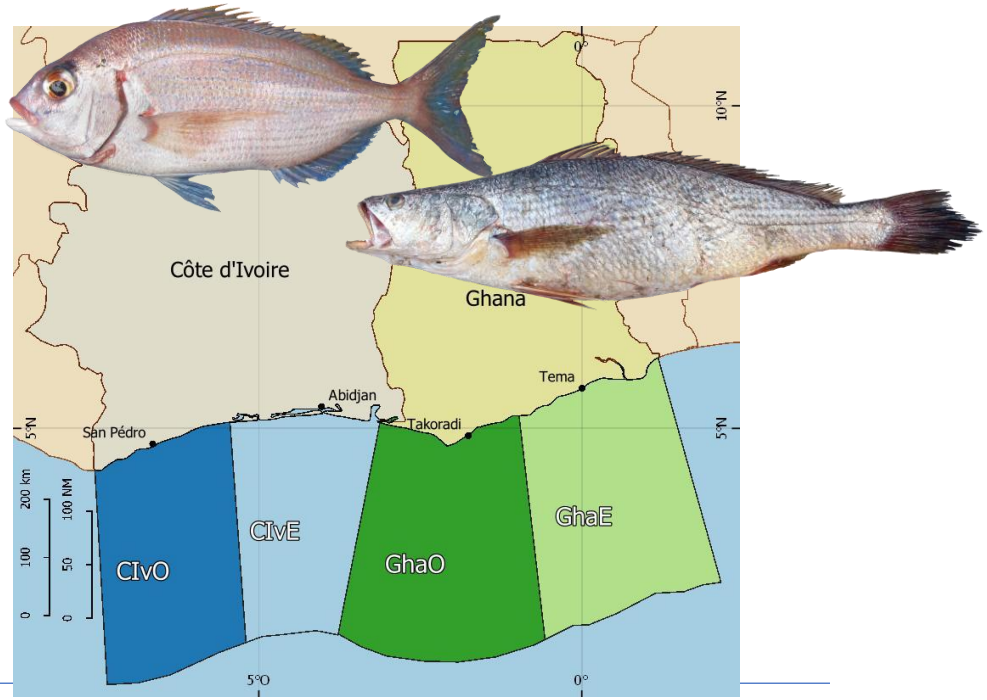
Species	Country	Zone	Sampling port	Surveys
Epinephelus aeneus	Mauritania	North	Nouadhibou	
		South	Nouakchott	
	Senegal	North	Kayar	
		South	Saloum	
Penaeus notialis	Mauritania	North	Nouadhibou	
		South	Nouakchott	x
	Senegal	North	Saint Louis / Dakar	
		South	Saloum / Casamance	
	The Gambia	—	Banjul	
	Guinea-Bissau	North	Cacheu	x
Pagrus caeruleostictus	Guinea-Bissau	North	Bissau _NO	
		South	Buba	x
	Guinea	North	Kamsar	x
		South	Conakry	x
Pseudotolithus elongatus	Guinea-Bissau	North	Cacheu	
		South	Cacine / Buba	
	Guinea	North	Kamsar, Katchek	
		South	Conakry	
Pseudotolithus senegalensis	C. Ivoire	West	San Pedro	
		East	Abidjan	
	Ghana	West	Takoradi	
		East	Takoradi	
Pagellus bellottii	C. Ivoire	West	San Pedro	
		East	Abidjan	
	Ghana	West	Tema	
		East	Takoradi	

Sampling places

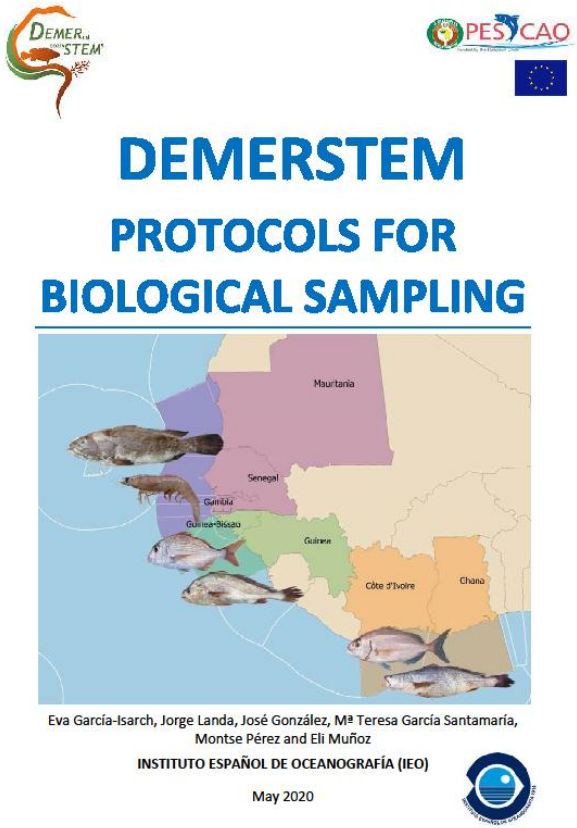


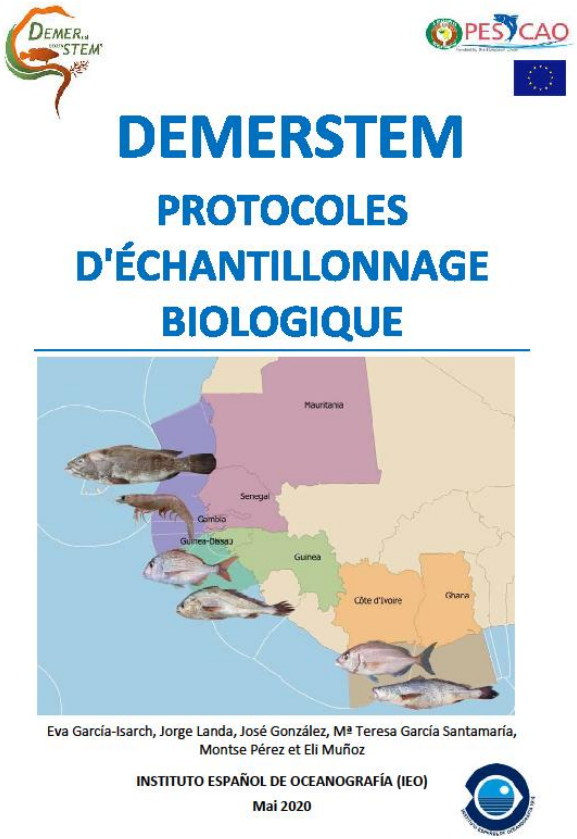






Sampling protocols





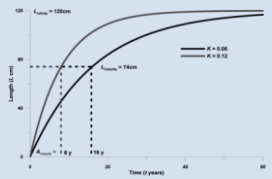
http://pescao-demerstem.org/

3- LIFE HISTORY TRAITS: DATA ANALYSIS AND PRELIMINARY RESULTS

STOCK IDENTIFICATION- HOLISTIC APPROACH

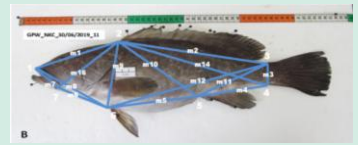
Life History Traits

- Weight parameters, reproduction, etc



Morphometry

- Study based on morphometric measurements of the species.



Genetics

- Study of the genetic structure of the populations to identify the geographical limits of stocks using microsatellite markers.

Weight parameters

- Weight–length relationships for combined sexes (total and by sex). Using :
  - Total weight (Wt)
  - Gutted weight (Wg)

$$W = a(Lt)^b$$

- Weight Conversion factor (Wt – Wg)

$$Wt = aWg$$

- Gonadosomatic index (GSI), by sex and different temporal frames.

$$GSI = (Wgo/Wg) \times 100$$

- Le Cren's relative condition factor (K):

$$K = Wg/aLt^b$$

Reproduction parameters and features

- GSI (only matures) by sex-month/quarter
- Le Cren's relative condition factor (K) (only for matures) by sex-month/quarter
- % matures by sex and month
- Determination of spawning period (based on females spawning peaks)
- L50 (by sex)
- Sex ratio by length

Data analysis → comparisons among country-zones, using the same length ranges

Weight parameters

- ANCOVA
- ANOVA

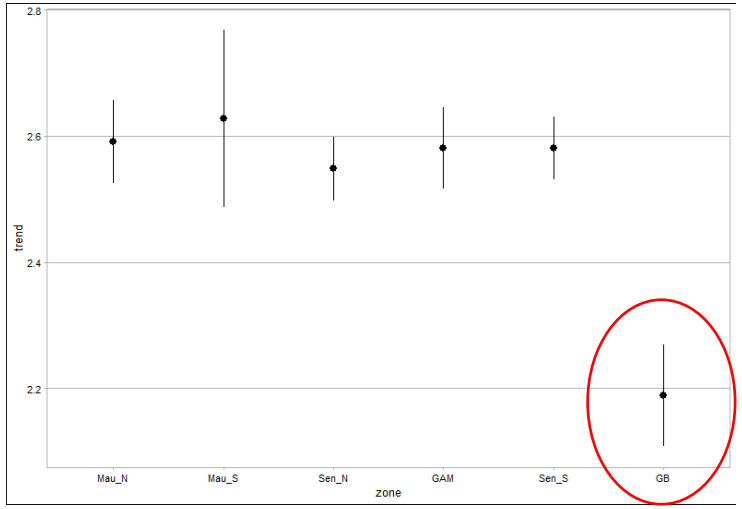
Reproduction parameters and features

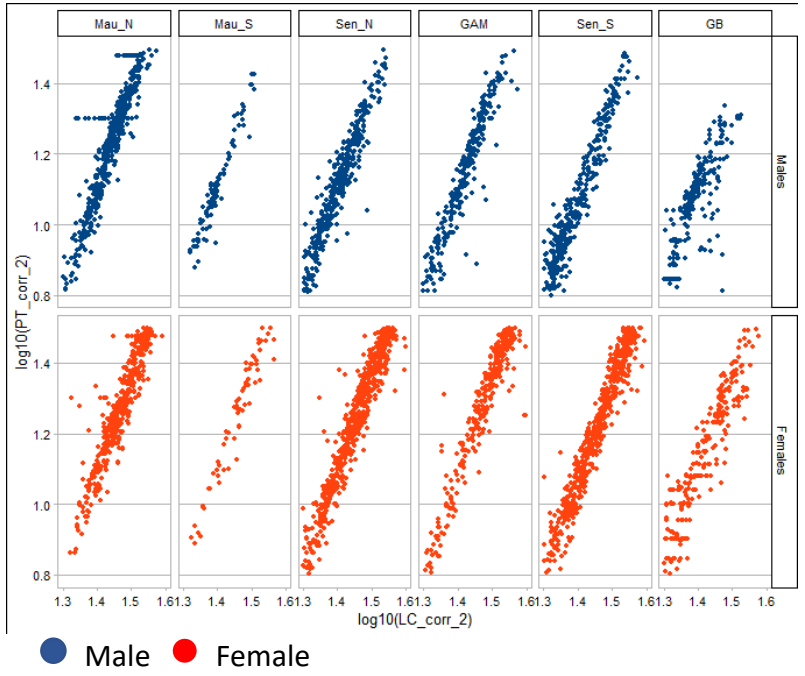
- Visual observation (GSI, spawning periods)
- Comparison of CI (L50s)

- In general, no significant difference between country-zones for most parameters and species.
- When significant differences were found , they could be attributed to different sampling issues.
- With the data available and sampling limitations, this method revealed not to be robust for stock identity.
- However, this is study has been very relevant to improve/provide knowledge of the biology of target species in the studied areas.

Weight parameters (example *Penaeus notialis*)

Contry-Zone	Length- Weigth relationship		Le Cren's condition factor (k)		
	Slope (b)	SE	median	mean	sd
MAU_N	2.62	0.03	1.07	1.09	0.17
MAU_S	2.66	0.05	1.06	1.05	0.08
SEN_N	2.58	0.02	1.00	1.00	0.13
GAM	2.63	0.03	1.01	1.00	0.12
SEN_S	2.62	0.02	0.96	0.97	0.1
G. BISS	2.23	0.04	1.06	1.02	0.18





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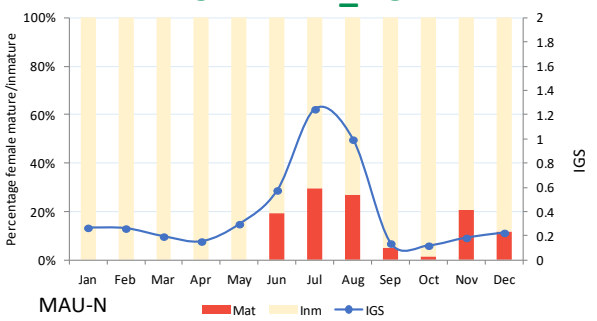
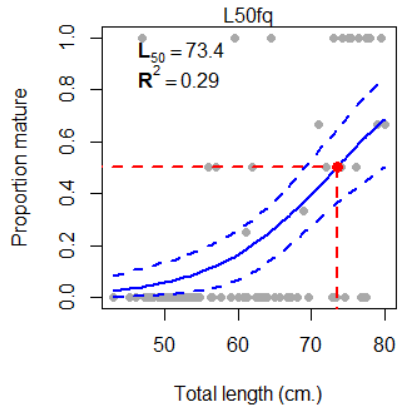
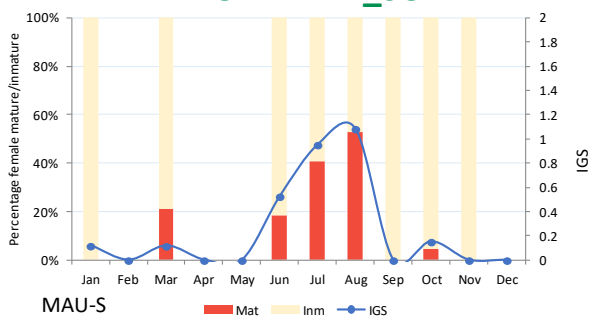
Reproduction parameters and features (example: *Epinephelus aeneus*)

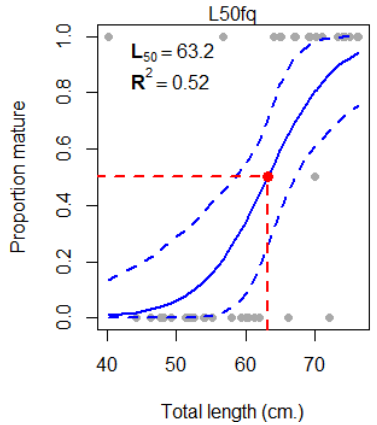
MAURITANIA_NORD



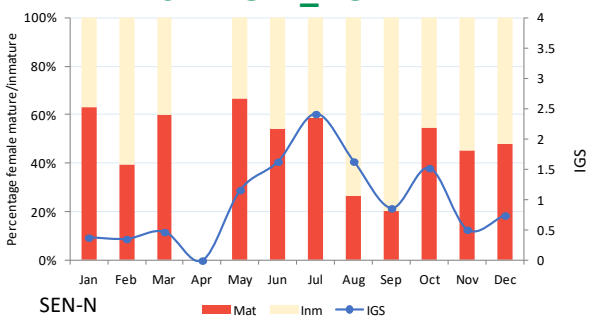


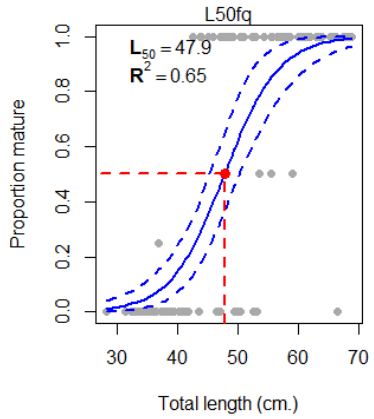
MAURITANIA_SUD



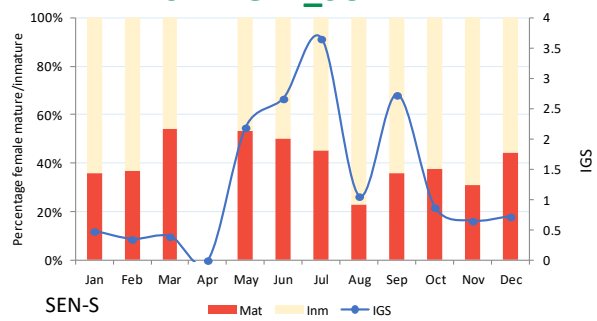


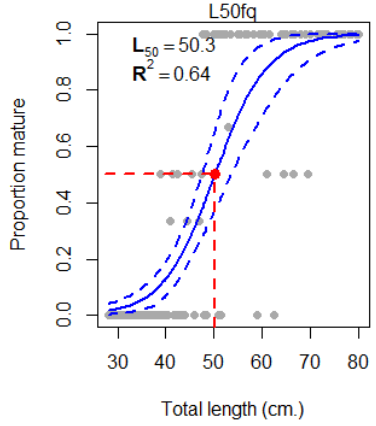
SENEGAL_NORD





SENEGAL_SUD





FEMALES	MAURITANIA_NORD	MAURITANIA_SUD	SENEGAL_NORD	SENEGAL_SUD
Spawning period	June-December	March-October	All year	All year
Spawning peak	July-August	July-August	May-August	May-September
L50	—	—	47.9	50.3
Confidence intervals	—	—	45.4 - 50.3	47.6 - 53.7
N	—	—	119	160

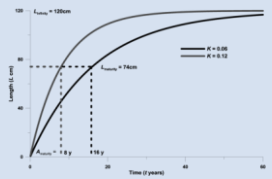
Visit our posters to see the results of each species!

4- MORPHOMETRY: DATA ANALYSIS AND PRELIMINARY RESULTS

STOCK IDENTIFICATION- HOLISTIC APPROACH

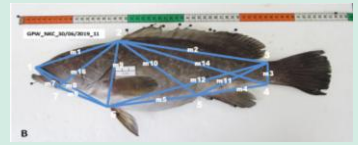
Life History Traits

- Weight parameters, reproduction, etc



Morphometry

- Study based on morphometric measurements of the species.

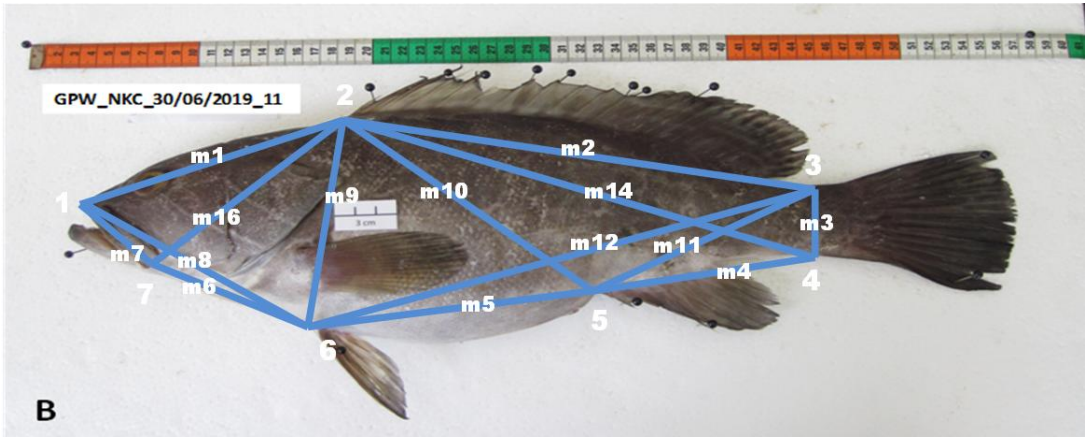


Genetics

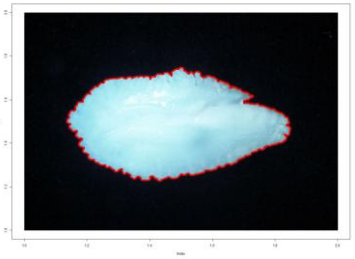
- Study of the genetic structure of the populations to identify the geographical limits of stocks using microsatellite markers.

MORPHOMETRY

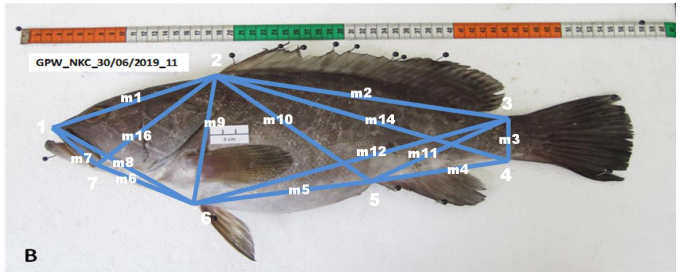
Body shape (TRUSS NETWORK)



Otolith shape (FOURIER ANALYSIS)



Body shape (TRUSS NETWORK)



Species photographing during biological sampling (bi-annual) and by country-zone.

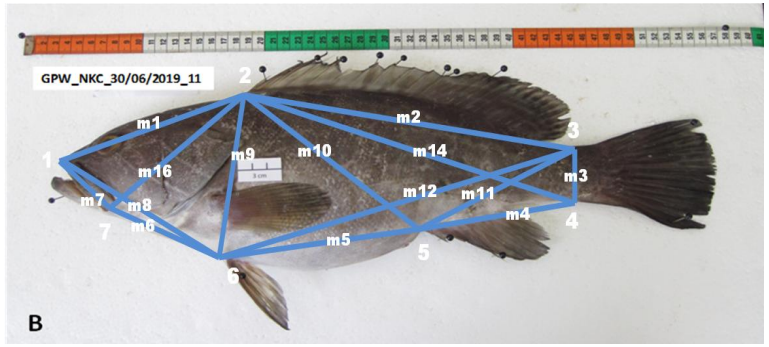
Measurements on selected pictures.

3 SPECIES GROUPS

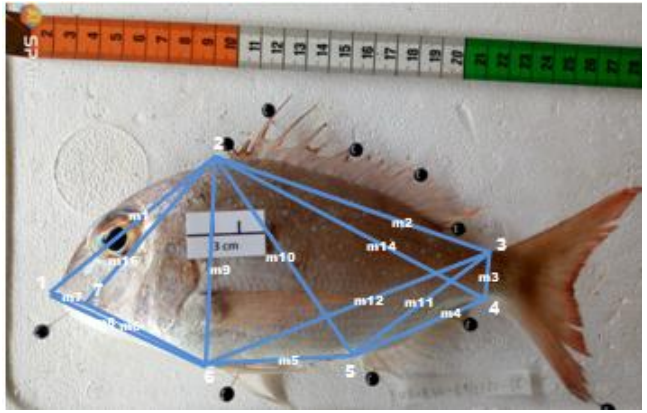
Body shape (TRUSS NETWORK)

GROUP 1: 1 dorsal fin fish

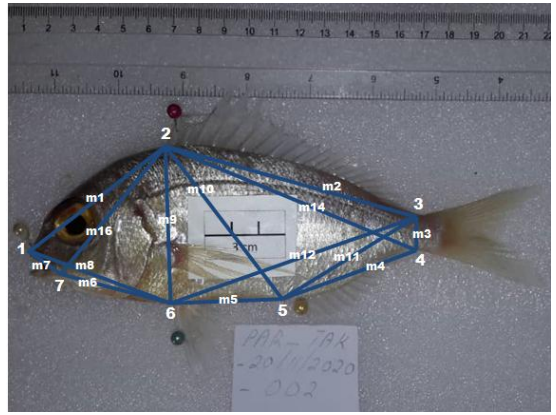
8 landmarks→ 15 measurements



Epinephelus aeneus (GPW)



Pagrus caeruleostictus (BSC)



Pagellus bellottii (PAR)

COUNTRY/ZONE	Photos	Measures
Mauritania_Nord	70	1050
Mauritania_Sud	98	1320
Senegal_Nord	91	1350
Senegal_Sud	116	1620
TOTAL	375	5340

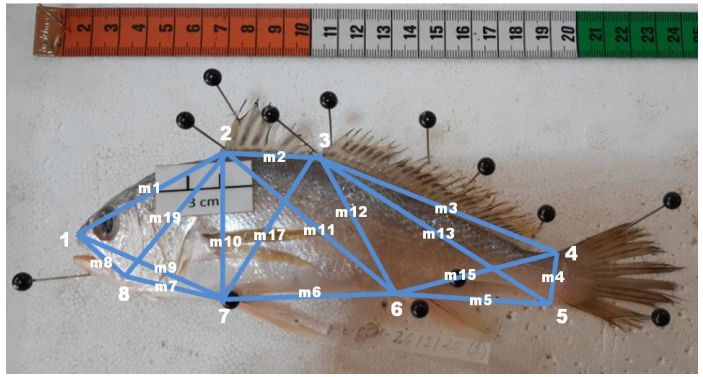
COUNTRY/ZONE	Photos	Measures
G. Bissau_Nord	86	1290
Guinea_Nord	100	1470
Guinea_Sud	89	1320
TOTAL	275	4080

COUNTRY/ZONE	Photos	Measures
C.Ivoire_Ouest	50	540
C.Ivoire_Est	98	1110
Ghana_Oust	103	1005
Ghana_Est	117	1080
TOTAL	318	3195

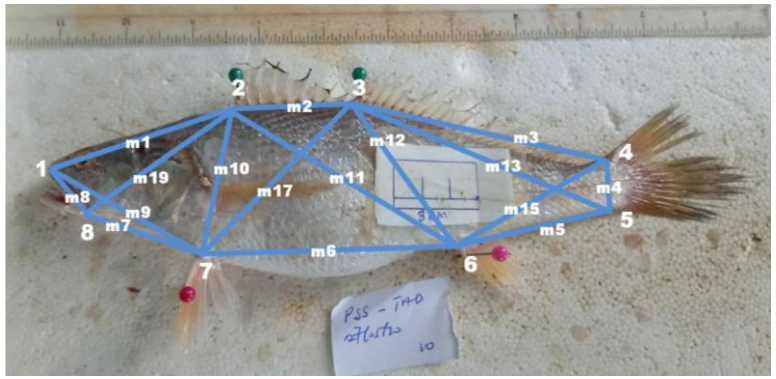
Body shape (TRUSS NETWORK)

GROUP 2: 2 dorsal fin fish

9 landmarks→ 17 measurements



Pseudotholitus elongatus (PSE)



Pseudotholitus senegalensis (PSS)

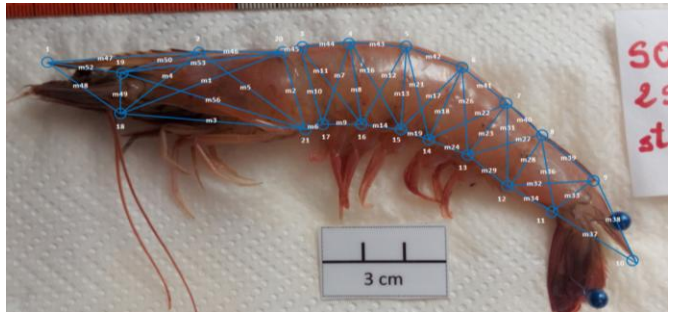
COUNTRY/ZONE	Photos	Measures
G. Bissau_Nord	105	1105
G. Bissau_Sud	82	1071
Guinea_Nord	177	1224
Guinea_Sud	164	1275
TOTAL	528	4675

COUNTRY/ZONE	Photos	Measures
C.Ivoire_Ouest	49	612
C.Ivoire_Est	103	1241
Ghana_Ouest	50	612
Ghana_Est	118	1173
TOTAL	271	3026

GROUP 3: Shrimps

21 landmarks→

46 measurements



COUNTRY/ZONE	Photos	Measures
Mauritania_Nord	116	2438
Mauritania_Sud	50	1656
Senegal_Nord	171	1472
The Gambia	96	1702
Senegal_Sud	171	1978
Guinea-Bissau_Nord	100	1610
TOTAL	704	10856

Body shape (TRUSS NETWORK) → Data analysis

1) Data matrix: measurements on selected pictures (species photographed during biological sampling and by country-zone.

Multivariate analysis:

2) Principal Component Analysis (PCA)

3) Linear Discriminant Analysis (LDA):
   - Detection of potential significant differences between groups
   - Selection of measures producing them (ANOVA)
   - Correct classification (CC)

Otolith shape (FOURIER ANALYSIS)

1) Extraction of otolith samples (biological sampling) and photographing.

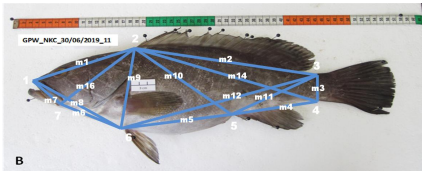
2) Otolith outline extraction (R)

3) Fourier analysis
   - Crossing with biological data
   - Scale the outlines to the same size
   - Transform shapes into numbers

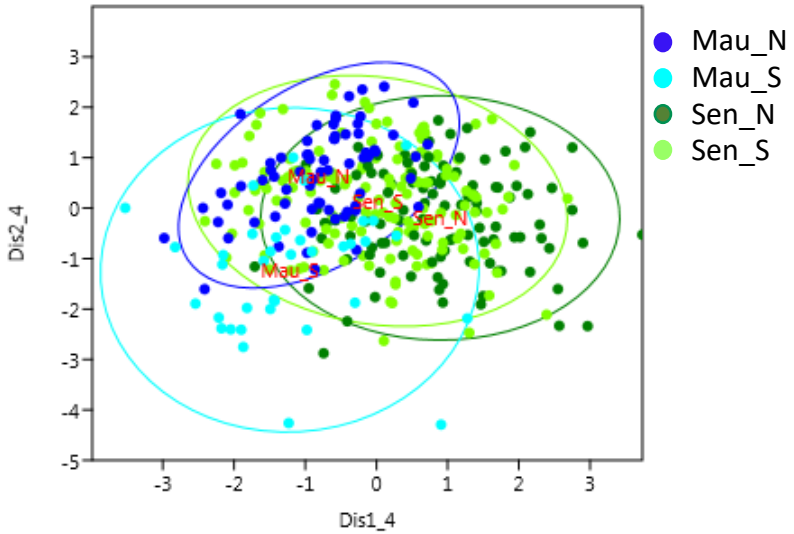
4) Classification and multivariate analysis of shapes (PCA, **LDA**)
   - Correction of the possible allometric effect

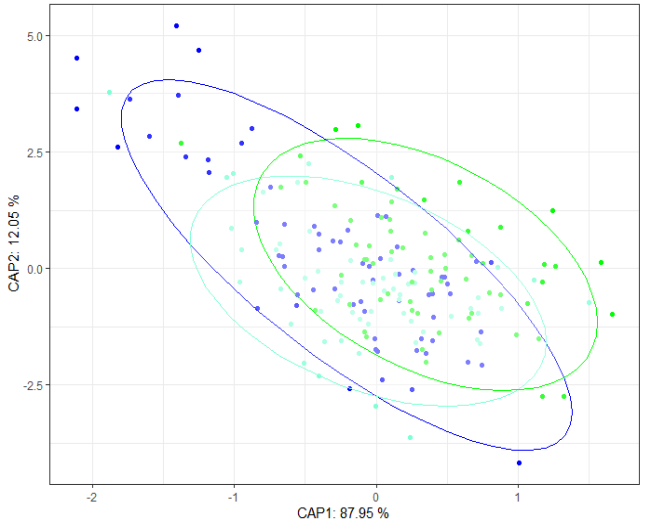
Some results:
Epinephelus aeneus (example 1)

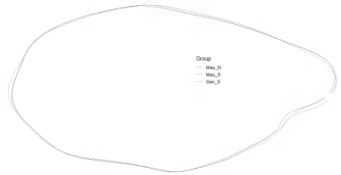
Body shape (TRUSS NETWORK)



Otolith shape (FOURIER ANALYSIS)







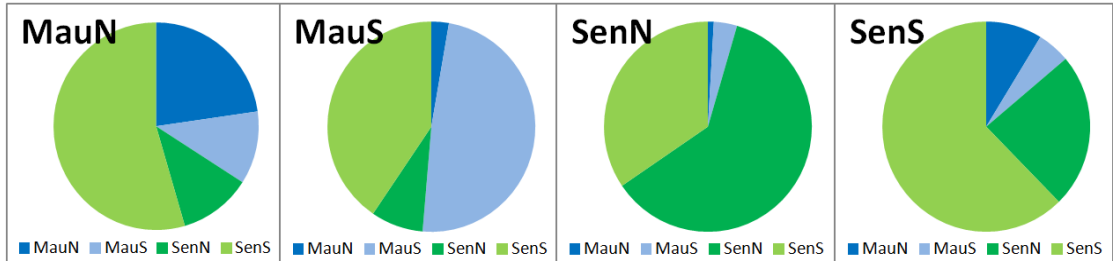
Linear Discriminant Analysis (LDA) → Overlap among areas

Some results:
Epinephelus aeneus
(example 1)

Correct classification from LDAs (Body shape and Otolith shape)

Body shape

Correct classification of individuals: 55 %



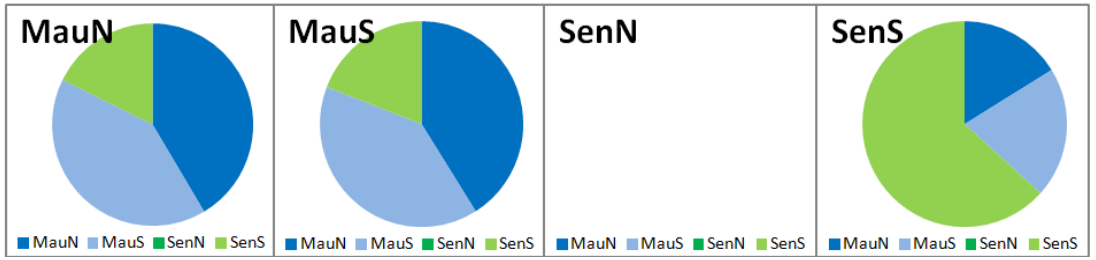
Classification Results(a)

		Country area	Predicted Group Membership				
			MauN	MauS	SenN	SenS	Total
Original	Count	MauN	10	5	5	24	44
		MauS	1	18	3	15	37
		SenN	1	4	67	38	110
		SenS	12	7	33	86	138
	%	MauN	22.7	11.4	11.4	54.5	100
		MauS	2.7	48.6	8.1	40.5	100
		SenN	0.9	3.6	60.9	34.5	100
		SenS	8.7	5.1	23.9	62.3	100

a. 55,0% of original grouped cases correctly classified.

Otolith shape

Correct classification of individuals: 49 %



Classification Results(a)

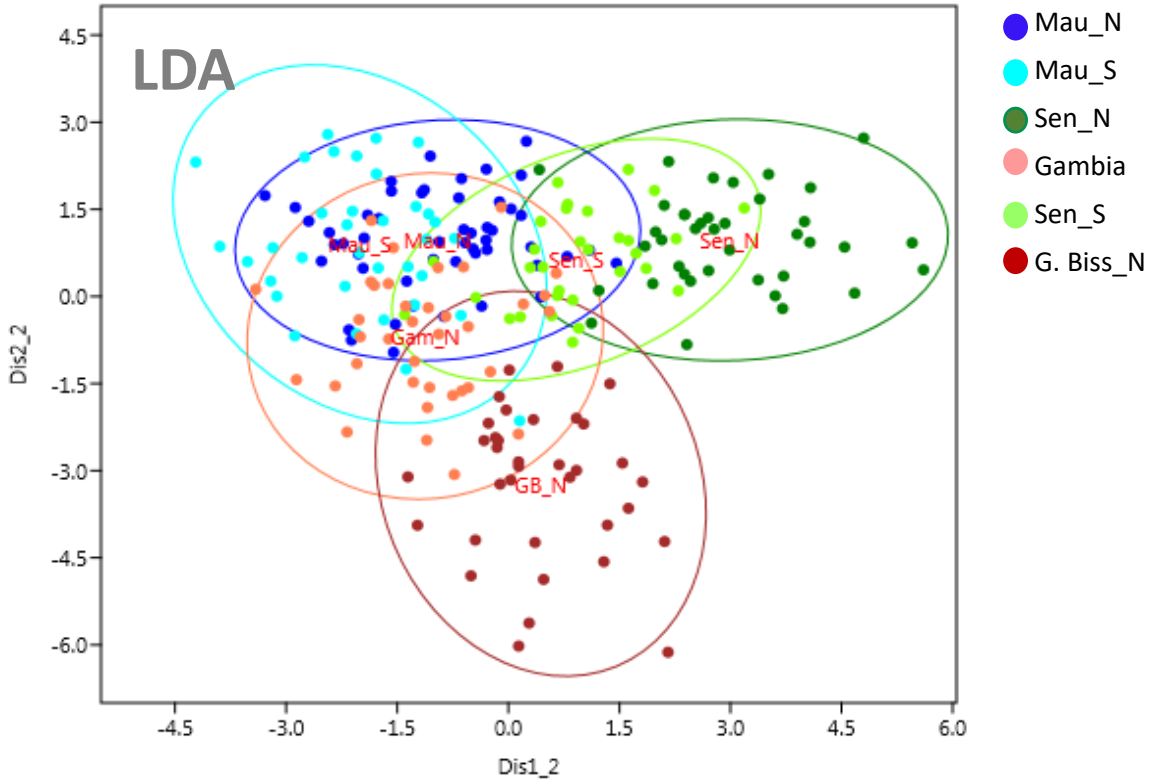
		Country area	Predicted Group Membership				
			MauN	MauS	SenN	SenS	Total
Original	Count	MauN	27	27		12	66
		MauS	24	23		11	59
		SenN					
		SenS	11	14		42	66
	%	MauN	41.4	40.8		17.7	100
		MauS	41.1	39.8		19.1	100
		SenN					
		SenS	16.2	20.5		63.4	100

a. 48.5 % of original grouped cases correctly classified.

Following morphometric techniques, the overlap among zones in thiof indicates the greatest mixing compared with other studied species in this project→ potential single stock in the studied area.

Some results: *Penaeus notialis* (example 2)

Body shape (TRUSS NETWORK)

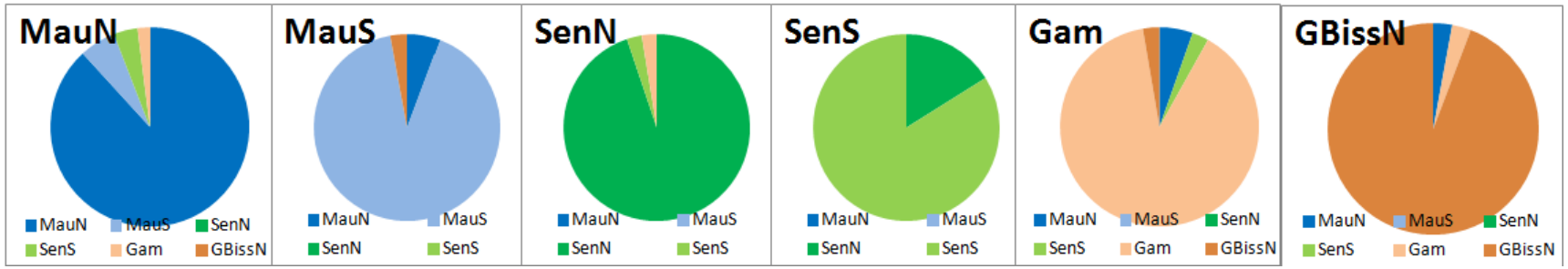


Some results:
Penaeus notialis
(example 2)

Correct classification from LDAs

Specimen shape

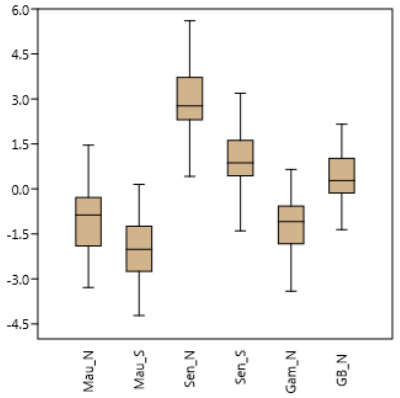
Correct classification of individuals: 91%



Classification Results(a)

		Country area	Predicted Group Membership						
			MauN	MauS	SenN	SenS	Gam	GBissN	Total
Original	Number	MauN	45	3	0	2	1	0	53
		MauS	2	32	0	0	0	1	35
		SenN	0	0	37	1	1	0	43
		SenS	0	0	5	26	0	0	32
		Gam	2	0	0	1	33	1	37
		GBissN	1	0	0	0	1	33	35
	%	MauN	88,2	5,9	0	3,9	2	0	100
		MauS	5,7	91,4	0	0	0	2,9	100
		SenN	0	0	94,9	2,6	2,6	0	100
		SenS	0	0	16,1	83,9	0	0	100
		Gam	5,4	0	0	2,7	89,2	2,7	100
		GBissN	2,9	0	0	0	2,9	94,3	100

a. 90.6% of original grouped cases correctly classified.

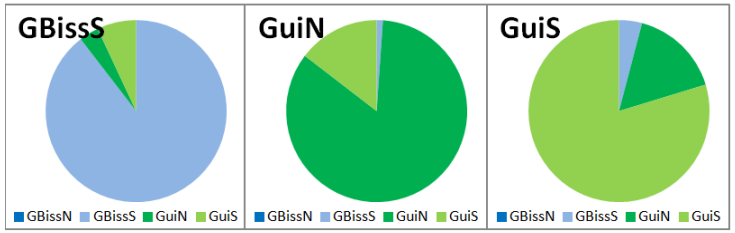
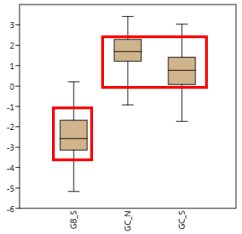
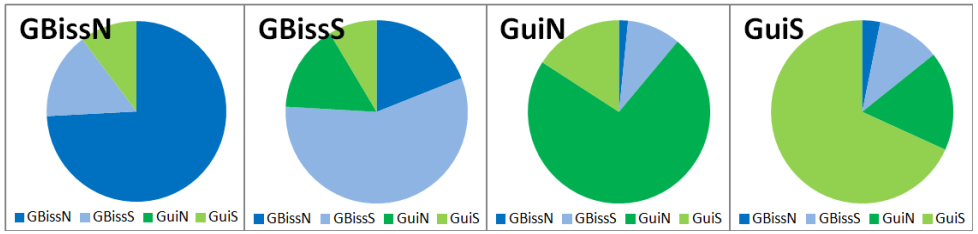
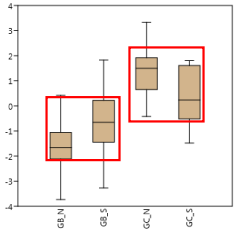
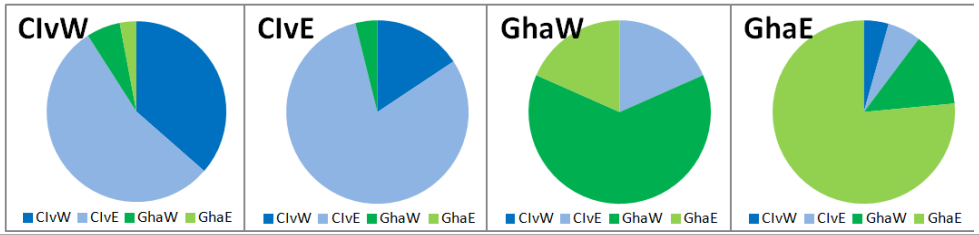
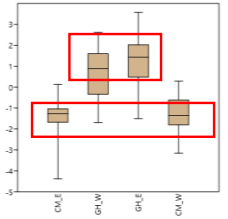
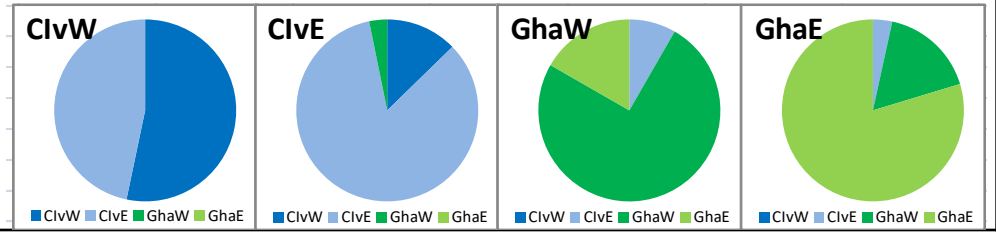
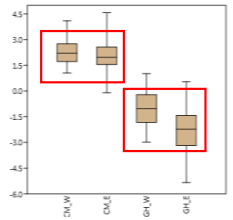


Discriminant Factor 1

The correct classification of individuals using specimen shape is the highest of the studied species.

- High correct classification (84-95%) in all the areas
- Correct classification from LDAs, comparison tests on factor 1 → individuals in each area could be clearly differentiated from those in other areas (phenotypically homogeneous groups in each country-zone).

RESULTS OTHER SPECIES-SUMMARY TABLE

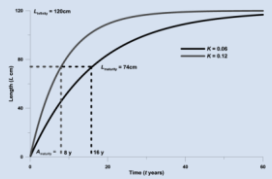
SPECIES	CC % LDA (Body)	CC % LDA (Oto)	LDA- Correct classification from LDA (Body shape)	Discriminant factor 1	Results
P. caeruleos. (BSC)	85%	58%			Individuals from G.Bissau and Guinea could be differentiated (phenotypically homogeneous groups)
P. elongatus (PSE)	68%	51%			
P. senegalens. (PSS)	68%	61%			Individuals from C.Ivoire and Ghana could be differentiated (phenotypically homogeneous groups)
P. bellottii (PAR)	76%	53%			

5- GENETICS:
DATA ANALYSIS AND PRELIMINARY RESULTS

STOCK IDENTIFICATION- HOLISTIC APPROACH

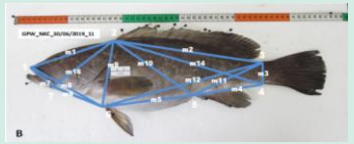
Life History Traits

- Weight parameters, reproduction, etc



Morphometry

- Study based on morphometric measurements of the species.



Genetics

- Study of the genetic structure of the populations to identify the geographical limits of stocks using microsatellite markers.

Genetics goals

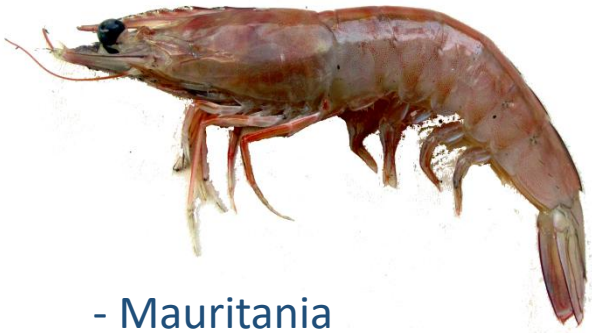
1.- Study of the genetic structure of populations to identify the geographical limits of stocks using **microsatellite markers**.

Two species selected
Those with previously developed molecular markers (microsatellites).

Epinephelus aeneus

- Mauritania
- Senegal

Penaeus notialis



- Mauritania
- Senegal + The Gambia
- Guinea-Bissau

2.- To provide genetic information. Sequencing of mitochondrial gene cytochrome oxidase I.

Microsatellite markers- *E. aeneus*

The final design allowed amplification of eight microsatellite loci in two multiplex PCR (M1 and M2) and a single PCR (M3)

Múltiplex	Locus	Primer F	Primer R
M1	ARO1105	TGATAGCTTTACATGCACTCA	CTGAACCTCACCCTGAAA
M1	ARO1045	CACGAAGTATTTGGCTGAT	GAGAAAGTGGCAATATTTGAC
M1	ARO1083	CCGGTTCTTCTTCTCTCCC	TTACTGTTGATTGAGTTGTTGT
M1	ARO1084	GGGTTTATTTCAAAGGTCAG	CCCAATGAGGTGTTCAATAT
M2	ARO1003	GTGCAAGGCAAGCTGTGTTA	AGCAGGCATCTTGTTATCTGG
M2	ARO1120	CTCTGATGCTGTTTACACAAC	TCTCCATCGAAGGTAAAGG
M2	ARO1137	ATGGGTATAATTAGGACACACT	AGGAAAGGAGGGAGGAAA
M3	ARO1131	TGTGTGTCAGAGGTGGGTT	TGAATTTCACTGCATGTTTC

(Dor et al., 2014)

Microsatellite markers

The final design allowed amplification of five microsatellite loci in one multiplex PCR (M1) and two single PCRs (PnS01 and PnS20).

	Locus	F	R
M1	**PnS03**	F-5' TGCTAA ATAAAAGTTTCTCGGTGAG	R-5' AAGCTTGTATTTGCGTGTCG
M1	**PnS04**	F-5' CGATTTGCAGAACCCGTTTA	R-5' GGGGGAGGGGTTAGAAAGAG
M1	**PnS18**	F-5' GTCTTATCAAAACCCAAAGG	R-5' GAACCAGTCCCGGCCCTCTGC
	PnS01	F-5' TGCTGTTTGTGAGTCTT	R-5' TGGCATGTTGCAGACAGTCC
	PnS20	F-5' CTTCCATATTCGCATGATGG	R-5' ACCCGGGATCAAGCCCTTGC

(Robainas-Barcia et al., 2002 and 2008)

Data Analysis

Genetic diversity estimation

GenAlEx — Number of alleles (Na), No. of Effective Alleles (Ne), Observed Heterozygosity (Ho), Expected Heterozygosity (He), Unbiased Expected Heterozygosity (uHe)

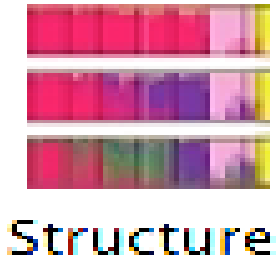
Genepop — Departures from Hardy-Weinberg equilibrium (HWE), Inbreeding coefficient F_{IS}

Genetic differentiation and migration

GenAlEx — pairwise F_{ST}, Number of migrants (Nm)

Genepop — pairwise F_{ST}, Number of migrants (Nm)

adegenet R package — Discriminant Analysis of Principal Components (DAPC), distance-method approach



STRUCTURE with STRUCTURE HARVESTER and CLUMPAK: model-based clustering, Bayesian approach

RESULTS – Molecular markers assessment

Genetic diversity by microsatellite and population

N /Na

Pop[a]	ARO1105	ARO1045	ARO1084	ARO1083	ARO1003	ARO1120	ARO 1137	ARO 1131
MAU_N	57/23	58/21	65/22	65/30	65/27	65/26	66/24	66/19
MAU_S	35/23	41/18	50/27	49/26	50/30	50/28	50/24	47/19
SEN_N	72/26	71/22	92/31	93/30	93/33	93/35	93/26	91/22
SEN_S	120/28	120/24	143/35	140/33	145/33	145/24	144/28	141/24

RESULTS - Genetic diversity

Pop[a]	N	Na	Ne	H_O	H_E	uH_E
MAU_N	63	24	13	0.871	0.903	0.910
MAU_S	47	24	13	0.893	0.909	0.919
SEN_N	88	28	14	0.861	0.913	0.919
SEN_S	137	90	14	0.866	0.912	0.915

N, number of individuals analyzed;
Na, number of different alleles;
Ne, number of effective or equally frequent alleles;
H_O, observed heterozygosity;
H_E; expected heterozygosity according to allele frequencies;
uH_E, unbiased expected heterozygosity according to sample size

RESULTS - Population structure Fst - Migration

F_{ST} pairwise comparison of GPW genetic diversity at 8 loci in 4 populations.

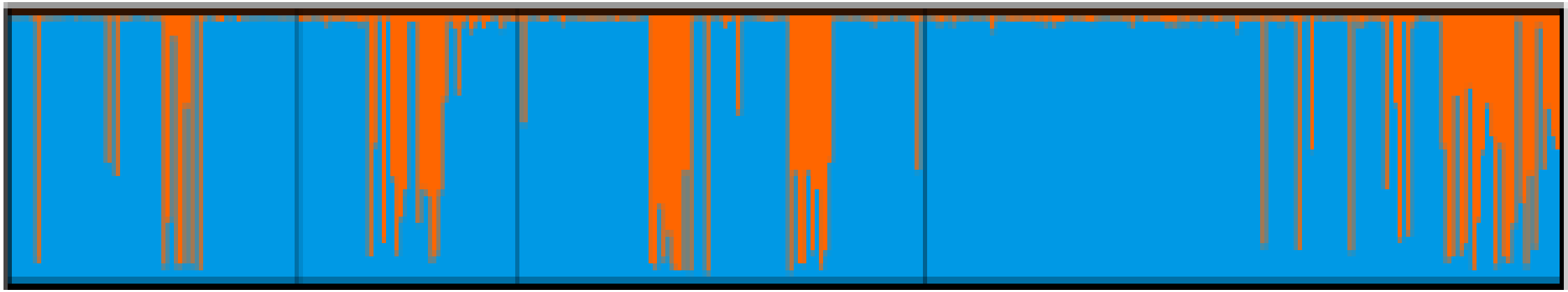
	MAU_N	MAU_S	SEN_N	SEN_S
MAU_N				
MAU_S	0.004			
SEN_N	0.003	0.004		
SEN_S	0.003	0.005	0.002	

Number of migrants

Locus	All Pops
ARO1105	52
ARO1045	37
ARO1084	47
ARO1083	48
ARO1003	35
ARO1120	55
ARO1137	54
ARO1131	84
Mean ± SE	51 ± 5

RESULTS - Structure

Bayesian analysis, 354 GPW, 8 loci (K 1 to 4, 25 iterations per k)



MAU_N MAU_S SEN_N SEN_S

RESULTS – Molecular markers assessment- *P. notialis*

Genetic diversity by microsatellite and population N /Na

Pop	**PnS03**	**PnS18**	**PnS01**	**PnS04**	**PnS20**
MAU-N	55/25	94/36	96/15	97/12	93/93
MAU-S	27/17	44/28	45/12	43/10	44/65
SEN-N	102/40	154/43	157/16	150/13	147/114
SEN-S	79/29	121/39	128/15	123/13	127/103
GAM	24/15	36/32	46/13	47/11	42/56
BIS	38/25	52/32	59/13	54/11	55/58

RESULTS - Population structure Fst (5 loci, 6 pops, N536)

Pairwise Population Matrix of G''st Values for Total

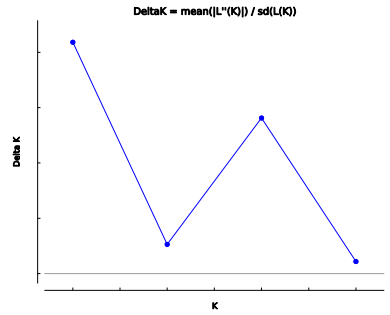
	GB-S	GAM	MAU-N	SEN-S	SEN-N	MAU-S	Code
GB-S		0,895	0,866	0,000	0,538	0,891	**CCH**
GAM	-0,024		0,704	0,011	0,932	0,950	**GAM**
MAU-N	-0,013	0,001		0,000	0,202	0,575	**NDB**
SEN-S	0,146	0,084	0,108		0,000	0,000	**SAL**
SEN-N	0,005	-0,021	0,018	0,110		0,598	**SLO**
MAU-S	-0,022	-0,035	0,009	0,130	0,003		**NKC**

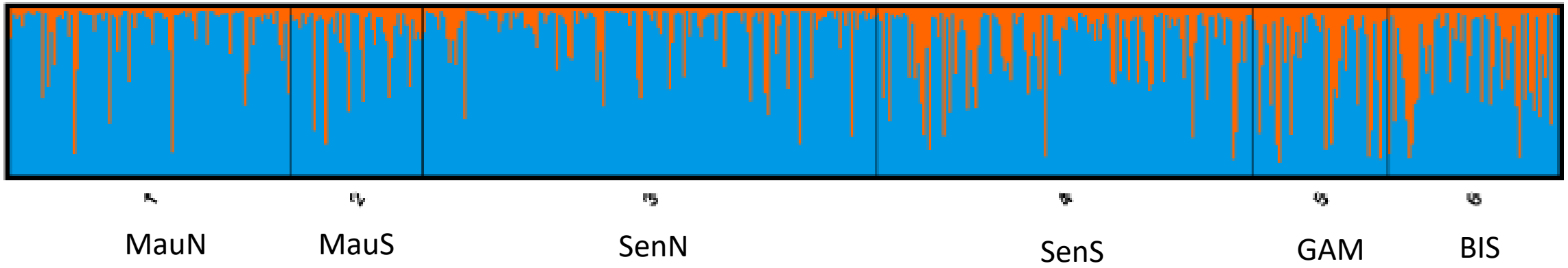
G''st values below the diagonal. Probability, P(rand >= data) based on 9999 permutations is shown above diagonal.

RESULTS - Structure

Bayesian analysis, 5 loci, 6pop, 536 SOP (K 1 to 6, 25 iterations per k)

K = 2





SEQUENCES

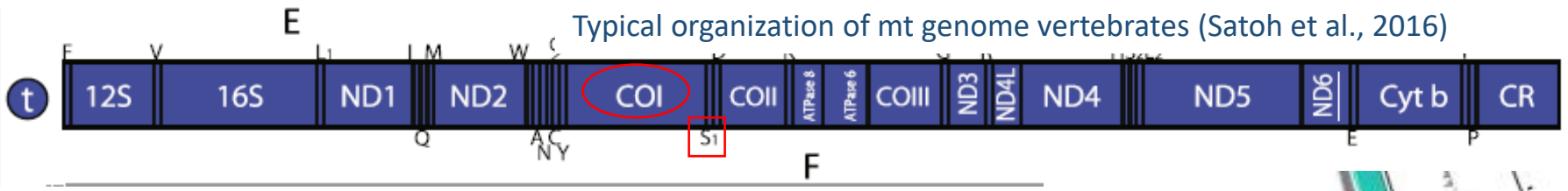
2.- To provide genetic information – COI Sequences.

Pagellus bellottii

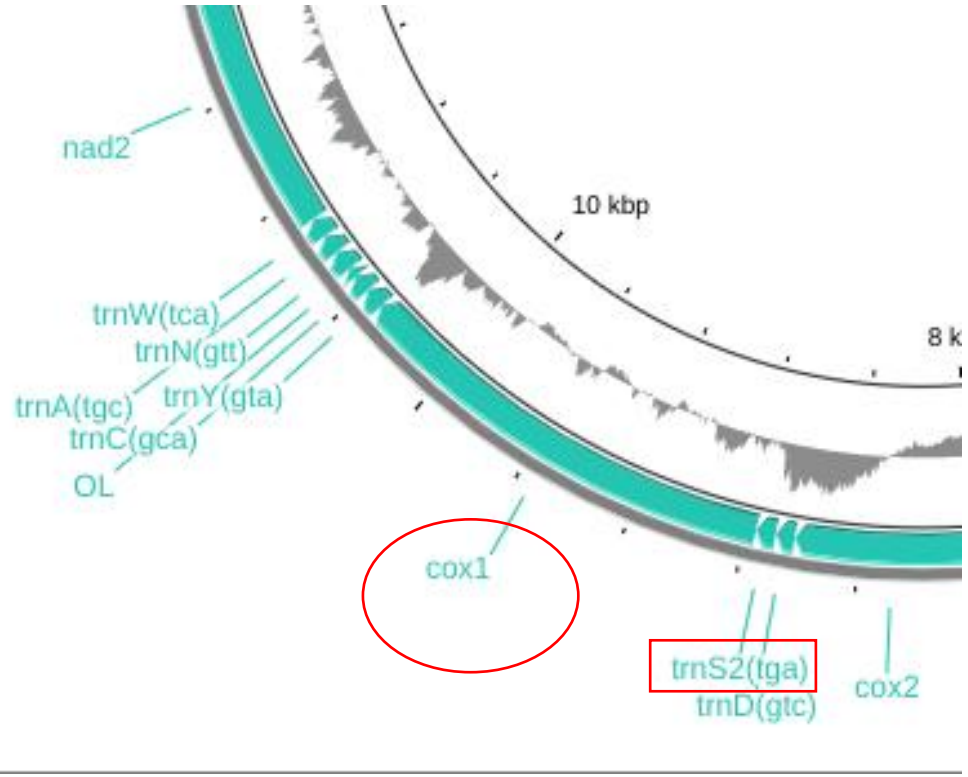
Pseudotolithus senegalensis

Pseudotolithus senegalensis has a different organization of the mitochondrial genome

Typical organization of mt genome vertebrates (Satoh et al., 2016)



Mitogenome organization *P. senegalensis*



Epinephelus aeneus

Penaeus notialis

6- CONCLUSIONS

6- CONCLUSIONS

1) A holistic approach has been used for stock identification of the 6 target species. The different techniques used are complementary and provide basic information with different perspectives for a biological-based stock identification.
2) Data from life history traits do not show conclusive results. However, this work has contributed to improve the biological knowledge of the species in the study area.
3) The two morphometric techniques used show reliable information for stock identification. Among the two methods, body shape has provided better results for differentiation among areas than otolith shape.
4) Genetics tools provide a direct basis for stock structuring and interpreting phenotypic-based patterns.
5) For thiof, the results of morphometry and genetic techniques are consistent showing one single stock in Mauritania and Senegal, although its boundaries still unknown. In addition, genetics show introgression from other areas.

6) For *P.* notialis, results from morphometry show low variability within samples, suggesting that each sampled country-zone conforms a phenotypically homogeneous group, with clear differences to the others. The number of genetics samples used for *P. notialis* is insufficient to recover the genetic diversity of the species. More individuals are still under analysis. Other markers should be tried.

7) For the rest of species, phenotypically homogeneous groups can be distinguished by morphometry at least at country level: *P. caeruleostictus* and *P. elongatus* (1 from Guinea-Bissau and 1 from Guinea, each); *P. senegalensis* and *P. bellottii* (1 from C. Ivoire and 1 from Ghana, each).

8) One of the main outputs of the project is the development of a new and reliable genetic tool for stock identification of thiof.

9) Another relevant output of the project is that we will obtain barcoding information of 4 new species in free genetic data bases.

10) A more in-depth analysis of the information obtained by all techniques is being carried out and the results may be useful for fisheries assessment and management recommendations of these species within CECAF .

11) The extension of this study to longer periods and to neighboring areas is highly recommended to determine geographic boundaries, needed to define the structure and distribution of these West African stocks.

Thank you
Merci