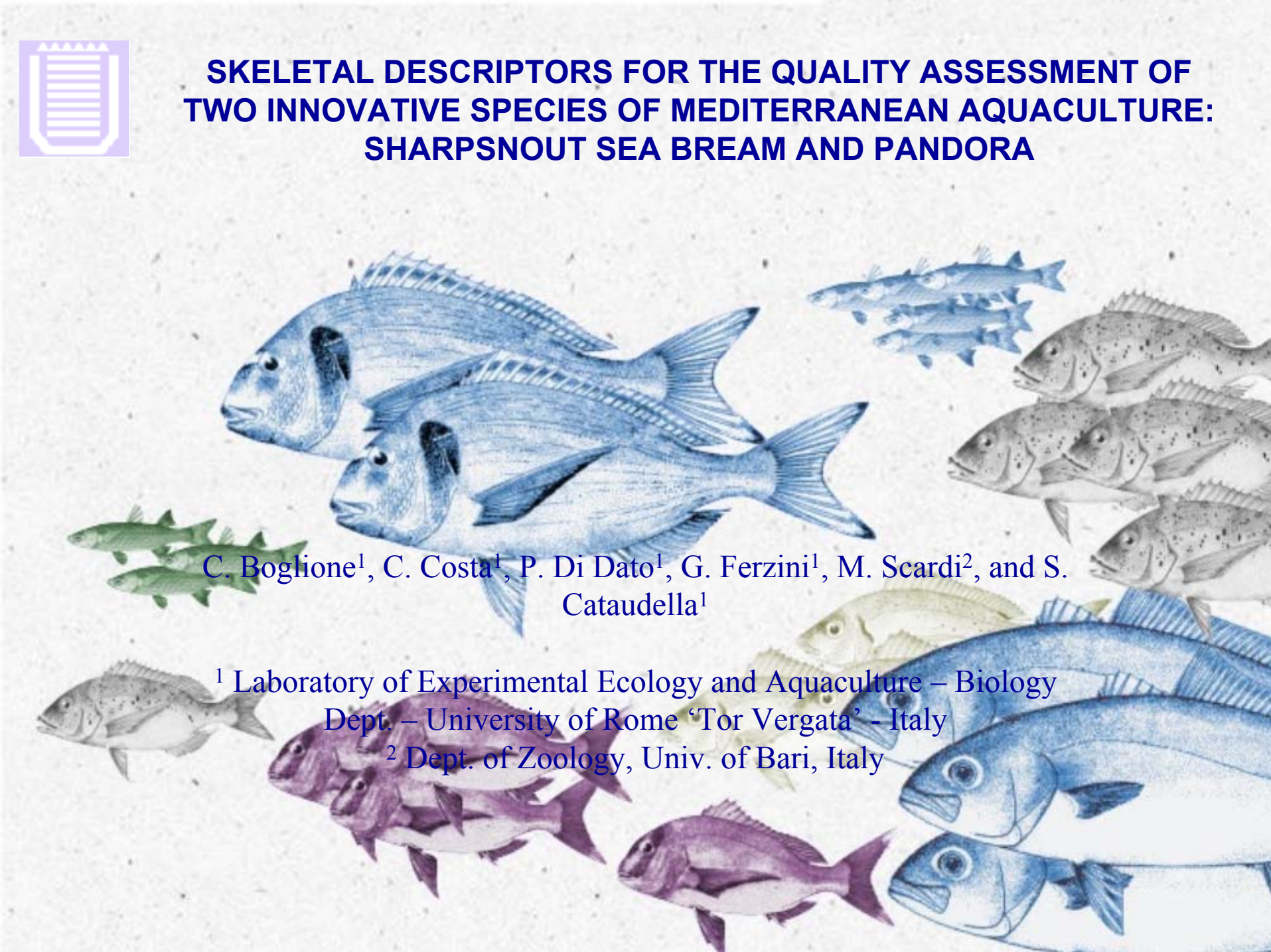
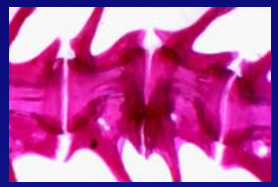
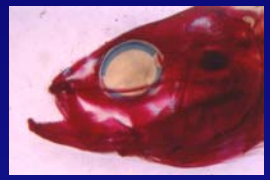
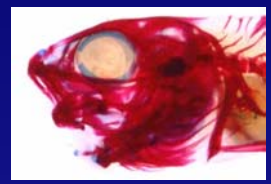
SKELETAL DESCRIPTORS FOR THE QUALITY ASSESSMENT OF TWO INNOVATIVE SPECIES OF MEDITERRANEAN AQUACULTURE: SHARPSNOUT SEA BREAM AND PANDORA

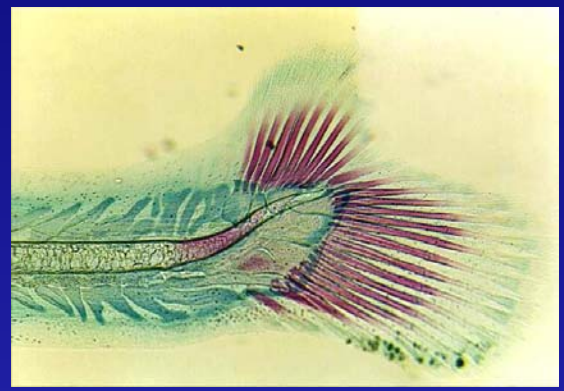


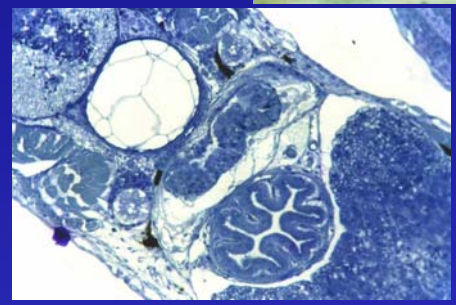
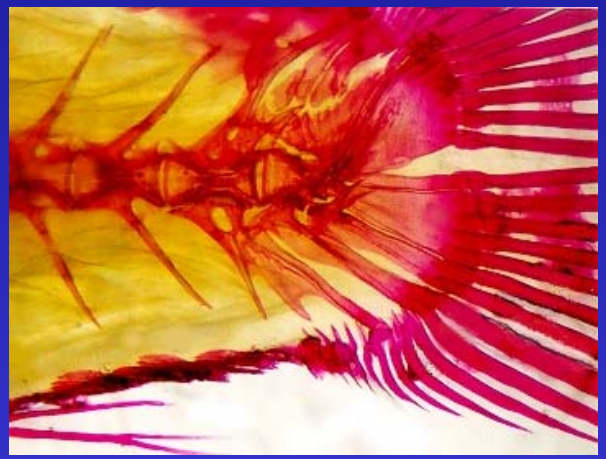
C. Boglione[1], C. Costa[1], P. Di Dato[1], G. Ferzini[1], M. Scardi[2], and S. Cataudella[1]

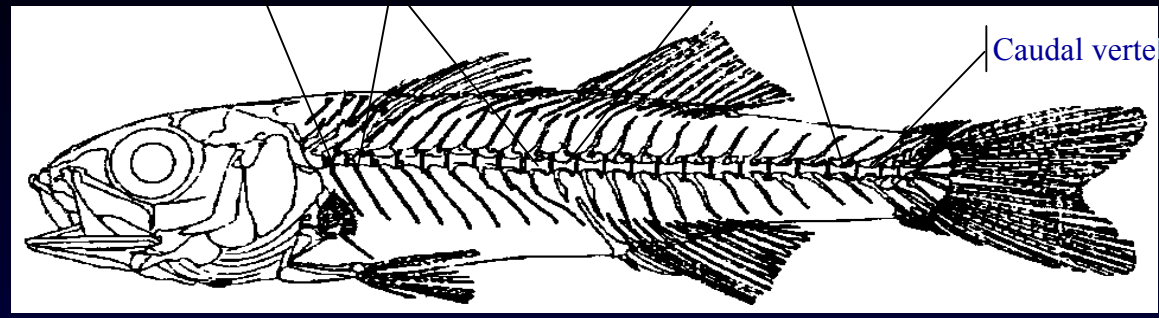
[1] Laboratory of Experimental Ecology and Aquaculture – Biology Dept. – University of Rome 'Tor Vergata' - Italy
[2] Dept. of Zoology, Univ. of Bari, Italy

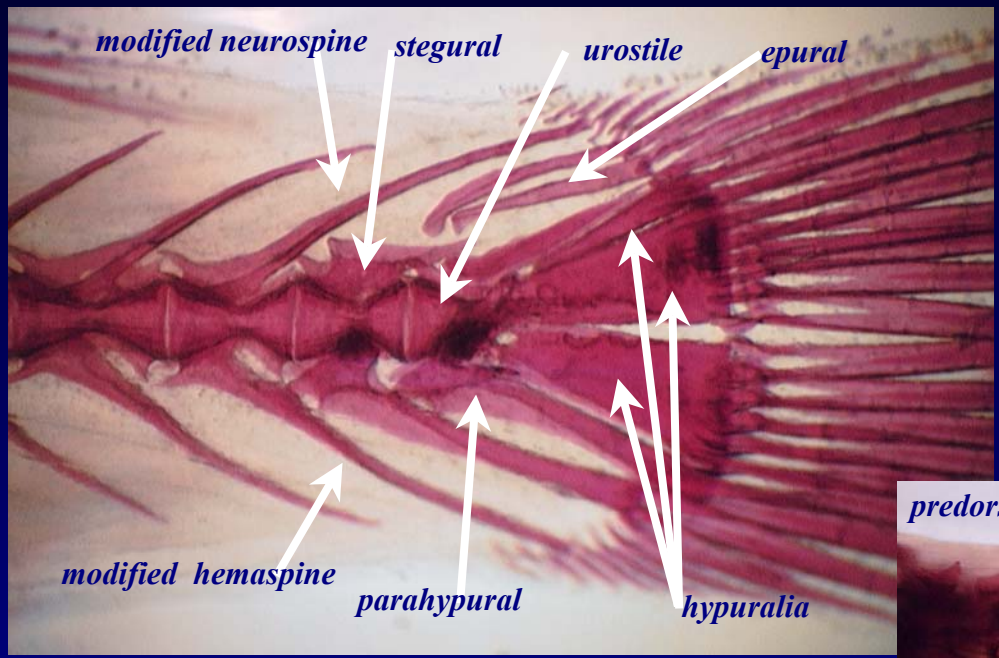





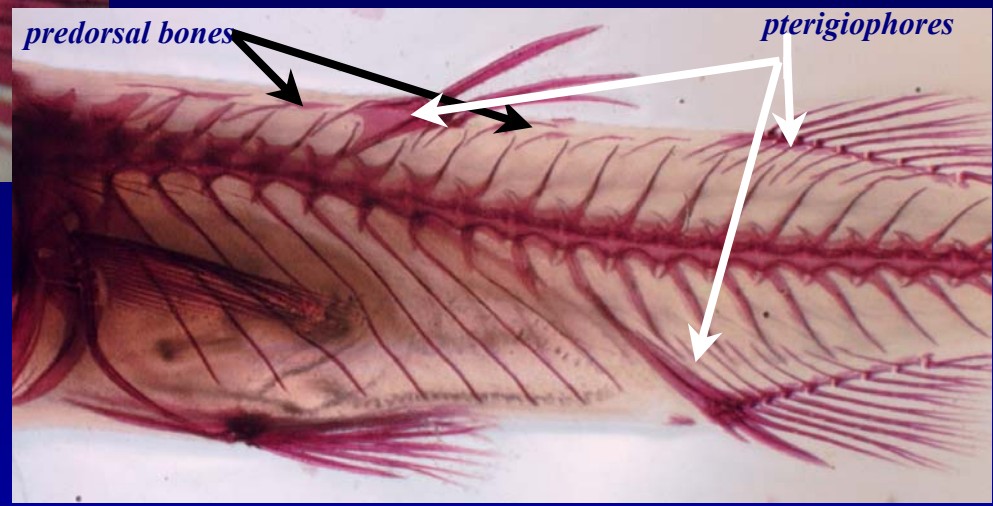


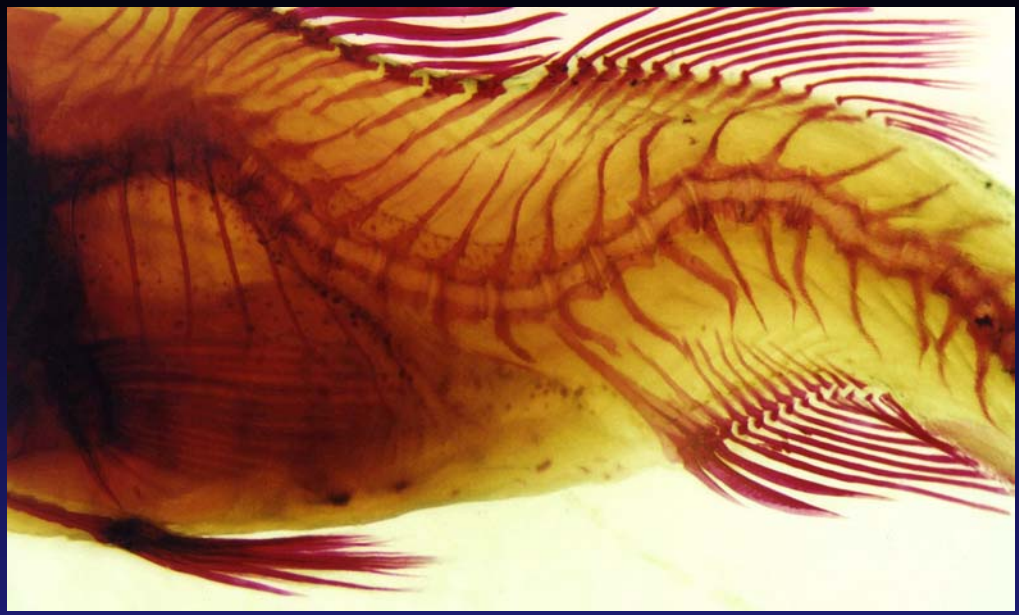


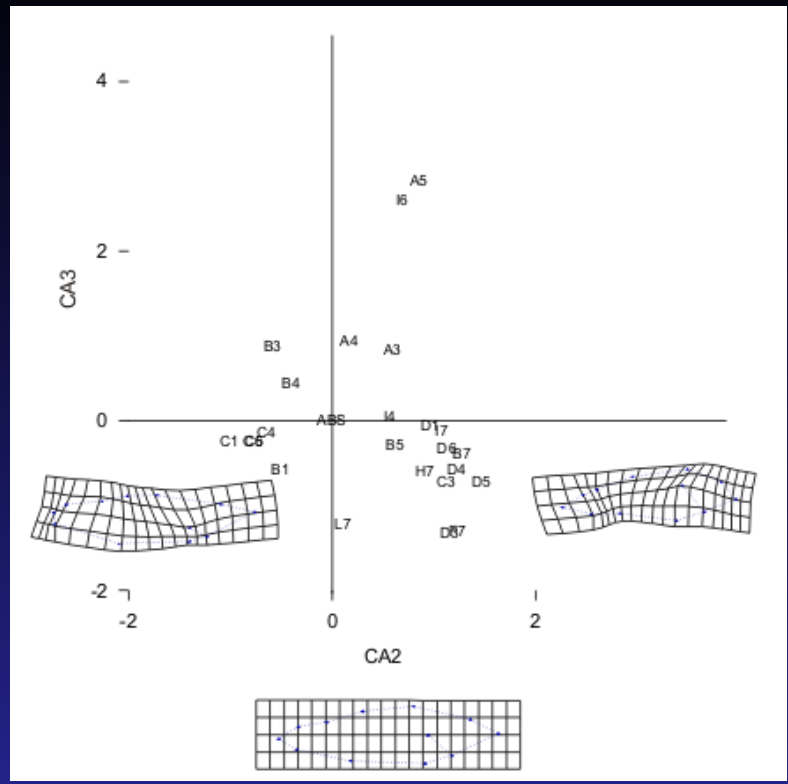





Hemal vertebrae
Cephalic vertebrae
Pre-hemal vertebrae
Caudal vertebrae


modified neurospine
stegural
urostile
epural
modified hemaspine
parahypural
hypuralia


predorsal bones
pterigiophores




4
2
0
-2
CA3
-2
0
2
CA2
A5
I6
B3
A4
A3
B4
I4
D1
I7
C1
C6
C4
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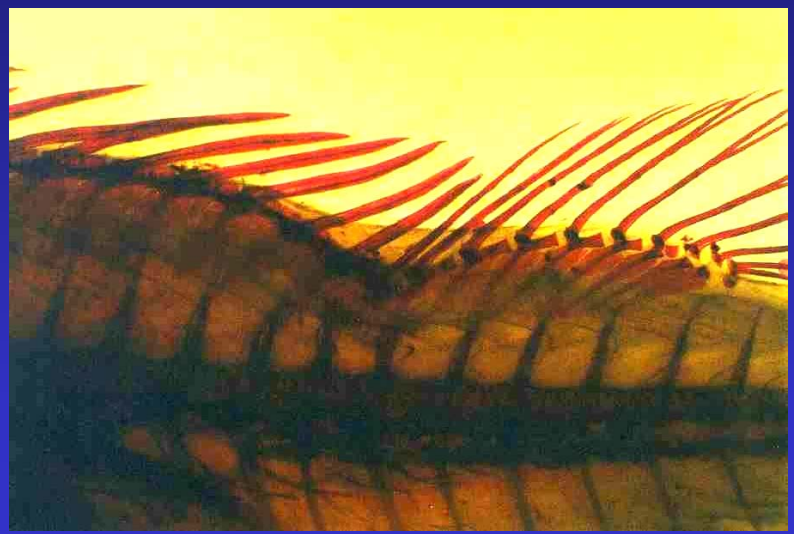
D6
B7
B1
H7
D4
C3
D5
L7
D7



LOT	n	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D1	D2	D3	D4	D5	D6	F7	F8	G7	G9	G10	H7	H8	I7	I8	12	13	14	15	16	18	19	S	SB
A	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
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A	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
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A	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SPECIES					
ORIGIN					
AGE					
INDIVIDUAL					
Standard lenght					
Vertebrae					
Upper principal caudal rays					
Lower principal caudal rays					
Upper secondary caudal rays					
Lower secondary caudal rays					
Epurals					
Hypuralia					
Anal rays					
Anal formula					
First dorsal fin rays					
First dorsal fin formula					
Second dorsal rays					
Second dorsal formula					
Pectoral rays					
Pectoral radialia					
Notes					

During the ontogenesis the expression of a genetically predetermined phenotype is modulated by the **developmental homeostasis**, which withstands **environmental and genetic disturbances**. Such homeostasis has two main components: canalization and developmental stability.

Canalization acts reducing the phenotypic variation associated with a particular trait, that might otherwise result from genetic and environmental variability (Clarke, 1995).

Developmental stability can be defined as the ability of a genotype to repeatedly and precisely produce the same phenotype when exposed to the same environmental conditions during development (Alford *et al.*, 1997).


-Juvenile Squawfish-
-Collected 8/12/92-
-Portland Harbor-
2 cm

i) heavy malformation charges and wide variability in meristic counts characterize farmed finfish (Boglione *et al.*, 1998a, b, c);

ii) there are evident effects of both larval and on growing phase conditions on malformation pattern (Boglione *et al.*, 1998b);

iii) in sea bass, hatchery-specific anomalies have been individuated (Boglione *et al.*, 1994, 1998a);

iv) in gilthead sea bream the anomalies are concentrated mostly in the caudal region (vertebrae and fin) and differences among different hatcheries productions arise for the frequencies and not for the types of anomalies (Boglione *et al.*, 2001);

v) by using these morphological 'markers', it is possible to compare the survival of wild and artificially reproduced juveniles of sea bass in the same environment – the 'valle' – identifying at capture (fish trap) to which group single individual belongs (Boglione *et al.*, 1996);

vi) it is possible to discriminate between "sibling-lots" both of sea bass and gilthead sea bream reared with different technologies (intensive vs. semi-intensive) (unpublished data);

vii) it's possible to quantify qualitative characteristics, allowing the generation of a hierarchy among the different farm productions, discriminating among different rearing technologies (Boglione *et al.*, 1994, 2001).


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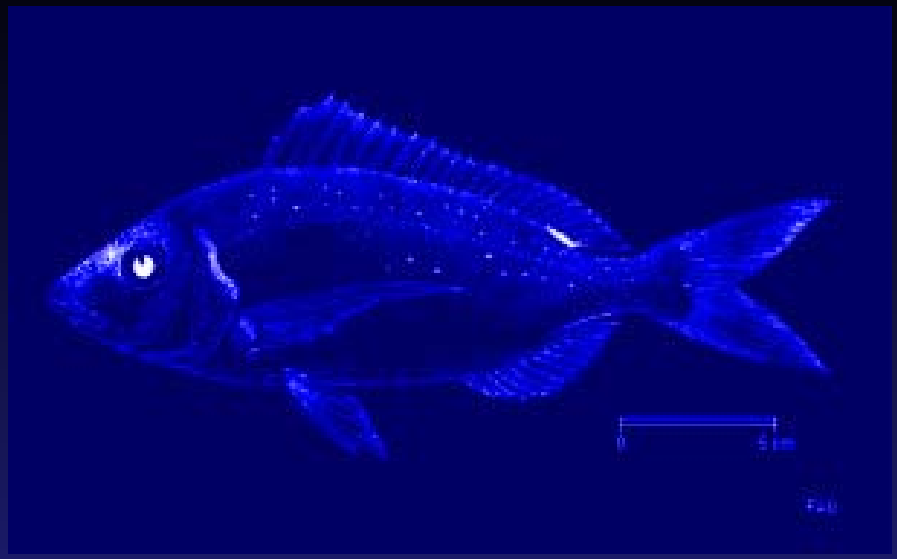


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Materials

Characteristics of observed individuals.
Age is expressed as days from hatching.

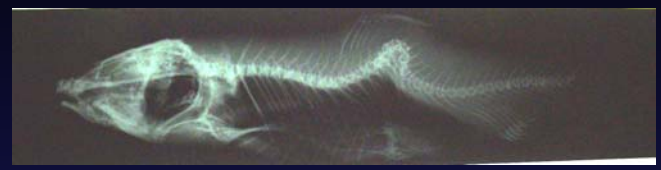
Species	code	total n.	subcode	origin	n.
D. puntazzo	DPw	*126*	L1	wild	70
			L2	wild	56
	DPr	*621*	PP50	Sicily I	89
			PP75	Sicily I	120
			PP100	Sicily I	102
			PT75	Sicily II	101
			PT100	Sicily II	110
			U100	Puglia	102
			sub total		*750*
P. erythrinus	PEw	*111*	F	wild	17
			W	wild	94
	PEr	*155*	A	Puglia	101
			B	Puglia	15
			C	Puglia	15
			D	Puglia	15
			E	Puglia	9
			sub total		*266*
			total obs.		*1016*

standard length (cm)

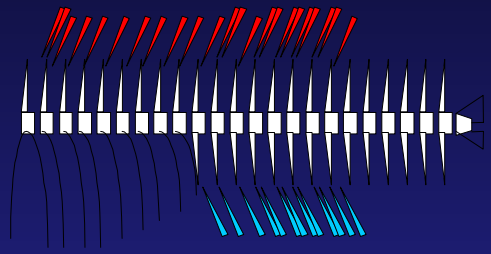
Code	Subcode	Valid N	Mean	Minimum	Maximum	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
DPw	L1	70	2.11	1.4	2.9	0.3230	0.0386	0.1119	0.2868	-0.5267	0.5663
	L2	56	2.37	1.7	2.9	0.2880	0.0385	-0.2054	0.3190	-0.7411	0.6283
DPr	PT75	101	2.35	1.8	3.1	0.2265	0.0225	0.7753	0.2402	1.8590	0.4761
	PP75	120	1.83	1.3	2.3	0.1722	0.0157	-0.3302	0.2209	0.2881	0.4383
	PP50	86	1.13	0.9	1.5	0.1272	0.0137	0.0141	0.2597	-0.2399	0.5139
	U100	102	1.78	1.2	2.5	0.3145	0.0311	0.1042	0.2391	-0.9192	0.4738
	PT100	212	3.25	2.5	4.2	0.3411	0.0234	0.0085	0.1671	-0.2653	0.3326

Code	Subcode	Valid N	Mean	Minimum	Maximum	Std.Dev.	Standard Error	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
PEr	A	103	4.3524	0	6	0.7695	0.0758	-3.3268	0.2379	18.8545	0.4716
	B	15	5.2533	4.1	7.3	0.8585	0.2217	1.2693	0.5801	1.4874	1.1209
	C	15	3.8067	3.2	4.6	0.4183	0.1080	0.2771	0.5801	-0.8336	1.1209
	D	15	3.9733	3.3	4.8	0.4682	0.1209	0.3146	0.5801	-0.6181	1.1209
	E	9	3.1111	2.7	3.4	0.2571	0.0857	-0.2708	0.7171	-0.9568	1.3997
PEw	WF	17	5.2353	3.7	6.2	0.7141	0.1732	-0.5685	0.5497	-0.1506	1.0632
	WG	94	3.7298	2.9	5.5	0.5485	0.0566	0.6786	0.2487	0.1072	0.4926

Methods

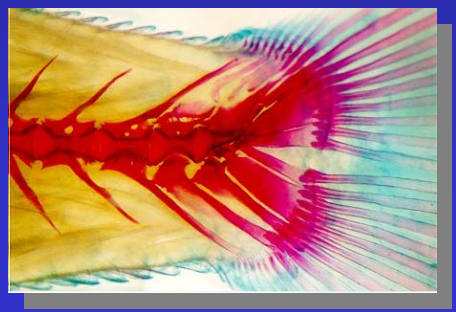


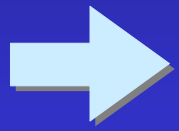
in toto staining (Park e Kim, 1984) or X-radiographs



Meristic counts

Skeletal anomalies observations





Region

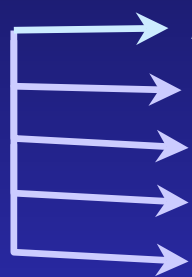
A	Cephalic vertebrae (carrying epipleural ribs)
B	Pre-hemal vertebrae (carrying epipleural and pleural ribs and with open hemal arch, without hemal spine)
C	Hemal vertebrae (with hemal arch closed by a hemal spine)
D	Caudal vertebrae (with hemal and neural arches closed by modified spines)
E	Pectoral fin
F	Anal fin
G	Caudal fin
H	Dorsal spines
I	Dorsal soft rays

Type

S	Scoliosis
SB	*Saddle-back*
1	Lordosis
2	Kyphosis
3	Incomplete vertebral fusion
3*	Complete vertebral fusion
4	Malformed vertebral body
5	Malformed neural arch and/or spine
5@	Extra-ossification in the neural region
6	Malformed hemal arch and/or spine and/or rib
6@	Extra-ossification in the hemal region
7	Malformed ray (deformed, absent, fused, supenumerary)
7*	bony notches on ray
8	Malformed pterygophore (deformed, absent, fused, supenumerary)
9	Malformed hypural (deformed, absent, fused, supenumerary)
10	Malformed epural (deformed, absent, fused, supenumerary)
12	Swim-bladder anomaly
13	Presence of calculi in the terminal tract of the urinary ducts
14	Prognatism of dental
15	Reduced dental
16	Dislocation of glossohyal
17sx	Deformed or reduced left opercle
17dx	Deformed or reduced right opercle
18	Malformed predorsal bones
19	*Malformed pre-maxillary and/or maxillary*

Methods

Skeletal anomaly observations:



- **Anomalies Frequencies**
- **Malformation Index**
- **Correspondences Analysis** ***(Benzecri et al., 1973)***
- **Multi-Response Permutation Procedure**
- **Indicator Species Analysis** ***(Dufrene & Legendre, 1997)***

Results: sharpsnout sea bream

meristic counts

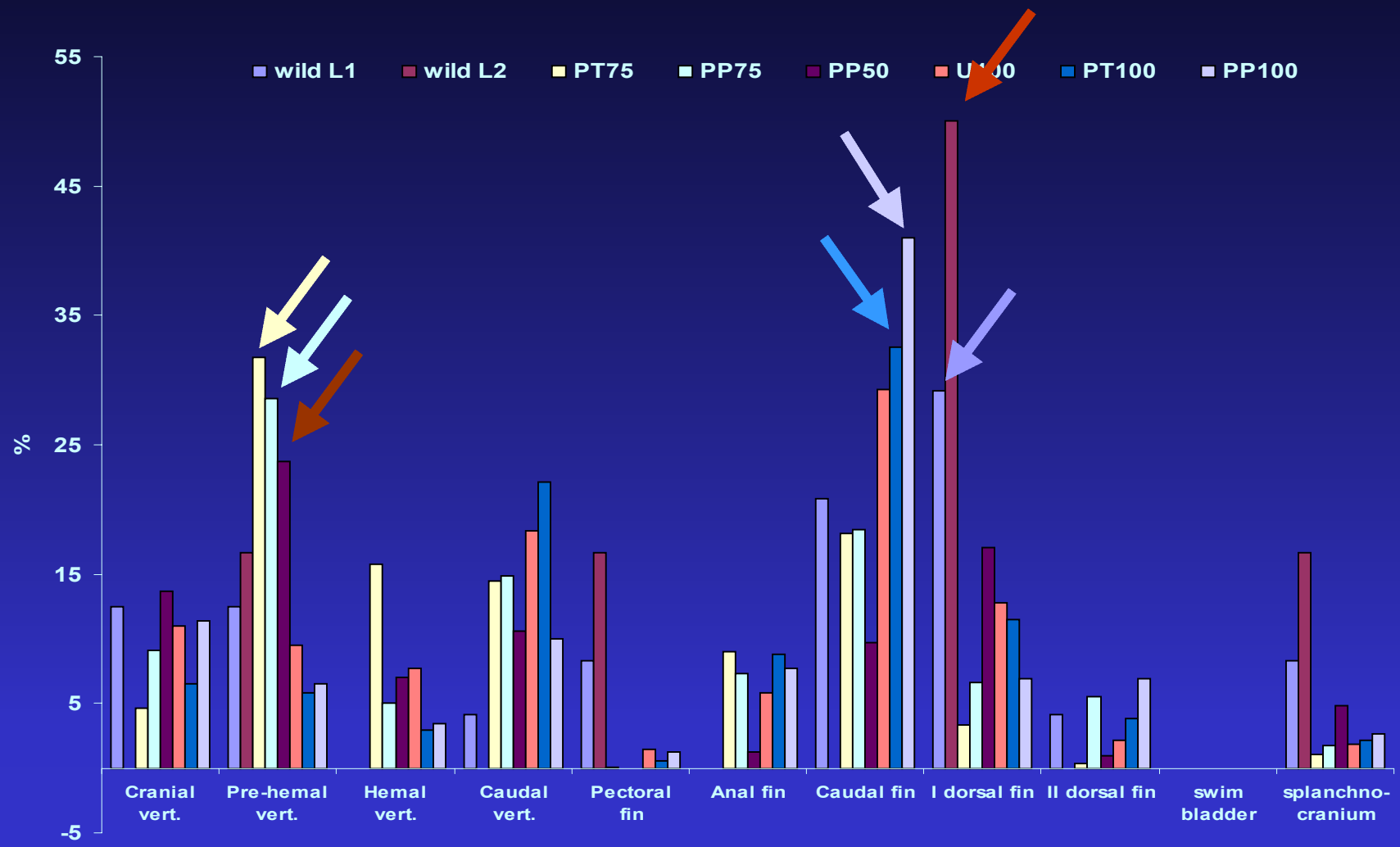
meristic character		Wild	PP50	PP75	PP100	PT75	PT100	U100
vertebrae	Median	24	24	24	24	24	24	24
	(max-min)	-	(24-22)	(24-20)	(24-23)	(25-22)	(25-19)	(24-23)
epuralia	Median	3	3	3	3	3	2	3
	(max-min)	-	(4-2)	(4-2)	(5-1)	(4-1)	(4-1)	(4-1)
hypuralia	Median	5	5	5	5	5	5	5
	(max-min)	-	(5-4)	(5-4)	(5-2)	(5-3)	(5-3)	(5-4)
hemal spine on the 1st caudal vertebra	Median	1	1	1	1	1	1	1
	(max-min)	-	-	-	(2-1)	(2-1)	(2-0)	-
parhypural	Median	1	1	1	1	1	1	1
	(max-min)	-	(1-0)	(1-0)	(2-0)	(2-0)	(2-0)	(1-0)
lower caudal rays	Median	8	8	8	8	8	8	8
	(max-min)	-	(9-8)	(9-8)	(9-8)	(9-7)	(9-7)	(9-8)
upper caudal rays	Median	9	9	9	9	9	9	9
	(max-min)	(10-9)	(9-8)	(9-8)	-	(9-8)	(9-8)	-
right pectoral rays	Median	15	14	14	14	15	14	15
	(max-min)	(16-14)	(15-13)	(16-7)	(15-13)	(16-14)	(16-13)	(16-13)
left pectoral rays	Median	15	14	14	14	15	15	15
	(max-min)	(16-14)	(16-13)	(15-13)	(15-13)	(16-14)	(16-13)	(16-13)
right pectoral radials	Median	4	4	4	4	4	4	4
	(max-min)	-	-	-	(4-3)	-	(4-3)	(4-3)
left pectoral radials	Median	4	4	4	4	4	4	4
	(max-min)	-	-	-	(5-3)	-	(4-3)	-
right pelvic rays	Median	6	6	6	6	6	6	6
	(max-min)	-	(6-5)	(7-4)	(6-3)	(6-2)	-	-
left pelvic rays	Median	6	6	6	6	6	6	6
	(max-min)	-	(7-6)	(7-3)	(6-4)	(6-2)	(7-3)	(6-3)
anal pterygophores	Median	13	13	12	13	12	12	13
	(max-min)	(13-12)	(14-11)	(13-11)	(15-11)	(14-11)	(14-11)	(15-12)
anal rays	Median	15	15	14	15	14	14	15
	(max-min)	(15-14)	(16-13)	(16-13)	(16-14)	(16-13)	(16-13)	(16-14)
dorsal pterygophores	Median	23	23	23	23	23	23	23
	(max-min)	(24-22)	(25-21)	(25-21)	(25-22)	(25-21)	(25-21)	(25-21)
dorsal spines	Median	11	10	11	11	11	11	10
	(max-min)	(12-8)	(11-9)	(12-10)	(12-10)	(12-10)	(12-10)	(12-10)
dorsal soft rays	Median	13	14	13	13	13	13	14
	(max-min)	(15-12)	(15-10)	(15-12)	(14-12)	(15-12)	(15-12)	(15-12)
predorsal bones	Median	3	3	3	3	3	3	3
	(max-min)	-	(4-1)	(3-2)	(5-2)	(3-2)	(4-2)	(4-3)

Results: sharpsnout sea bream

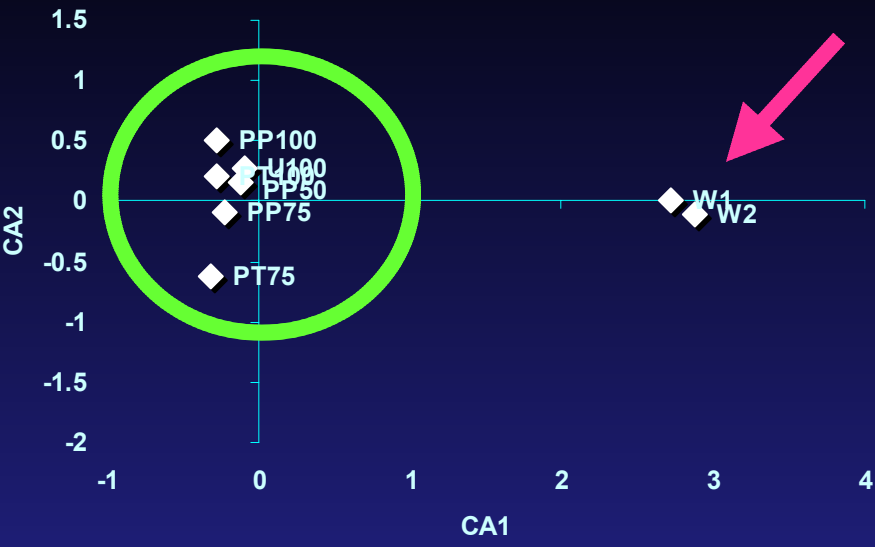
Skeletal anomalies

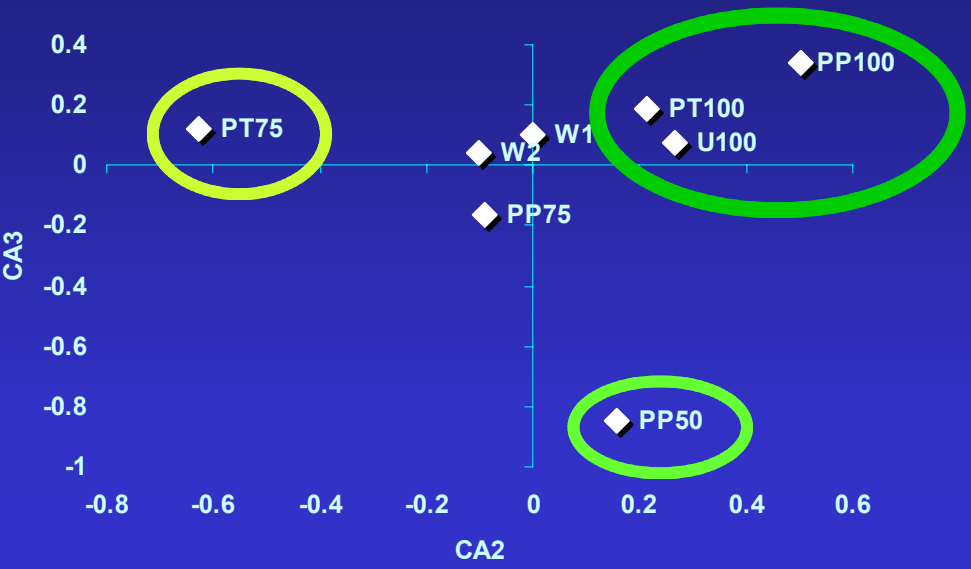
Results of quality assessment of sharpsnout sea bream lots								
	DPw		DPr					
	L1	L2	PT75	PT100	PP50	PP75	PP100	U100
n. observed individuals	70	56	101	110	89	120	102	102
individual with no anomaly	55	45	0	1	9	7	1	12
n. of malformation typologies	9	5	36	40	34	39	38	34
individuals with at least one anomaly	15	11	101	109	80	113	101	90
incidence (%) of malformed individuals	21.4	19.6	100.0	99.1	89.9	94.2	99.0	88.2
n. of inspected anomalies	24	53	925	737	329	559	490	273
total anomalies charge	1.6	4.8	9.2	6.8	4.1	4.9	4.9	3.0
individuals with at least one heavy anomaly	2	2	29	53	62	44	31	20
n. of heavy anomalies	2	2	59	87	89	68	43	34
heavy anomalies charge	1.0	1.0	2.0	1.6	1.4	1.5	1.4	1.7
heavy anom. /total anom.	8.3	3.8	6.4	11.8	27.1	12.2	8.8	12.5

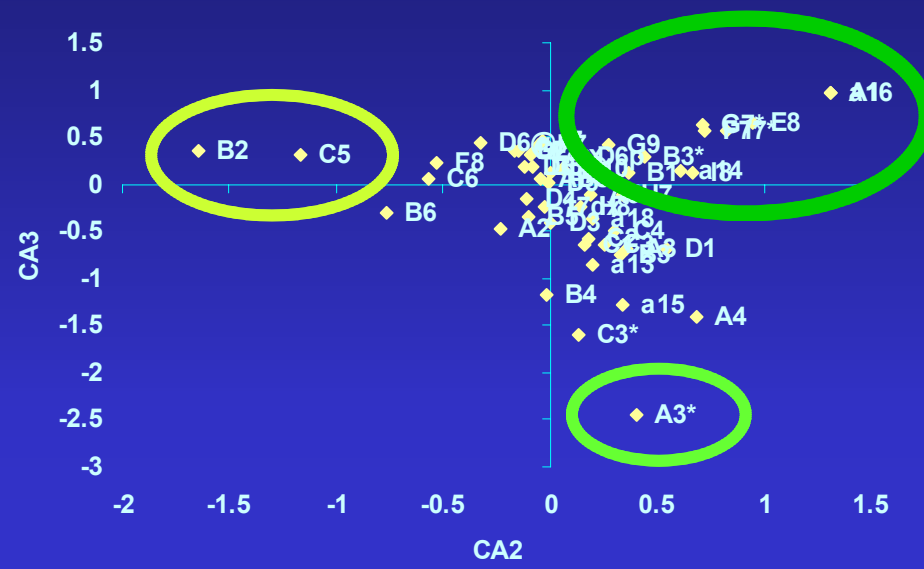
Skeletal anomalies



Skeletal anomalies: correspondence analysis







Skeletal anomalies:
multi-response permutation procedure

	Avg (d)
reared	2.463*
wild	0.537

Test T statistic		-232.302
Observed delta		2.140
Expected delta		2.318
p(T)		>0.01
for p-level = 0.01		Ho rejected

	Avg (d)
PP100	2.218
PP50	2.214
PP75	2.228
PT100	2.837*
PT75	2.549*
U100	1.924

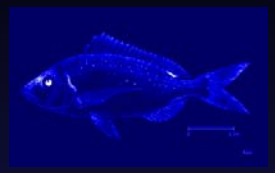
Test T statistic		-77.590
Observed delta		2.334
Expected delta		2.463
p(T)		>0.01
for p-level = 0.01		Ho rejected

Skeletal anomalies: indicator species analysis

anomaly code		Avg	Max	reared	wild	p
A5		18	35	35	0	0.000
B6		13	27	27	0	0.000
C5		4	8	8	0	0.015
C6		9	17	17	0	0.000
D3*		3	6	6	0	0.021
D4		3	5	5	0	0.023
D5		9	18	18	0	0.000
D5@		2	5	5	0	0.032
D6		8	17	17	0	0.000
D6@		6	12	12	0	0.000

anomaly code		Avg	Max	reared	wild	p
E7		1	3	0	3	0.018
F8		10	19	19	0	0.000
G9		18	36	36	0	0.000
G10		26	53	53	0	0.000
H7		10	19	19	2	0.008
H8		8	16	16	0	0.000
I7*		2	5	5	0	0.045
13		8	16	16	0	0.000
18		10	20	20	0	0.000
ABS		30	60	0	60	0.000

Results:



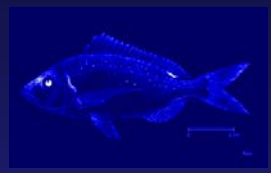
pandora

meristic counts

meristic character		WF	W	A	B	C	D	E
vertebrae	Median	24	24	24	25	24	24	24
	(max-min)	-	-	24-23	25-24	24-23	-	24-23
epuralia	Median	3	3	3	3	3	3	3
	(max-min)	-	-	3-2	-	4-2	-	-
hypuralia	Median	5	5	5	5	5	5	5
	(max-min)	5-4	5-4	6-3	-	-	-	-
lower caudal rays	Median	8	8	8	8	8	8	8
	(max-min)	-	-	-	-	-	-	8-7
upper caudal rays	Median	9	9	9	9	9	9	9
	(max-min)	-	-	-	-	-	-	-
right pectoral rays	Median	15	15	15	15	15	15	15
	(max-min)	15-14	16-13	15-14	15-14	15-14	16-14	16-14
left pectoral rays	Median	15	15	15	15	15	15	15
	(max-min)	15-14	16-13	15-14	16-14	16-14	16-14	16-14
right pectoral radials	Median	4	4	4	4	4	4	4
	(max-min)	-	4-3	-	-	-	-	-
left pectoral radials	Median	4	4	4	4	4	4	4
	(max-min)	-	-	-	-	-	-	-
right pelvic rays	Median	6	6	6	6	6	6	6
	(max-min)	-	-	-	-	-	-	-
left pelvic rays	Median	6	6	6	6	6	6	6
	(max-min)	-	6-4	-	-	-	-	-
anal pterygophores	Median	10	10	10	10	10	10	10
	(max-min)	-	11-9	11-9	11-9	10-9	11-9	10-9
anal rays	Median	12	12	12	12	12	12	12
	(max-min)	12-11	13-11	13-11	13-11	12-11	12-11	12-11
dorsal pterygophores	Median	20	20	20	20	20	20	20
	(max-min)	20-19	21-19	22-18	20-19	20-19	20-19	20-19
dorsal spines	Median	12	12	12	12	12	12	12
	(max-min)	13-12	12-11	15-11	13-11	13-12	13-11	-
dorsal soft rays	Median	10	10	10	10	10	10	10
	(max-min)	11-9	11-9	11-8	11-9	10-9	10-9	10-9
predorsal bones	Median	3	3	3	3	3	3	3
	(max-min)	-	-	3-2	-	-	-	-

Results:

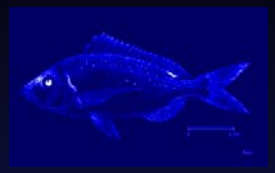
pandora



skeletal anomalies

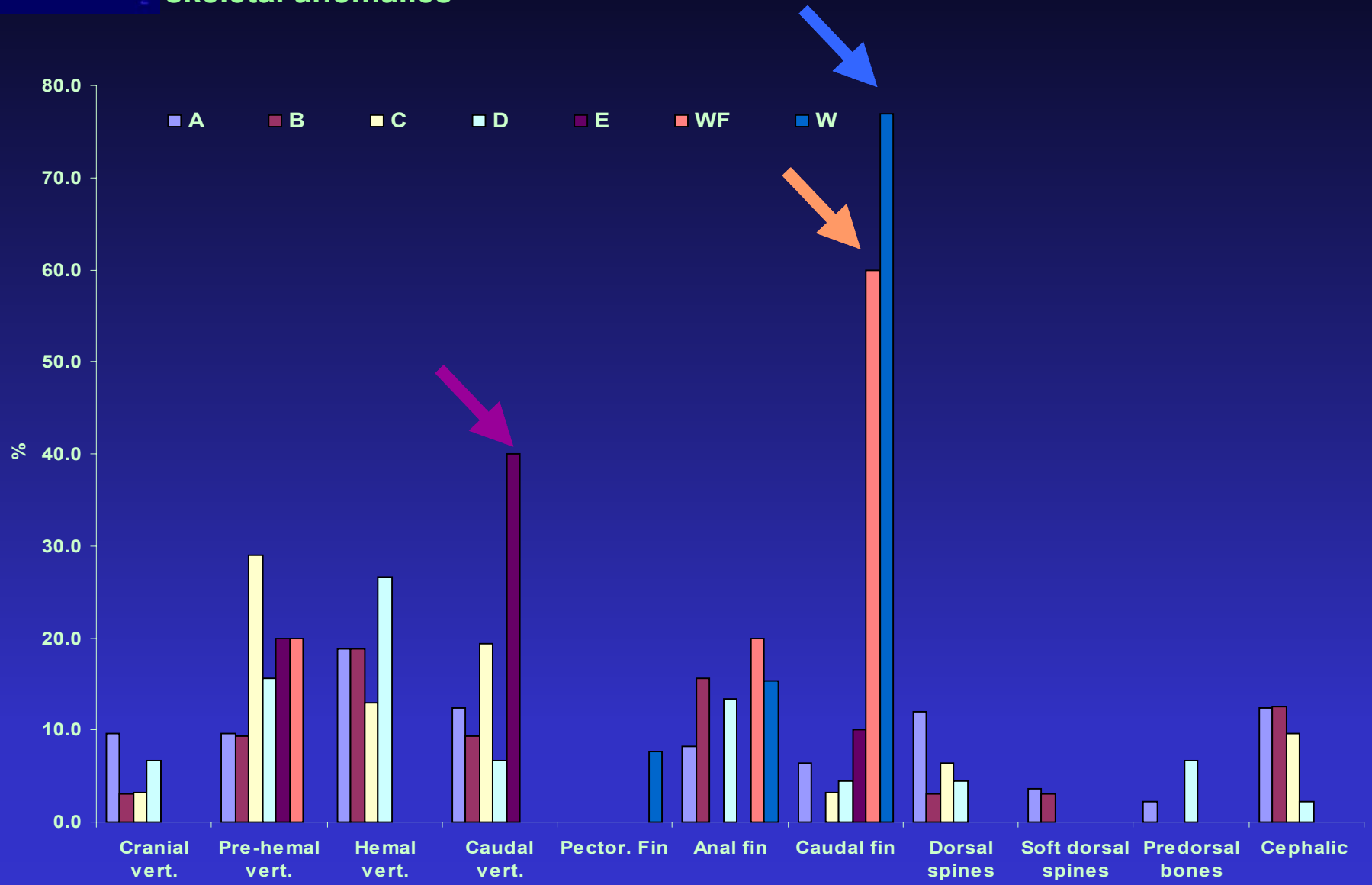
	PEw		PEr				
	F	*W*	A	B	C	D	E
n. observed individuals	*17*	*94*	101	15	15	15	9
individual with no anomaly	*13*	*82*	27	4	3	3	5
n. of malformation typologies	*3*	*4*	34	15	15	20	6
individuals with at least one anomaly	*4*	*12*	74	11	12	12	4
incidence (%) of malformed individuals	*23.5*	*12.8*	73.3	73.3	80.0	80.0	44.4
n. of inspected anomalies	*5*	*13*	218	32	31	45	10
total anomalies charge	*1.2*	*1.1*	2.9	2.9	2.6	3.7	2.5
individuals with at least one heavy anomaly	*0*	*0*	45	10	8	8	3
n. of heavy anomalies	*0*	*0*	89	19	17	3	5
heavy anomalies charge	-	-	2.0	1.9	2.1	0.4	1.7
heavy anom. /total anom.	-	-	40.8	59.4	54.8	6.7	50.0

Results:

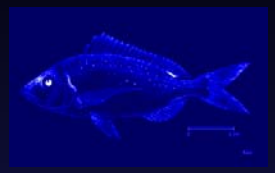


pandora

skeletal anomalies

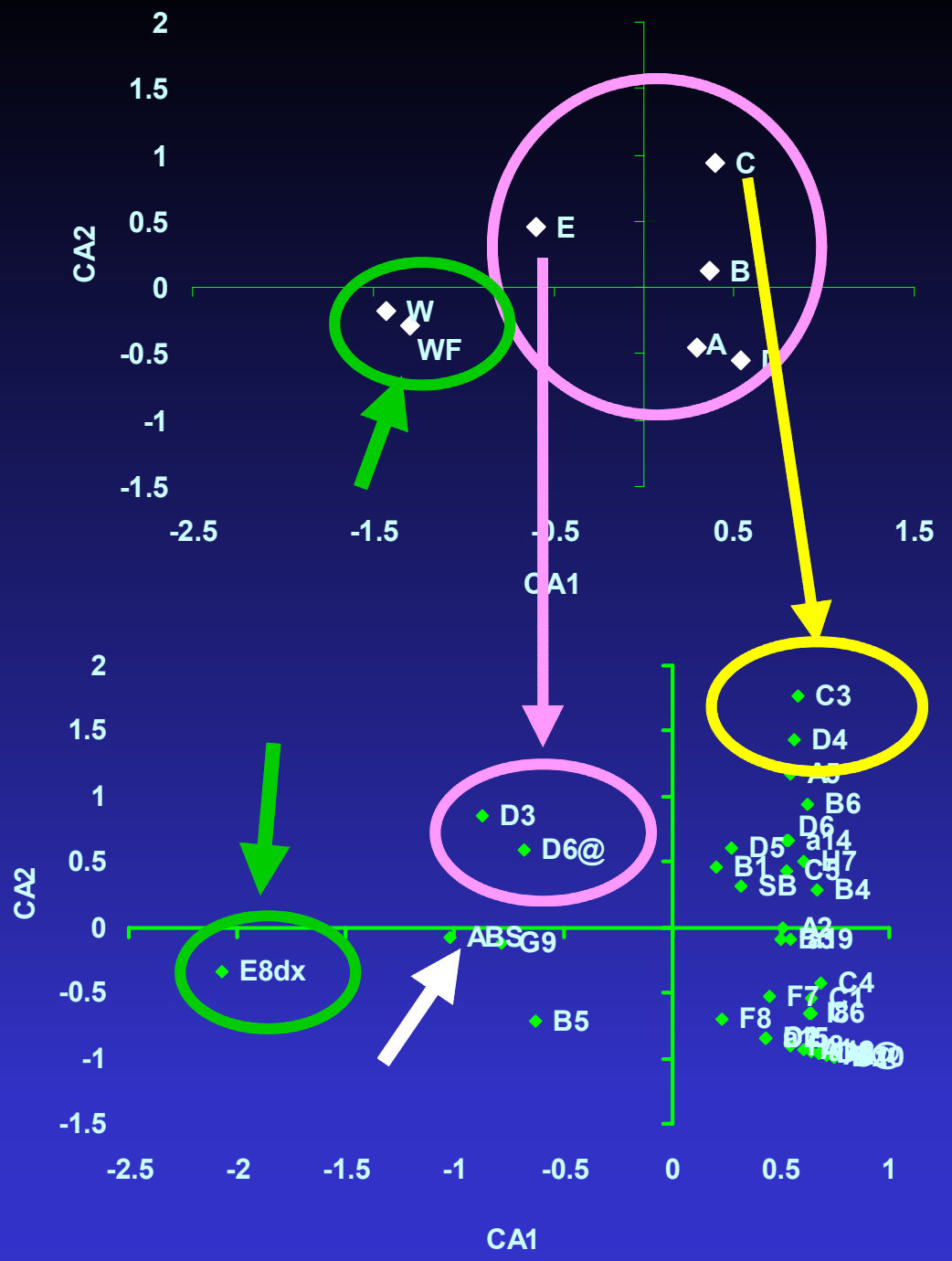


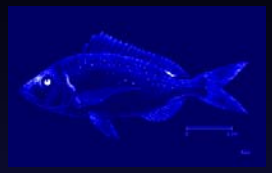
Results:



pandora

skeletal anomalies:
correspondence analysis





pandora

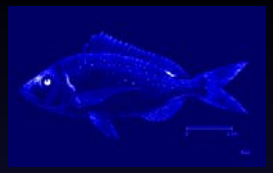
skeletal anomalies:
multi-response permutation procedure

	Avg (d)
reared	1.826*
wild	0.374

Test T statistic		-60.888
Observed delta		1.224
Expected delta		1.363
p(T)		>0.01
for p-level = 0.01		Ho rejected

	Avg (d)
A	1.813
B	1.740
C	1.835
D	2.138
E	1.274

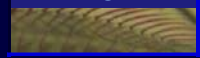
Test T statistic		-2.529
Observed delta		1.808
Expected delta		1.826
p(T)		>0.01
for p-level = 0.01		Ho accepted



pandora

skeletal anomalies: indicator species analysis

anomaly code		avg	max	reared	wild	p
A1		5	11	11	0	0.001
B1		4	8	8	0	0.005
B6		2	5	5	0	0.037
C1		5	11	11	0	0.000
C4		4	7	7	0	0.007
C5		3	5	5	0	0.015
C6		4	7	7	0	0.005
D5		5	10	10	0	0.001
D5@		3	5	5	0	0.024
D6		4	8	8	0	0.004

anomaly code		avg	max	reared	wild	p
F8		4	7	7	0	0.026
H7		3	6	6	0	0.010
H8		5	10	10	0	0.002
I8		3	5	5	0	0.022
14		3	6	6	0	0.005
18		3	5	5	0	0.013
19		7	14	14	0	0.000
SB		10	20	20	0	0.000
ABS		36	66	5	66	0.000

Conclusions

- The meristic counts showed a certain level of variability in reared lots only, indicating conditions of major developmental stability in the wild lots with respect to the hatchery-reared ones.
- Different regions are affected by anomalies in the different species of the same family, the Sparids.
- The skeletal anomalies survey indicated that in reared sharpsnout sea bream and pandora age-specific-anomalies exist.
- The average incidence of malformed individuals in reared sharpsnout sea bream was 58.5%, in reared pandora 72.9% while in reared gilthead sea bream lots it varied from 98.3 to 100% (Boglione *et al.*, 2001).
- The absence of an activated swim-bladder was never found.
- The CA applied to the frequencies matrix of anomalies evidenced that the quality both in reared sharpsnout sea bream and pandora lots can worsen with age.

An elevated occurrence of severe anomalies in hatchery-reared pandora could be linked to the very experimental rearing of such demersal necto-benthonic species. Further knowledge on larval behaviour and trophism of new candidate species is required in order to set up satisfactory rearing protocols.

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