Supplementary Material on the Methodology Part XV
Final report on meristic analyses of sardine and European hake

The identification of sardine and hake stocks in the Alboran Sea and adjacent waters was realized from samples collected from four countries: Morocco, Algeria, Spain and Tunisia. These samplings were carried out from May to September 2018 for sardine and from October 2018 to February 2019 for hake. This study was based on two meristic characteristics namely the number of vertebrae and the number of gill rakers. 736 individuals of sardine and 551 individuals of hake were processed for vertebrae count and a total of 862 individuals of sardine and 592 individuals of hake for gills count. Analysis of samples of studied species was carried out by grouping sampling sites into geographical sub-areas: North Atlantic "N. Atlantic" (Cadiz, Huelva); South Atlantic "S. Atlantic" (Mehdia, Agadir); North Alboran "N. Alboran" (Estepona, Malaga, Roquetas, Torrevierja, Castellon); South Alboran "S. Alboran" (M'diq, Al Hoceima, Nador, Ghazaouet); South Mediterranean "S. Medit" (Cherchell, Annaba) and East Mediterranean "E. Medit" (Tabarka, Gulf of Tunis).

Sardine: *Sardina pilchardus*

The average of vertebrae varies between 50.613 in S. Alboran and 51.428 in N. Alboran, while the average for gill rakers was between 53.045 in S. Medit and 62.460 in S. Atlantic (Table 1). According to these two variables, global analysis of variance ANOVA between the different geographical sub-areas showed a significant difference at the level of 5%.

Table 1. Average number of vertebrae and gill rakers for sardine

Area	Average number of vertebrae	Average number of gill rakers
N. Atlantic	51.407 ± 0.016	55.640 ± 0.114
S. Atlantic	50.720 ± 0.015	62.460 ± 0.131
N. Alboran	51.428 ± 0.013	54.123 ± 0.145
S. Alboran	50.613 ± 0.032	57.330 ± 0.096
S. Medit	51.218 ± 0.014	53.045 ± 0.103
E. Medit	51.080 ± 0.014	53.510 ± 0.088

The pairwise comparison of geographical sub-areas showed that for both variables, the most significant difference was observed between N. Atlantic and S. Atlantic, N. Alboran and S. Alboran and between S. Medit and S. Alboran. However, analysis of vertebrae count showed that sardine samples from S. Atlantic have an affinity with those from the south of the Mediterranean (S. Alboran, S. and E. Medit), while a significant difference was recorded between these samples according to gill rakers (Table 2).

Table 2: Pairwise comparison of Tukey's test for Sardine

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Fit: aov(formula = glm(Nb.Vertebrae ~ Area, data = data, family = quasipoisson))

$Area
                         diff          lwr          upr      p adj
N.Alboran-E.Medit      0.34774566   0.110720335   0.58477099 0.0004439
N.Atlantic-E.Medit     0.32740741   0.008767646   0.64604717 0.0399924
S.Alboran-E.Medit     -0.19500000  -0.426090513   0.03609051 0.1536747
S.Atlantic-E.Medit    -0.05000000  -0.316840340   0.21684034 0.9947171
S.Medit-E.Medit        0.13818182  -0.122523441   0.39888708 0.6550586
N.Atlantic-N.Alboran  -0.02033826  -0.314461595   0.27378508 0.9999585
S.Alboran-N.Alboran   -0.54274566  -0.738653973  -0.34683736 0.0000000
S.Atlantic-N.Alboran  -0.39774566  -0.634770995  -0.16072033 0.0000291
S.Medit-N.Alboran     -0.20956385  -0.439660505   0.02053281 0.0979412
S.Alboran-N.Atlantic  -0.52240741  -0.811769388  -0.23304543 0.0000048
S.Atlantic-N.Atlantic -0.37740741  -0.696047169  -0.05876765 0.0097535
S.Medit-N.Atlantic    -0.18922559  -0.502745545   0.12429437 0.5158993
S.Atlantic-S.Alboran   0.14500000  -0.086090513   0.37609051 0.4709959
S.Medit-S.Alboran      0.33318182   0.109203492   0.55716014 0.0003460
S.Medit-S.Atlantic     0.18818182  -0.072523441   0.44888708 0.3083463




Fit: aov(formula = glm(Nb.Gill.rakers ~ Area, data = data, family = quasipoisson))

$Area
                        diff          lwr          upr       p adj
N.Alboran-E.Medit      0.6129508   -1.6275533    2.8534548986 0.9706591
N.Atlantic-E.Medit     2.1300000   -0.5385567    4.7985566615 0.2034411
S.Alboran-E.Medit      3.8200971    1.5203052    6.1198889546 0.0000360
S.Atlantic-E.Medit     8.9500000    6.2814433   11.6185566615 0.0000000
S.Medit-E.Medit       -0.4653571   -3.0614508    2.1307364773 0.9957210
N.Atlantic-N.Alboran   1.5170492   -0.7234549    3.7575532593 0.3820445
S.Alboran-N.Alboran    3.2071463    1.4217313    4.9925612068 0.0000053
S.Atlantic-N.Alboran   8.3370492    6.0965451   10.5775532593 0.0000000
S.Medit-N.Alboran     -1.0783080   -3.2319946    1.0753786342 0.7086756
S.Alboran-N.Atlantic   1.6900971   -0.6096948    3.9898889546 0.2887007
S.Atlantic-N.Atlantic  6.8200000    4.1514433    9.4885566615 0.0000000
S.Medit-N.Atlantic    -2.5953571   -5.1914508    0.0007364773 0.0501134
S.Atlantic-S.Alboran   5.1299029    2.8301110    7.4296947798 0.0000000
S.Medit-S.Alboran     -4.2854542   -6.5007533   -2.0701551394 0.0000007
S.Medit-S.Atlantic    -9.4153571  -12.0114508   -6.8192635227 0.0000000
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Hake: *Merluccius merluccius*

The average number of vertebrae varies between 50.697 and 51.348 observed successively in N. Atlantic and N. Alboran, while for gill rakers, the average is between 9.332 in N. Alboran and 9.951 in S. Medit (Table 3). According to these two variables, global analysis of variance ANOVA between the different geographical sub-areas showed a significant difference at the 5% level.

Table 3. Average number of vertebrae and gill rakers for Hake

Area	Average number of vertebrae	Average number of gill rakers
N. Atlantic	50.697 ± 0.015	9.338 ± 0.056
S. Atlantic	51.154 ± 0.015	9.625 ± 0.082
N. Alboran	51.348 ± 0.015	9.332 ± 0.070
S. Alboran	51.101 ± 0.015	9.802 ± 0.063
S. Medit	51.341 ± 0.018	9.951 ± 0.059
E. Medit	51.211 ± 0.016	9.513 ± 0.069

The pairwise comparison based on the vertebrae count showed that N. Atlantic hake stock is different from all samples of the other geographical sub-areas, but according to gill rakers count, the difference is recorded only with S. Alboran and S. Mediterranean. Considering this second variable, a significant difference was observed between N. Alboran, S. Alboran and S. Mediterranean and between E. and S. Mediterranean (Table 4).

Table 4: Pairwise comparison of Tukey's test for Hake

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Fit: aov(formula = glm(Nb.Vertebrae ~ Area, data = data_hk, family = quasipoisson))

$Area
                          diff           lwr          upr      p adj
N.Alboran-E.Medit      0.137299771 -0.17769911   0.45229865 0.8135936
N.Atlantic-E.Medit    -0.513157895 -0.88032416  -0.14599163 0.0010257
S.Alboran-E.Medit     -0.109685980 -0.44203285   0.22266089 0.9348723
S.Atlantic-E.Medit    -0.056680162 -0.42148520   0.30812488 0.9978120
S.Medit-E.Medit        0.130937099 -0.30764285   0.56951705 0.9570307
N.Atlantic-N.Alboran  -0.650457666 -0.96545654  -0.33545879 0.0000001
S.Alboran-N.Alboran   -0.246985751 -0.52060532   0.02663382 0.1035527
S.Atlantic-N.Alboran  -0.193979933 -0.50622334   0.11826347 0.4817388
S.Medit-N.Alboran     -0.006362672 -0.40229903   0.38957369 1.0000000
S.Alboran-N.Atlantic   0.403471915  0.07112504   0.73581879 0.0073342
S.Atlantic-N.Atlantic  0.456477733  0.09167269   0.82128277 0.0050332
S.Medit-N.Atlantic     0.644094994  0.20551505   1.08267494 0.0004454
S.Atlantic-S.Alboran   0.053005818 -0.27673059   0.38274222 0.9974258
S.Medit-S.Alboran      0.240623078 -0.16924977   0.65049592 0.5463502
S.Medit-S.Atlantic     0.187617261 -0.24898785   0.62422237 0.8225699



Fit: aov(formula = glm(Nb.Gill.rakers ~ Area, data = data_hk, family = quasipoisson))

$Area
                          diff           lwr          upr      p adj
N.Alboran-E.Medit     -0.180921053 -0.42675274   0.06491063 0.2864420
N.Atlantic-E.Medit    -0.175000000 -0.46664046   0.11664046 0.5219025
S.Alboran-E.Medit      0.289152893  0.02336321   0.55494258 0.0239109
S.Atlantic-E.Medit     0.112500000 -0.17914046   0.40414046 0.8801582
S.Medit-E.Medit        0.438719512  0.08445020   0.79298882 0.0057307
N.Atlantic-N.Alboran   0.005921053 -0.23991063   0.25175274 0.9999998
S.Alboran-N.Alboran    0.470073945  0.25554372   0.68460417 0.0000000
S.Atlantic-N.Alboran   0.293421053  0.04758937   0.53925274 0.0089550
S.Medit-N.Alboran      0.619640565  0.30201531   0.93726582 0.0000006
S.Alboran-N.Atlantic   0.464152893  0.19836321   0.72994258 0.0000116
S.Atlantic-N.Atlantic  0.287500000 -0.00414046   0.57914046 0.0559337
S.Medit-N.Atlantic     0.613719512  0.25945020   0.96798882 0.0000141
S.Atlantic-S.Alboran  -0.176652893 -0.44244258   0.08913679 0.4029320
S.Medit-S.Alboran      0.149566620 -0.18374516   0.48287840 0.7943520
S.Medit-S.Atlantic     0.326219512 -0.02804980   0.68048882 0.0910861
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