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Comparing monkfish (*Lophius piscatorius* and *L. budegassa*) abundance in ICES Division VIIIc by year and depth strata

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Abstract

The abundance of white and black monkfish in ICES Division VIIIc is compared by year and depth strata using an unbalanced analysis of variance design. The abundance indices were derived from the catch rates (Kg/30min) by species observed during the Spanish bottom trawl surveys carried out between 1983 and 1993 in that area. The analysis suggests that black monkfish abundance has been stable in this area along the 10 years period, while different abundance levels emerge for white monkfish; the former, with higher values, between 1983-19886 and the latter between 1990-1993. Depth strata ranging from 30m to 500m were also considered in the model, but no significant differences were retained for both species, as supported by the statistical power analysis performed. It is, therefore, concluded that between 1988 and 1993, white and black monkfish do not present abundance stratification by depth in the ICES Division VIIIc.

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Introduction

The species of monkfish (*Lophius* spp.) are widely distributed in the Atlantic. Both species are caught as a whole in the Southern stock (ICES Divisions VIIIc and IXa) by trawl and fixed nets fisheries.

Since 1980 the Spanish Institute of Oceanography carried out bottom trawl surveys having among its objectives the estimation of the abundance indices of the most important commercial species. Sánchez *et al.* (1991) analyze the evolution of the results of these surveys. The bathymetric distribution of the species of the Cantabrian Sea has been studied by Sánchez (1993) indicating that black monkfish (L. *budegassa*) appears between 75m and 400m depth, preferencially to the 200m depth while white monkfish (L. *piscatorius*) is distributed between 50m and 300m depth, with preference for the depth range 75-175m.

During the ICES Southern Shelf Demersal Stocks Working Group meeting (ICES, 1994) monkfish abundance index, obtained from Spanish and from Portuguese surveys, were plotted in order to visually analyze the abundance trend along the available time series.

This paper is presented with the aim of improving the knowledge about monkfish spatial distribution, as well as its abundance trend between 1983 and 1993 in the Cantabrian Sea (ICES Division VIIIc).

Material

A data series of white and black monkfish catch rates, expressed in Kg/30min., was obtained between 1983 and 1993 during the Spanish bottom trawl surveys, which followed a stratified random design (Sánchez *et al.*, 1991); the year 1987 was not covered. The sampled area ranges from the mouth of Bidasoa river and the Cape Finisterre, included in ICES Division VIIIc and the depth strata ranges from 30m to 500m, resulting in a total of 656 sampled units. The observed mean catch rates by species are presented in Table 1.

Table 1 - Monkfish mean catch rates (Kg/30min) in ICES Division VIIIc, by species, observed during the Spanish bottom trawl surveys carried out between 1983 and 1993.

Year	White monkfish			Black monkfish		
	Depth (m)			Depth (m)		
	30-100	101-200	201-500	30-100	101-200	201-500
1983	1.01	3.29	5.84	1.38	0.98	0.75
1984	2.77	2.65	7.00	0.73	0.74	0.49
1985	0.32	1.79	3.34	0.90	0.48	0.88
1986	1.85	5.19	4.24	0.05	1.85	1.66
1988	2.70	3.81	7.31	2.06	3.34	2.03
1989	1.01	0.64	0.41	1.08	0.65	0.35
1990	1.62	1.73	2.18	1.37	3.23	0.76
1991	0.76	1.70	0.64	1.59	1.78	0.85
1992	0.53	1.37	1.49	1.00	2.17	0.73
1993	0.14	1.39	2.21	1.31	1.13	1.84

Methods

The continuous random variable, catch rate (Kg/30min), assumed to be obtained randomly from normal populations, with equal variances is analyzed by year (1983-1993), by depth strata (30m-500m) and by species. It is also assumed that the effects of the factors levels are additive. So, the comparisons were performed using an analysis of variance. Since the design is unbalanced, i.e, nonorthogonal, two approaches for computing the sum of squares can be applied: the unweighted mean approach or the analysis of unique sources, following the regression approach to the analysis of variance (Netter, *et. al.*, 1990). The former was used. As there still may be a slight bias associated with the tests performed this way (Netter, *et. al.*, 1990; Lindman, 1992) than to compensate for any positive bias, associated with the *omnibus* test, a more stringent significance level was used (Keppel, 1991) for the experimentwise error rate, being α_{exp} set equal to 0.03. As a consequence, the familywise error rate was set equal to α_{fw}=0.03/c, where c stands for the number of F tests performed.

The requirements of normality, homocedasticity, stated previously and also uncorrelation between means and standard deviations, were checked. The data deviated from these requirements, both for white and black monkfish raw data and therefore, data transformation was applied.

The effects of factor Year (10 levels: 1983-1986, 1988-1993), factor Depth (3 levels: 30-100m, 101-200m, 201-500m) and of the interaction Year*Depth, in the abundance of white and black monkfish were assessed. *Post hoc* comparisons were performed whenever a significant effect was detected. Power analysis was also conducted in order to evaluate the probability of having committed a type II error.

Results

Transformation of raw data

White monkfish raw data was transformed to $(Kg/30min)^{0.25}$ and black monkfish data to $(Kg/30min)^{0.15}$. The different form of the random variables resulted in uncorrelated means *vs* standard deviations for both species (the critical r value at 5% significance level was considered). Homogeneity hypothesis, tested with Bartlett test and compared to the 5% significance level, was not rejected for black monkfish (p=0.988), although rejected for white monkfish (p<<0.05). Normality assumption was checked on within-cell residuals for both species and considered not to be violated.

Unbalanced analysis of variance

Table 2 presents the outputs of the *omnibus* test performed for white monkfish. The p values were compared to α_{fw}= 0.01, as previously explained. Only differences between years are outlined. This feature is also inferred for black monkfish (Table 3).

Table 2 - Analysis of variance outputs for white monkfish (df - degrees of freedom, MS - mean square).

Source of variation	df	MS	F	p value
Year	9	1.362	4.466	0.000
Depth	2	0.273	0.895	0.409
Year*Depth	18	0.344	1.129	0.319
error	626	0.305		

Table 3 - Analysis of variance outputs for black monkfish (df - degrees of freedom, MS - mean square).

Source of variation	df	MS	F	p value
Year	9	0.741	2.873	0.002
Depth	2	0.169	0.657	0.519
Year*Depth	18	0.330	1.280	0.194
error	626	0.258		

Post hoc comparisons

Pairwise comparisons were performed taking into account the nonorthogonal design used and controlling the αfw error rate. The summary of the results is presented in Table 4 for white monkfish, which should be read as pairs (1983, 1991), (1983, 1993), (1984, 1989), (1984, 1991) and so on.

Table 4 - Summary of the results of the *post hoc* comparisons performed for white monkfish.

Year level	Significant pairwise differences (αfw=0.01)
1983	1991, 1993
1984	1989, 1991, 1992, 1993
1986	1991, 1992, 1993
1988	1991

It is stressed the significant differences in white monkfish abundance between 1983, 1984 and 1986 and the most recent years (1991, 1992 and 1993), with the exception of the pair (1983, 1992). Year 1984 also differ from 1989 and 1988 from 1991. It is also stressed that most recent years do not differ between each other. It is observed that along the analyzed period the lowest monkfish abundance occurred between 1991 and 1993; backtransforming the random variable to the original scale, Kg/30min., the mean catch rate of those years range from 0.12 to 0.37 Kg/30min., when in 1983, 1984 and 1986 it was observed a mean abundance ranging from 1.62 to 1.78 Kg/30min.

Table 5 presents the results for black monkfish. They show that significant differences occur between 1988 and the previous years (period 1983-1986) and also between 1992. It is therefore concluded that, with the exception of 1988, when the highest mean abundance was observed, no abundance differences in black monkfish have occurred along the analyzed period.

Table 5 - Summary of the results of the *post hoc* comparisons performed for black monkfish.

Year level	Significant pairwise differences (αfw=0.01)
1988	1983, 1984, 1985, 1986, 1992

Power analysis

Power analysis was performed for the main effect Depth. It was considered that if medium to large effects were really present, than the null hypothesis tested is a true statement about the population sampled. The results, under these conditions, show that the probability of having committed a type II error is very low for both species, resulting in power levels beyond 99%.

Conclusions

It is concluded that black monkfish abundance by year has been stable, in ICES Div. VIIIc, along the 10 years period (1983-1993). The year 1988 is an exception, since it was observed a higher mean abundance. A similar analysis, carried out for black monkfish in ICES Division IXa (Portuguese waters - south and southwest coast) between 1990 and 1992 and between 100-400m depth strata (Azevedo, 1994), shows an abundance decrease between those years in the southwest coast (37°00'N -

38°40'N), although this feature was not infered to the south zone (7°25'W - 9°00'W). With respect to depth strata, the author points out that black monkfish abundance levels differ between 100-200m and 300-400m depth strata, in the south coast. Therefore, when comparing these results it seems that black monkfish present different distribution patterns and abundance trends in ICES Division VIIIc and IXa. In the former area the abundance of this species has been relatively stable between 1983 and 1993 and shows no abundance stratification by depth, while in the latter area the analysis performed (Azevedo, 1994) suggests that black monkfish occur preferentially in the continental shelf in the Portuguese south zone and that the species abundance decreased in most recent years (1990-1992), at least in the Portuguese southwest zone.

The abundance of white monkfish in ICES Division VIIIc was higher between 1983 and 1986 (exception to the year 1985) and after 1988 has decreased. No significant differences between the depth strata analyzed (30m-500m) were retained, suggesting that the abundance levels of this species in the this area do not differ between the continental shelf and the shelf edge.

References

Azevedo, M., 1994. A statistical analysis of black monkfish catch rates in ICES Division IXa. 11pp. (unpublished).

ICES, 1994. Report of the Working Group on the Assessment of the Southern Shelf Demersal Stocks. ICES, *C.M. 1994/Assess:3.*

Keppel, G., 1991. *Design and analysis. A researcher's handbook.* Prentice Hall, N.J. (3rd. ed.).

Lindman, H.R., 1992. *Analysis of variance in experimental design.* Springer-Verlag, N.Y.

Netter, J.; Wasserman, W.; Kutner, M. H., 1990. *Applied linear statistical models. Regression, analysis of variance and experimental designs.* IRWIN, Boston (3rd. ed.).

Sánchez, F.; Pereiro, F.J.; Rodriguez-Marín, E., 1991. Abundance and distribution of the main commercial fish on the northern coast of Spain (ICES Division VIIIc and IXa) from bottom trawl surveys. ICES, *C.M. 1991/G:53.*

Sánchez, F., 1993. Las comunidades de peces de la plataforma del Cantábrico. Tésis doctoral. *Publ. Espec. Inst. Esp. Oceanogr.*, **13**.