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STANDARDIZED CATCH RATES FOR MEDITERRANEAN SWORDFISH (*XIPHIAS GLADIUS* LINNAEUS, 1758) FROM THE SPANISH LONGLINE FISHERY. 1988-2018

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SUMMARY

*Standardized relative abundance indices for swordfish (*Xiphias gladius *Linnaeus, 1758) caught by the Spanish surface longline in the western Mediterranean Sea were estimated for the period 1988-2018. Standardized CPUEs in number were estimated through a General Linear Mixed Modeling (GLMM) approach under a negative binomial (NB) error distribution assumption. Standardized CPUEs in biomass were estimated through a General Linear Mixed Modeling (GLMM) approach under a log-normal error distribution assumption. The main factors in the standardization analysis were fishing area and time of the year (quarter). The standardized indices showed notable annual fluctuations without any definite trend for the period under study.*

RÉSUMÉ

*Les indices d'abondance relative standardisés pour l'espadon (*Xiphias gladius, *Linnaeus, 1758) capturés par la palangre de surface espagnole en Méditerranée occidentale ont été estimés pour la période 1988-2018. Des CPUE standardisées en nombre ont été estimées au moyen d'une approche de modélisation linéaire mixte généralisée (GLMM) en postulant une distribution d'erreur binomiale négative. Des CPUE standardisées en biomasse ont été estimées au moyen d'une approche de modélisation linéaire mixte généralisée (GLMM) en postulant une distribution d'erreur lognormale. Les principaux facteurs de l'analyse de la standardisation étaient la zone de pêche et la période de l'année (trimestre). Les indices standardisés présentaient des fluctuations annuelles importantes sans présenter de tendance claire pour la période à l'examen.*

RESUMEN

*Se estimaron índices de abundancia relativa estandarizados para el pez espada (*Xiphias gladius *(Linnaeus, 1758) capturado por la flota española de palangre de superficie en el Mediterráneo occidental para el periodo 1988-2018. Las CPUE estandarizadas en número se estimaron mediante un enfoque de modelación lineal mixto generalizado (GLMM) bajo un supuesto de distribución de error binomial negativo (NB). Las CPUE estandarizadas en biomasa se estimaron mediante un enfoque de modelación lineal mixto generalizado (GLMM) bajo un supuesto de distribución de error log-normal. Los factores principales en el análisis de estandarización fueron la zona de pesca y el momento del año (trimestre). Los índices estandarizados presentaban notables fluctuaciones anuales sin ninguna tendencia definida para el periodo que se estaba estudiando.*

KEYWORDS

Swordfish, abundance indices, catch/effort, generalized linear mixed model, pelagic longline fisheries, Mediterranean Sea

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Introduction

The Spanish longline fleet targeting swordfish in the western Mediterranean operates using several gears which cover a wide range of depths. From the beginning of the fishery until year 2000, the fleet operated by using only a surface gear: the traditional or home based longline (LLSWO). About 2000, part of the fleet began to use a weighed gear (piedras) and floats (bolas), having access to deeper waters, close to the sea bottom. The gear was termed piedra-bola or bottom longline (LLPB). After 2002, the fleet began to use the American longline (LLAM): a surface gear that introduced some new elements such as the spool, a thicker main-line, and larger distance between hooks. Finally, in 2007 a semi-pelagic longline (LLSP) that operates in mesopelagic waters began to be used.

A comprehensive description of the Spanish longline fishery directed to swordfish in the Mediterranean Sea, including fishing gears technical characteristics, was previously presented in (de la Serna et al., 2004; García-Barcelona *et al*., 2010).

Currently the main gears used are LLSP (in summer months), and LLSWO (in Winter months). In addition, swordfish is also caught seasonally, in small quantities, as a by-catch species on the longline fisheries targeting bluefin tuna and albacore.

Globally, the fishery has remained quite stable regarding total fishing effort. As regards catches, they remained stable for the period between 1988 and 2007, with a tendency to increase since 2008 up to date.

1. Material and Methods

1.1 Data

Data for the analysis were obtained from the Spanish longline fishery targeting swordfish in the western Mediterranean Sea from 1988 to 2018.

As in previous analyses (Mejuto and de la Serna, 1995; Ortiz de Urbina and de la Serna, 1999; Ortiz de Urbina et al., 2004, 2008, 2011, 2015, 2019), information on catch by vessel/trip (fishing date, area of the catch, catch in number, catch in weight and fishing effort) was recorded by the Information and Sampling Network of the Spanish Institute of Oceanography (IEO) at the most important landing ports for the aforementioned fleet. Raw data for positive trips (trips with at least one fish) were structured as follows: vessel code, date of landing, landing in number of fish, landing in weight, number of sampled fish, size composition of the catch (Lower Jaw Fork Length-LJFL, 5 cm length-classes), quadrant, area (5 x 5 degrees), number of sets, hooks by set and type of bait. After data cleansing, a total of 28 768 records were available for the analysis.

Following standard criteria, nominal fishing effort by trip was defined as the number of hooks (in thousands of hooks) computed from the number of sets carried out during the trip, and the mean number of hooks by set during the trip.

1.2 Data exclusions

Data inspection basically entailed the elimination of incomplete and erroneous records, such as incorrectly recorded number or biomass of fish, number of sets by trip, or erroneously geo-referenced sets. Whenever possible, incorrect measurement units were corrected. As a result, approximately one per cent (1 %) of the records available for the period 1988-2018 was eliminated for later analysis.

1.3 Analytical approach

For a response variable recording catch in number of fish, both the Poisson distribution and the negative binomial distribution (NB) describe the probabilities of the occurrence of numbers greater than or equal to 0. Unlike the Poisson distribution, the variance and the mean for the negative binomial are not equivalent. The variance of a negative binomial distribution is a function of its mean and has an additional parameter, the dispersion parameter, θ or k, which might serve as a proper approach for modeling counts with variability different from its mean.

An exploratory analysis (results not shown in the document) of the available data assuming a Poisson error distribution pointed both to the existence of overdispersion and to statistically significant interactions between year and other explanatory factors in the model. Thus, standardized indices of abundance were estimated by a generalized linear mixed modeling (GLMM) approach assuming a negative binomial model (NB), and including the significant interactions year:area and year:quarter as random effects in the model.

The NB generalized linear mixed model was parameterized as a rate model in which the fishing effort (number of hooks) was implemented as an offset, which reflects the total effort by set over which the count response (number of fish) was generated. In fact, the offset is an exposure variable with a coefficient constrained to a value of 1.0 (i.e., enters into the model as a constant). Since the natural logarithm (loge) is the canonical link for the NB model, the offset was logged prior to entry into the estimating algorithm.

Regarding catch recorded in biomass (kg), it was modelled by a generalized linear mixed modeling (GLMM) approach assuming a log-normal error distribution[2], and including the significant interactions year:area and year:quarter as random effects in the model.

The analyses were conducted and the graphs designed by using R statistical software (R Core Team, 2017). Among others, packages MASS (Venables and Ripley, 2002), lme4 (Bates et al., 2015), glmmTMB (Brooks et al., 2017), emmeans (Lenth, 2018), and ggplot2 (Wickham, 2016) were of particular help.

A bias adjustment was applied to the estimated marginal means when we back-transformed to the linear scale.

1.4 Model specification

Three previously defined areas (Mejuto and de la Serna, 1995) were implemented to take account of the spatial structure. As regards the temporal definition, it corresponded to the four natural quarters.

The GLMM NB model was defined as:

number ~ year + quarter + area + quarter:area +
offset(log(effort)) +
(1|year:quarter) + (1|year:area)

The GLMM lognormal model was defined as:

log(biomass/effort) ~ year + quarter + area + quarter:area +
(1|year:quarter) + (1|year:area)

1.5 Management measures

The Mediterranean swordfish stock is subjected to a multi-annual recovery plan, starting in 2017 and continuing through 2031 (15 years), with the goal of achieving BM SY with at least 60% probability (ICCAT Rec [16-05]).

The recovery plan prescribes, among others, Total Allowable Catches (TACs), capacity limitations, closed fishing season (from 1 October to 30 November and during an additional period of one month between 15 February and 31 March or, alternatively, during the period from 1 January to 31 March each year), minimum size (100 cm LJFL or, in alternative, 11.4 kg of round weight or 10.2 kg of gilled and gutted weight), and technical characteristics of the fishing gear (maximum number of hooks fixed at 2500 hooks, hook size should never be smaller than 7 cm of height, and the length of the pelagic longlines will be of maximum 30 NM -55 km).

2. Results and Discussion

Fishing ground for the Spanish longline fishery targeting swordfish is shown in **Figure 1**.

[2] Implemented as a GLMM with log-transformed response, normal error distribution and identity link function

A total of 28 768 fishing sets for the period 1988-2018 were available for analysis. An annual summary of the information available for the analysis (number of sets, fishing effort, nominal catch in number and weight and corresponding nominal catch rates) is given in **Table 1**.

Sampling coverage (in terms of annual percentage of weight sampled with respect to total Task 1 reported to ICCAT) is shown in **Figure 2**, for the period 1998-2017. Sampling coverage was around 43 % on average for the period 1988-2017, with an increasing trend for the last years of the series.

Figure 3 shows the distribution of factors (month, quarter and area) used in the standardization analysis. Treatment combinations across years were reasonably satisfactory.[3]

Table 2 and **Table 3** report type-II and type-III analysis-of-variance results for the final GLMM-NB and GLMM log-normal models.

As regards the GLMM-NB model, factors year, quarter, and the area:quarter interaction were statistically significant ($\alpha = 0.01$). Despite not being statistically significant, according to the principle of marginality and in order to take into account the area:quarter interaction, factor area was included in the model. Regarding the GLMM log-normal model, factors quarter, and the area:quarter interaction were statistically significant ($\alpha = 0.01$). Despite not being statistically significant, according to the principle of marginality and in order to take into account the area:quarter interaction, factor area was included in the model. In addition, with a view to obtaining estimates of an annual index, factor year (not statistically significant) was also included
in the final model.

Figure 4 and **Figure 5** show residual diagnostics for assessing the final NB-GLMM and GLMM-log normal model fit. Even though the residual patterns show some departures from distributional assumptions at the tails, generally adequate fit the model.

Table 4, **Table 5**, **Table 6**, and **Table 7** record estimated standardized relative abundance indices, standard errors and corresponding 95% confidence limits for both models (NB-GLMM and GLMM-log normal) and both scales (log and linear). **Figure 6** shows estimated standardized relative abundance indices for both models (NB-GLMM and GLMM-log normal) in the linear scale. The standardized indices showed notable annual fluctuations without any definite trend for the period under study (1988-2018).

[3] Note here that swordfish fishing in the western Mediterranean from year 2017 on might be influenced by the implementation of ICCAT Mediterranean Swordfish Rebuilding Plan (ICCAT Rec [16-05]).

References

Bates, D., Mächler, M., Bolker, B., Walker, S., 2015. Fitting linear mixed-effects models using lme4, Journal of Statistical Software 67 (1), 1–48.

Brooks, M., Kristensen, K., van Benthem, K., Magnusson, A., Berg, C., Nielsen, A., Skaug, H., Maechler, M., Bolker, B., 2017. glmmTMB balances speed and flexibility among packages for zero-inflated generalized linear mixed modeling, The R Journal 9 (2), 378–400.

de la Serna, J., Macías, D., Ortiz de Urbina, J., Alot, E., Rioja, P., 2004. Análisis de la pesquería española de pez espada (*Xiphias gladius*) en el Mediterráneo, Collect. Vol. Sci. Pap. ICCAT 56 (3), 864–871.

García-Barcelona, S., Ortiz de Urbina, J., de la Serna, J., Alot, E., Macías, D., 2010. Seabird bycatch in spanish mediterranean large pelagic longline fisheries, 2000-2008, Aquat. Living Resour 23, 363–371.

Lenth, R., 2018. emmeans: Estimated Marginal Means, aka Least-Squares Means. R package version 1.3.1.

Mejuto, J., de la Serna, J., 1995. Standardized catch rates in number and weight for the swordfish (*Xiphias gladius* L.) from the Spanish longline fleet in the Mediterranean Sea, 1988-1993, Collect. Vol. Sci. Pap. ICCAT 44 (1), 124–129.

Ortiz de Urbina, J., de la Serna, J., 1999. Updated standardized catch rates in number and weight for the swordfish (*Xiphias gladius* L.) from the Spanish longline fleet in the Mediterranean Sea, 1988-1997, Collect. Vol. Sci. Pap. ICCAT 49 (1), 105–109.

Ortiz de Urbina, J., de la Serna, J., Mejuto, J., Rioja, P., Macías, D., 2004. Updated standardized catch rates in number and weight for the swordfish (*Xiphias gladius* L.) from the Spanish longline fleet in the Mediterranean Sea, 1988–2001, Collect. Vol. Sci. Pap. ICCAT 56 (3), 872–880.

Ortiz de Urbina, J., de la Serna, J., Mejuto, J., Rioja, P., Macías, D., 2008. Updated standardized catch rates in number and weight for the swordfish (*Xiphias gladius* L.) from the Spanish longline fleet in the Mediterranean Sea, 1988-2007, Collect. Vol. Sci. Pap. ICCAT 62 (4), 1122–1127.

Ortiz de Urbina, J., de la Serna, J., Mejuto, J., Rioja, P., Macías, D., 2011. Updated standardized catch rates in number and weight for the swordfish (*Xiphias gladius* L.) from the Spanish longline fleet in the Mediterranean Sea, 1988-2009, Collect. Vol. Sci. Pap. ICCAT 66 (4), 1515–1521.

Ortiz de Urbina, J., de la Serna, J., Mejuto, J., Macías, D., Saber, S., 2015. Updated standardized catch rates in number and weight for the swordfish (*Xiphias gladius* L.) from the Spanish longline fleet in the Mediterranean Sea, 1988-2013, Collect. Vol. Sci. Pap. ICCAT 71 (5), 1992–1997.

Ortiz de Urbina, J., Saber, S., García, S., Rioja, P., Gómez-Vives, M., Godoy, D., Meléndez, M., Puerto, M., Macías, D., 2019. Standardized catch rates for Mediterranean swordfish (*Xiphias gladius* L., 1758) from the Spanish longline fishery. 1988-2017, Collect. Vol. Sci. Pap. ICCAT 76 (3), 53–64.

R Core Team, 2017. R: A Language and Environment for Statistical Computing, R Foundation for Statistical Computing, Vienna, Austria.

Venables, W., Ripley, B., 2002. Modern Applied Statistics with S, Springer, New York, fourth edn. ISBN 0-387-95457-0.

Wickham, H., 2016. ggplot2: Elegant Graphics for Data Analysis, Springer-Verlag New York.

Table 1. Summary table. Spanish SWO surface longline, western Mediterranean, 1988-2018.

year	sets	Catch (number)	Catch (kg)	Effort (hooks 10−3)	CPUEn (nominal)	CPUEw (nominal)
1988	610	31685	499945.000	734.029	43.166	681.097
1989	50	1221	50295.000	48.880	24.980	1028.948
1990	69	2162	89091.000	66.240	32.639	1344.973
1991	862	30518	550002.000	1090.043	27.997	504.569
1992	1154	32270	473519.000	1457.988	22.133	324.776
1993	1551	46439	861516.000	1937.428	23.969	444.670
1994	1898	47212	787231.000	2289.327	20.623	343.870
1995	1992	57171	1109119.000	2900.091	19.714	382.443
1996	1493	29776	519955.000	2214.820	13.444	234.762
1997	1111	19961	346261.000	1565.228	12.753	221.221
1998	996	21643	323288.000	1500.437	14.424	215.463
1999	695	13744	235027.000	1124.568	12.222	208.993
2000	29	2760	86533.000	57.900	47.668	1494.525
2001	944	22809	418472.000	1483.834	15.372	282.021
2002	1192	38051	539496.000	1901.969	20.006	283.651
2003	799	19929	397290.000	1439.976	13.840	275.900
2004	536	12531	298328.000	903.206	13.874	330.299
2005	309	9806	215202.000	433.618	22.614	496.294
2006	240	8612	208757.000	290.472	29.648	718.682
2007	218	13363	236168.000	364.261	36.685	648.348
2008	404	14217	326407.000	621.676	22.869	525.044
2009	782	20369	624109.000	1507.988	13.507	413.869
2010	795	24971	707405.000	1499.929	16.648	471.626
2011	867	29135	777738.000	1584.496	18.388	490.843
2012	523	20387	521429.000	918.545	22.195	567.668
2013	1725	62677	1546730.000	3652.389	17.161	423.484
2014	1916	73966	2082780.000	3650.665	20.261	570.521
2015	2360	86848	2211426.856	4737.085	18.334	466.833
2016	2010	65266	1657105.000	4006.609	16.290	413.593
2017	311	12426	354822.940	661.881	18.774	536.083
2018	327	10347	285370.800	827.878	12.498	344.702

Table 2. Type-II (top) and type-III (bottom) analysis-of-variance tables for final GLMM NB model. Spanish SWO surface longline, western Mediterranean, 1988-2018.

	Chisq	Df	Pr(>Chisq)
year	89.02	30	0.0000
quarter	198.82	3	0.0000
area	0.10	2	0.9521
quarter:area	73.31	6	0.0000
(Intercept)	271.18	1	0.0000
year	89.02	30	0.0000
quarter	148.64	3	0.0000
area	1.80	2	0.4068
quarter:area	73.31	6	0.0000

Table 3. Type-II (top) and type-III (bottom) analysis-of-variance tables for final GLMM log-normal model. Spanish SWO surface longline, western Mediterranean, 1988-2018.

	Chisq	Df	Pr(>Chisq)
year	38.61	30	0.1347
quarter	137.90	3	0.0000
area	8.94	2	0.0115
quarter:area	151.76	6	0.0000
(Intercept)	621.42	1	0.0000
year	38.61	30	0.1347
quarter	138.06	3	0.0000
area	0.24	2	0.8867
quarter:area	151.76	6	0.0000

Table 4. Estimated standardized relative abundance indices (number of fish x hooks 10−3, log scale). Spanish surface longline, western Mediterranean, 1988-2018.

year	lsmean	SE	asymp.LCL	asymp.UCL
1988	2.4626	0.136	2.196	2.7293
1989	1.3942	0.2356	0.9324	1.8561
1990	1.5271	0.213	1.1097	1.9446
1991	1.9865	0.1358	1.7204	2.2526
1992	2.1128	0.1353	1.8475	2.378
1993	2.1086	0.1349	1.8443	2.373
1994	2.3408	0.134	2.0781	2.6035
1995	2.1752	0.1333	1.914	2.4364
1996	1.7928	0.1343	1.5296	2.0561
1997	1.7494	0.1359	1.483	2.0157
1998	1.9599	0.135	1.6952	2.2245
1999	1.7319	0.1357	1.4659	1.9978
2000	1.5387	0.2333	1.0815	1.9959
2001	1.8172	0.1433	1.5364	2.0981
2002	2.4316	0.1387	2.1597	2.7034
2003	1.9647	0.1415	1.6874	2.2419
2004	1.6301	0.1412	1.3534	1.9068
2005	1.8509	0.1457	1.5654	2.1365
2006	1.9593	0.1532	1.6592	2.2595
2007	2.2382	0.1424	1.9592	2.5173
2008	2.162	0.1396	1.8883	2.4356
2009	1.6025	0.137	1.3341	1.8709
2010	1.705	0.1368	1.4369	1.9731
2011	1.8306	0.136	1.564	2.0972
2012	2.1317	0.1369	1.8633	2.4001
2013	1.8888	0.1333	1.6276	2.15
2014	1.9173	0.1333	1.656	2.1786
2015	1.9186	0.1329	1.6582	2.1791
2016	1.9281	0.133	1.6674	2.1888
2017	1.8606	0.1593	1.5482	2.1729
2018	1.6394	0.1468	1.3517	1.9272

Table 5. Estimated standardized relative abundance indices (number of fish x hooks 10−3, linear scale). Spanish surface longline, western Mediterranean, 1988-2018.

year	lsmean	SE	asymp.LCL	asymp.UCL
1988	11.7357	1.5965	8.989	15.3216
1989	4.0319	0.9501	2.5406	6.3987
1990	4.605	0.9809	3.0333	6.991
1991	7.2899	0.9898	5.5866	9.5125
1992	8.2711	1.1194	6.344	10.7835
1993	8.237	1.111	6.3236	10.7294
1994	10.3897	1.3925	7.9894	13.5111
1995	8.8041	1.1734	6.78	11.4323
1996	6.0063	0.8067	4.6161	7.8151
1997	5.7509	0.7816	4.406	7.5062
1998	7.0983	0.9585	5.4477	9.249
1999	5.6512	0.7668	4.3316	7.3729
2000	4.6585	1.0867	2.9491	7.3588
2001	6.1547	0.8819	4.6477	8.1503
2002	11.3769	1.5779	8.6689	14.9308
2003	7.1325	1.0089	5.4055	9.4114
2004	5.1044	0.7207	3.8705	6.7317
2005	6.3659	0.9276	4.7844	8.4701
2006	7.0947	1.0866	5.2549	9.5786
2007	9.3767	1.3349	7.0937	12.3946
2008	8.6883	1.2131	6.6082	11.423
2009	4.9655	0.68	3.7966	6.4944
2010	5.5012	0.7526	4.2074	7.1929
2011	6.2377	0.8484	4.7781	8.1432
2012	8.4295	1.1543	6.4453	11.0246
2013	6.6116	0.8812	5.0916	8.5852
2014	6.8026	0.907	5.2382	8.8343
2015	6.8117	0.9052	5.2498	8.8383
2016	6.8764	0.9145	5.2985	8.9242
2017	6.4273	1.0242	4.7032	8.7835
2018	5.1521	0.7564	3.8638	6.8699

Table 6. Estimated standardized relative abundance indices (kg x hooks 10−3, log scale). Spanish surface longline, western Mediterranean, 1988-2018.

Year	lsmean	SE asymp	LCL asymp	UCL
1988	4.8501	0.177	4.5032	5.1971
1989	4.7493	0.2819	4.1968	5.3017
1990	4.8248	0.255	4.3251	5.3244
1991	4.453	0.1757	4.1087	4.7973
1992	4.3068	0.1757	3.9625	4.6511
1993	4.5884	0.1747	4.2461	4.9307
1994	4.7915	0.1741	4.4504	5.1326
1995	4.5664	0.1735	4.2263	4.9065
1996	4.4074	0.1743	4.0659	4.749
1997	4.4307	0.1757	4.0862	4.7751
1998	4.5409	0.1752	4.1975	4.8842
1999	4.4694	0.1757	4.125	4.8138
2000	4.8102	0.2878	4.2461	5.3743
2001	4.4506	0.1841	4.0896	4.8115
2002	4.855	0.1792	4.5037	5.2063
2003	4.4046	0.1829	4.0461	4.7631
2004	4.1152	0.1816	3.7593	4.4711
2005	4.4341	0.1873	4.0671	4.8012
2006	4.7246	0.196	4.3404	5.1089
2007	4.788	0.1841	4.4272	5.1489
2008	5.0294	0.1802	4.6762	5.3826
2009	4.5859	0.1771	4.2388	4.9331
2010	4.6699	0.1765	4.3239	5.0158
2011	4.6316	0.1761	4.2863	4.9768
2012	4.8809	0.1775	4.533	5.2287
2013	4.4816	0.1733	4.1419	4.8214
2014	4.5557	0.1734	4.2159	4.8955
2015	4.4549	0.1729	4.1161	4.7938
2016	4.2597	0.1731	3.9205	4.5989
2017	4.8048	0.2084	4.3964	5.2133
2018	4.666	0.1937	4.2863	5.0456

Table 7. Estimated standardized relative abundance indices (kg x hooks 10−3, linear scale). Spanish surface longline, western Mediterranean, 1988-2018.

year	lsmean	SE asymp.	LCL asymp	UCL
1988	127.7592	22.6132	90.309	180.7396
1989	115.5011	32.5551	66.4763	200.6806
1990	124.5556	31.7556	75.5697	205.295
1991	85.884	15.0864	60.8681	121.181
1992	74.2005	13.0338	52.5881	104.695
1993	98.3369	17.1747	69.8317	138.478
1994	120.4819	20.9706	85.6575	169.4643
1995	96.1986	16.6935	68.4634	135.1695
1996	82.0586	14.3	58.3162	115.4673
1997	83.9878	14.7593	59.5159	118.5222
1998	93.7718	16.4264	66.5217	132.1847
1999	87.3016	15.3406	61.8657	123.1955
2000	122.7585	35.3317	69.8334	215.7944
2001	85.6752	15.7766	59.7189	122.9133
2002	128.3817	23.0123	90.3496	182.4233
2003	81.829	14.9672	57.1763	117.1113
2004	61.2647	11.1235	42.9202	87.4498
2005	84.2795	15.7833	58.3868	121.6548
2006	112.689	22.0925	76.7369	165.4849
2007	120.0651	22.1045	83.6964	172.2371
2008	152.8373	27.5411	107.3604	217.5779
2009	98.0951	17.3749	69.3234	138.808
2010	106.6843	18.8312	75.4835	150.7819
2011	102.6752	18.0849	72.7006	145.0085
2012	131.7484	23.3827	93.041	186.5592
2013	88.379	15.3188	62.923	124.1335
2014	95.1709	16.5009	67.7518	133.6863
2015	86.0497	14.8772	61.3175	120.7576
2016	70.7878	12.2502	50.4258	99.3718
2017	122.0976	25.4443	81.1564	183.6925
2018	106.2688	20.5844	72.6988	155.3403

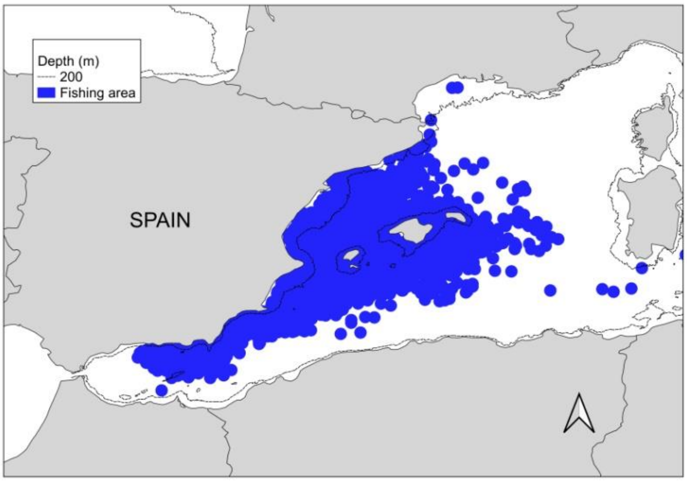

Figure 1. Map of the LLHB fishing ground. Fisheries operation observed and dolphinfish bycatches (number of fishes observed per 1000 hooks) per set.

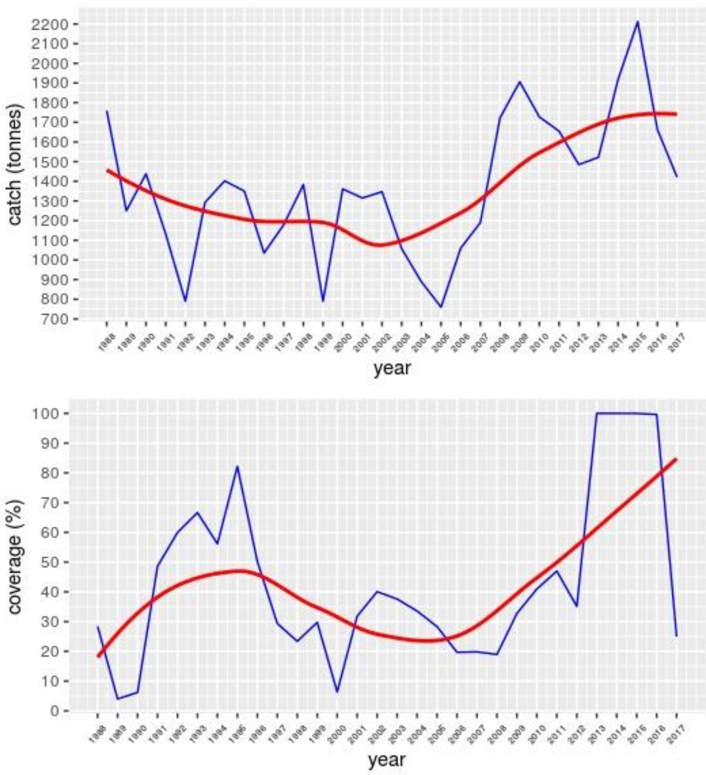

Figure 2. Reported catch (top) and Sampling coverage (bottom). Spanish SWO surface longline, western Mediterranean, 1988-2017 (coverage around 43%, on average, for the period 1988-2017).

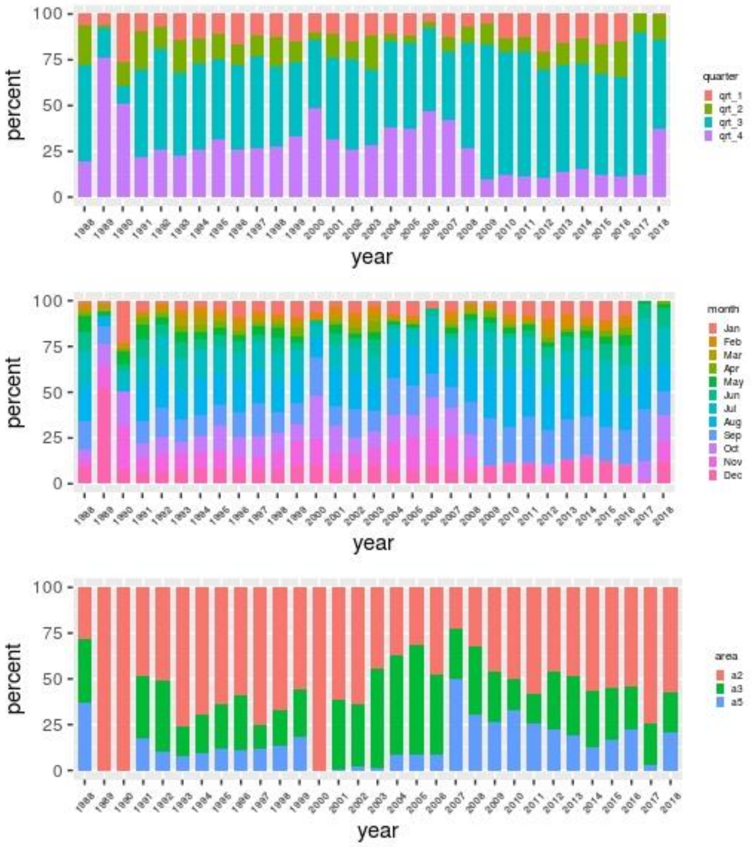

Figure 3. Temporal and spatial distribution of relevant factors in the data analyzed. Spanish

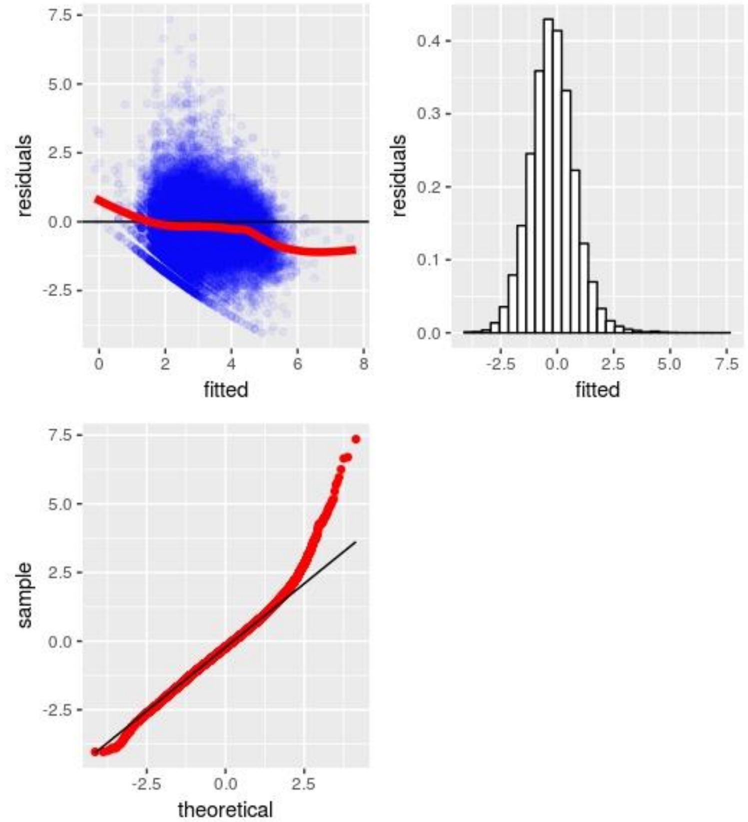

Figure 4. Residuals diagnostics (GLMM-NB). Spanish SWO surface longline, western Mediterranean, 1988-2018.

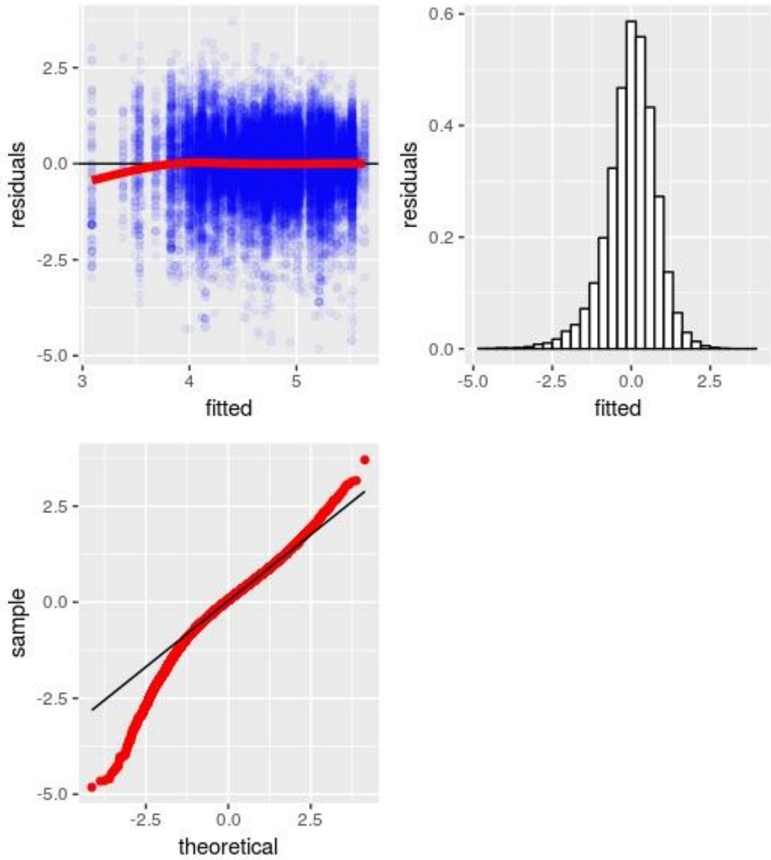

Figure 5. Residuals diagnostics (GLMM- log-Normal). Spanish SWO surface longline, western Mediterranean, 1988-2018.

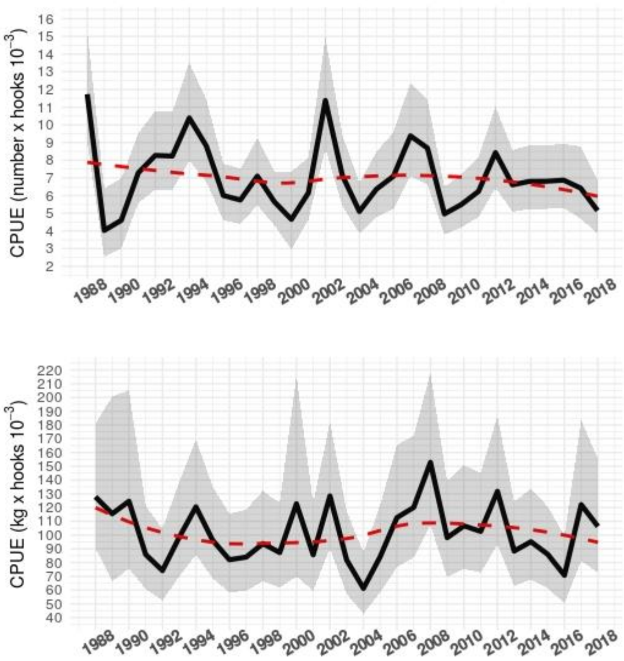

Figure 6. Estimated standardized relative abundance indices and corresponding 95% confidence limits (normal approximation). Spanish SWO surface longline, western Mediterranean, 1988-2018 (black line, standardized CPUE; red line, loess fit- as an aid to interpret CPUE trend ; upper panel, number of fish per 1000 hooks (linear scale); lower panel, kg per 1000 hooks, (linear scale).