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STANDARDIZED NORTH EAST ATLANTIC ALBACORE (*Thunnus alalunga*) CPUE´S FROM THE SPANISH TROLL FLEET, PERIOD 1981-2014.

Victoria Ortiz de Zárate[1], M. Ortiz[2], B. Pérez [1]

SUMMARY

*Nominal catch of number of fish per unit of effort (CPUE´s) of North Atlantic albacore (Thunnus alalunga) caught by the Spanish troll fleet in the North Eastern Atlantic were collected by individual trip for the period 1981-2014. Standardized index was estimated using Generalized Linear Random Effects Model (GLMM) with log-normal error distribution. The year*quarter interaction term and year*zone interaction term were included in the model as random effects to derived the annual standardized catch rates as index of abundance for the time period analysed.*

RESUMEN

Las capturas en número de peces por unidad de esfuerzo (CPUE´s) de atún blanco del Atlántico norte capturado por la flota española de cebo vivo fueron recogidas mediante muestreo de mareas individuales durante el período de 1981 a 2014. Se analizaron con un Modelo Generalizado Lineal con Efectos Aleatorios (GLMM). Los factores de interacción año y trimestre y año y zona fueron incluidos como factores aleatorios en el modelo para obtener la serie de CPUE estandarizada en el período analizado. En el modelo empleado se asumió una distribución log-normal del error.

KEYWORDS

Thunnus alalunga, Albacore, standardized CPUE´s, Spanish troll fleet, North Atlantic.

[1] Instituto Español de Oceanografía. Apdo.240. Santander 39080. Spain. victoria.zarate@st.ieo.es

[2] ICCAT Secretariat, C. Corazón de María 8. Madrid 28002.Spain. maurico.ortiz@iccat.int

1. Introduction

The North Atlantic albacore stock was assessed in 2013 (ICCAT, 2013a, b) by applying several methods among others: the statistical catch-at-size model MULTIFAN-CL (Fournier *et al*., 1998) and the stock production model incorporating covariates ASPIC (Prager, 1992). The non-equilibrium production model ASPIC was fitted to the North Atlantic albacore data (Merino *et al*., 2014) available to the analysis done during the assessment session in 2013 (ICCAT, 2013b). The non-equilibrium production model used time series of standardized catch rates by main commercial fleets and yield (weight) to estimate the status of the stock. Accordingly to the 2016 work plan elaborated for the 2016 North Atlantic stock assessment session it was requested to prepare several statistics and different sets of data derived from the monitoring of the commercial fleet activities targeting this stock.

Therefore the catch per unit of effort (CPUE) series for Spanish troll fishery by year had been standardized for the period 1981 to 2014; 2014 was determined as the last input year for the upcoming assessment.

The aim of this paper is to present the information on catch per unit of effort (CPUEn) expressed in number of albacore caught per fishing day by the Spanish troll fishery operating in the Bay of Biscay and adjacent Northeast Atlantic area during the time period mentioned. To derive the annual standardized index, the interactions terms *year*quarter* and *year*zone*, were modelled by means of the Generalized Linear Mixed Models with Random Effects (GLMMs) assuming the log-normal error distribution in the analysis.

The annual standardized troll CPUE´s in numbers of fish from 1981 to 2014 are presented to be examined and considered for use as input for the surplus production model ASPIC to estimate the state of the population of North Atlantic albacore stock during the 2016 assessment session.

2. Materials and Methods

The information used in this analysis was obtained from the monitoring of fishing trips from commercial troll randomly sampled and recorded at landing ports through interviews of skippers. Each record contains information on: date of landing, number of fishing days, area of effort, catch in number, likewise information on size of landed catches by commercial categories were obtained through random sampling. Catch in weight (kg) for each trip is obtained from sale market records.

The seasonal migration of immature albacore to the northeast Atlantic waters and the Bay of Biscay during summer months determines the spatial and temporal activity of the fleet according to the species annual behavior and spatial distribution in the Bay of Biscay and North Eastern Atlantic waters. The fishing ground for the bait boat fleet has remained unchanged in a broad temporal scale, however it shows important inter annual variability depending on availability of the resource to the fishing area and gear (Ortiz de Zárate *et al*., 2015). The stratification of the fishing area concerning trips location, is the same as in previous analyses (Ortiz de Zárate *et al*., 2010; 2014) defined by the explanatory variable ZONE as factor with four levels (1=NE, 2=SE, SW =3 and 4=NW) and considered in the analyses of catch rates (**Figure 1)**.

Based on seasonality of troll fleet, observations were grouped by calendar quarter, using the following description: QUARTER 2 (May-Jun), QUARTER 3 (Jul-Aug-Sep) and QUARTER 4 (Oct-Nov-Dec).

All trip observations from 1981 to 2014 indicated positive catches of albacore, thus nominal catch rates expressed in number of fish per fishing day were log transformed for standardization. In addition to the Zone and Quarter main factors *year*quarter* and *year*zone* interactions were evaluated, and included in the model as random effects to allow estimation of an annual standardized CPUE´s index.

Additionally the standardized CPUE´s by quarter were also estimated as was the case in previous standardization analysis of Spanish bait boat fleet (Ortiz de Zárate and Ortiz de Urbina, 2010; 2014).

Final models were:

Model formulation

$$\log(\text{CPUEn}) = \mu + Y_i + \text{Zone}_k + \text{Quarter}_l + Y_i * \text{Quarter}_l + Y_i * \text{Zone}_k + \varepsilon_{ikl}$$

Where:

μ= overall mean
Y = year factor; levels: 1981-2014
Zone = area factor; 4 levels: NE (1), SE (2), SW (3), NW (4)
Quarter = time factor; 3 levels: 2, 3, 4
ε_{ikl} = log-normal error distribution

Analyses were done using Generalized Linear Random Effects Model procedure of JMP v.10 (SAS, Institute Inc.) using restricted maximum likelihood (REML) solution algorithm.

Annual index of abundance was calculated as the back-transformed least squares means (LSmeans) of the *Year* factor.

$$CPUE\ \widehat{Y}_i = \exp\left(LSMean\ Y_i + 0.5 * RSE^2\right)$$

3. Results and Discussion

Data collected from the Spanish troll fishery comprised a total of 9417 trips compiled from 1981 through 2014. This data was used to estimate the nominal CPUE´s classified accordingly to the factor time (Quarter) and fishing area (Zone) included in the period modelled (**Table 1**). The observed trips were allocated in quarter 2, 3 and 4, covering the fishing season from the beginning in spring-summer to the end in autumn months.

The spatial distribution of trips in relation to the stratified fishing area named as ZONE factor is characterized by a more balanced design. The observations are located in all stratified levels used in the modelling of catch rates (**Table 1**) for the time period 1981-2014. In **Figure 1,** is reflected the annual change in the fishing area detected for the last three years of the time series that had been incorporated to the previous analysis of troll CPUEs standardized (Ortiz de Zárate *et al*., 2014). In the last year 2014, it is appreciated a decrease on number of trips located in the Bay of Biscay.

The results from the Generalised Linear Model with random effects fitted and the summary statistics of the maximum likelihood function that minimized the iterations search are shown in **Table 2**. The model accounted for 45.6 % of the variability of the observed log-cpue when incorporating the *year*quarter* interaction and *year*zone* interaction terms as random effects. Those results represent an improve fit respecting the fixed factor model fit to standardized the troll log-nominal catch rates used in the last assessment (ICCAT, 2013b; Ortiz de Zárate *et a*l., 2014). The present GLMM model with random effects in the model fit captures better the variability observed in the troll fleet in regards temporal and spatial annual distribution.

The quarterly least squares means and their standard error estimated by the GLMM model with random components are shown in **Table 3**. The annual least squares means, their standard error and derived coefficient of variation, were estimated by the defined model assuming a log-normal model distribution, likewise the standardized catch rates (CPUEn) were estimated and annual corresponding number of observed trips had been included in the summary **Table 4**.

Density and frequency distribution of the log transformed response variable (CPUEn) for years 1981 to 2014, is shown in **Figure 2 a.** Diagnostics plots of the fitted model were evaluated and shown in **Figure 2 b-c**. Plots of the normalized cumulative residuals (e.g. qq-residual plots), distribution of standardized residuals and standardized residuals by year for the dependent variable are presented. It is observed some negative residuals on the tail of the normal distribution, that don´t fit well the normal standard distribution. Those observations represent a number of trips with very low number of fish (i.e.1 or 2 fish) caught. On the other hand, a few large positive residuals are observed in the qq-plot, which represent

extremely productive trips, scarce in number. Overall, the distribution of normalized residuals and the distribution of residuals do not exhibit large deviations from the model assumptions, for the time series that had been analysed. The annual series of residuals show deviations around the mean with not clear trend except possibly the last five years with an up worth trend.

Standardized CPUEs series, expressed as number of fish per fishing day, for North Atlantic albacore and their estimated 95% confidence intervals are shown in **Figure 3.** An initial visual inspection of the standardized CPUEs may suggest a cyclical trend moving in cycles from higher to lower values. It shows a decreasing trend in the latest years, 2013 and 2014 from the higher value in 2012. However, as overall the highest and lowest values are levelled off in the observed time series.

On the other hand, the quarterly annual time series of least squares means estimated by the GLM with random effects model are display in **Figure 4,** with the purpose of showing the variability explained by seasonality in the troll fishery, that corresponds to spring- summer months (quarter 2,3) and autumn months (quarter 4) varying from one year to the next.

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References

FOURNIER, D.A., J. Hampton and J.R. Sibert.1998. MULTIFAN-CL: a length based, age-structured modle for fisheries stock assessment, with application to South Pacific albacore, *Thunnus alalunga*. Can. J. Fish. Aquat. Sci., 55: 2105-2216.

ICCAT. 2013a. Report of the 2013 ICCAT North and South Atlantic albacore data preparatory meeting. Collect.Vol.Sci.Pap.ICCAT,70 (3):717-829.

ICCAT. 2013b. Report of the 2013 ICCAT North and South Atlantic albacore assessment meeting. Collect. Vol. Sci. Pap. ICCAT, 70(3): 830-995

MERINO, G., P. De Bruyn G.P.Scott, L.T.Kell. 2014. A preliminary stock assessment of the albcore tuna (*Thunnus alalunga*) stock in the northern Atlantic Ocean using a non-equilibrium production model. Col. Vol. Sci. Pap. ICCAT, 70 (3): 1074-1085.

ORTIZ DE ZÁRATE, V. and Ortiz de Urbina, J. M. 2010. Standardized North East Atlantic albacore (*Thunnus alalunga*) CPUEs from the troll fleet by quarter, for the period 1981-2007. Collect. Vol. Sci. Pap. ICCAT, 65 (4): 1306-1314.

ORTIZ DE ZÁRATE, V., Ortiz de Urbina, J. M. and B. Pérez. 2014. Standardized North East Atlantic albacore (*Thunnus alalunga*) CPUEs from the Spanish troll fleet by quarter, for the period 1981-2011. Collect. Vol. Sci. Pap. ICCAT, 70 (3): 1033-1044.

ORTIZ DE ZÁRATE, V. B. Perez, B, and Ruiz, M. 2015. Statistics from the Spanish albacore (*Thunnus alalunga*) surface fishery in the North eastern Atlantic years: 2012 and 2013.Collect. Vol. Sci. Pap. ICCAT, 71(5): 2379-2389.

PRAGER, M. 1992. ASPIC -a sur-plus production model incorporating covariates. Col. Vol. Sci. Pap. ICCAT, 28: 218-229.

SAS Institute Inc. 2014. JMP Statistical Software®. Cary, NC: SAS Institute Inc.

Table 1. Number of trips (OBS) sampled by quarter, zone and year, period 1981-2014.

QUARTER	No.OBS	ZONE	No.OBS
2	1133	NE	1652
3	7536	NW	2094
4	748	SE	1476
		SW	4195
Total	9417		9417

Table 2. Results of Generalized Linear Random Effects Model with log-normal error distribution.

REML Variance Component Estimates

Random Effect	Var Ratio	Var Component	Std Error	95% Lower	95% Upper	Pct of Total
YEAR*QUARTER	0.3148541	0.1398872	0.0316973	0.0777616	0.2020128	18.533
ZONE*YEAR	0.3840403	0.1706261	0.0266753	0.1183435	0.2229087	22.605
Residual		0.4442923	0.0065423	0.4317433	0.4573991	58.862
Total		0.7548056	0.0413863	0.6798311	0.8429724	100.000

-2 LogLikelihood = 19652.478334

Note: Total is the sum of the positive variance components.

Total including negative estimates= 0.7548056

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
YEAR	33	33	112.8	16.987	0.0215*
QUARTER	2	2	51.4	40.615	0.0230*
ZONE	3	3	97.52	274.787	<.0001*

Table 3. Quarterly Standardized CPUEs series (nº of fish/fishing day) for albacore catch rates from Spanish troll fleet 1981-2014.

Year	Level Q2	Least Sq Mean	Std Error	Level Q3	Least Sq Mean	Std Error	Level Q4	Least Sq Mean	Std Error
1981	2	4.7247227	0.4061183	3	4.4605942	0.2480261	4		
1982	2			3	4.3400684	0.2273612	4		
1983	2			3	4.422184	0.2514149	4	3.9433771	0.4864854
1984	2			3	4.0571301	0.2583597	4		
1985	2	4.1639971	0.444938	3	3.9806961	0.2374361	4	4.2336664	0.3401557
1986	2			3	4.3189538	0.2185861	4	4.4836685	0.2658669
1987	2	4.641547	0.3963514	3	4.0566224	0.2658804	4	4.3314708	0.3686242
1988	2	3.9342992	0.3320912	3	4.2835875	0.2136857	4	4.5309048	0.249046
1989	2	3.6900639	0.2538485	3	3.8423258	0.2127062	4	3.9946256	0.2367099
1990	2	3.960539	0.2471057	3	4.2214738	0.2125512	4	4.2507677	0.2303723
1991	2	4.9333225	0.2472449	3	4.6833178	0.2123871	4	4.9588183	0.2415215
1992	2	5.2178155	0.2506717	3	4.4384138	0.2124211	4	4.7631711	0.2504296
1993	2	4.4704789	0.2396205	3	4.5142522	0.2123695	4	4.4923833	0.2884688
1994	2	3.9053872	0.2444049	3	4.6578033	0.2141395	4	3.7314695	0.3200307
1995	2	4.856299	0.2473565	3	4.6124125	0.2127071	4	5.0586062	0.2510906
1996	2	4.2791362	0.2470809	3	4.6049864	0.211908	4	4.5655084	0.2517534
1997	2	4.372086	0.2346665	3	4.5729845	0.2162668	4	5.1772196	0.2693338
1998	2	4.5511932	0.2330616	3	4.4281863	0.2127997	4	4.0573649	0.436729
1999	2	4.8963113	0.2285531	3	4.4663431	0.2112156	4	3.734003	0.307036
2000	2	3.6803984	0.2279872	3	3.7482343	0.2110913	4	2.8665345	0.2900179
2001	2	4.0986353	0.2337899	3	3.8977112	0.213513	4	2.4612409	0.3273053
2002	2	3.7199725	0.2479111	3	4.093556	0.2113371	4	3.663915	0.2469023
2003	2	3.5012966	0.2343321	3	4.4181803	0.211379	4	3.6609689	0.2476022
2004	2	4.2028678	0.2399425	3	4.5195528	0.2121532	4	3.9905952	0.2415196
2005	2	4.6099096	0.237063	3	4.5997992	0.212435	4	4.5583149	0.2554485
2006	2	4.4816986	0.2319021	3	4.9139518	0.215083	4	4.6588233	0.2532915
2007	2	4.224094	0.2367075	3	4.3484988	0.2127638	4	3.7787107	0.2324131
2008	2	4.9375403	0.2541911	3	4.8269653	0.2251276	4	3.8161926	0.270303
2009	2	4.4170245	0.2368471	3	4.210531	0.2190204	4	4.1929427	0.2443105
2010	2	3.4228144	0.2345302	3	4.0025049	0.2181541	4	3.0262693	0.2343691
2011	2	4.2733997	0.2435769	3	4.1379672	0.2141706	4	3.5314386	0.2365714
2012	2	4.6362848	0.249416	3	4.7581099	0.2162946	4	4.7325732	0.2293859
2013	2	3.8091843	0.2796839	3	4.3705497	0.2127613	4	3.3450682	0.2296866
2014	2	3.8699528	0.2489399	3	3.6068659	0.2198456	4	3.0125386	0.2355376

Table 4. Nominal and Standardized CPUEs series (nº of fish/fishing day) for albacore catch rates from Spanish troll fleet. Years 1981-2014.

Year	N Obs	Least Sq Mean	Std Error	CV(%)	Standard CPUE	Nominal CPUE
1981	32	4.508550	0.383444	8.50	100.2080	98.2844
1982	83	4.224703	0.441544	10.45	75.4448	78.1819
1983	89	4.209206	0.420776	10.00	74.2846	98.0449
1984	83	3.941765	0.458200	11.62	56.8526	89.4458
1985	94	4.126120	0.347842	8.43	68.3620	64.6255
1986	121	4.481390	0.327796	7.31	97.5229	101.5545
1987	33	4.220472	0.381325	9.04	75.1262	80.6000
1988	180	4.249597	0.315740	7.43	77.3465	87.8133
1989	255	3.842338	0.305395	7.95	51.4719	67.1416
1990	333	4.144260	0.303298	7.32	69.6135	81.0048
1991	362	4.858486	0.305502	6.29	142.1928	155.5301
1992	304	4.806467	0.305886	6.36	134.9851	120.5441
1993	299	4.492371	0.309878	6.90	98.5998	111.2532
1994	227	4.098220	0.313944	7.66	66.4811	116.1053
1995	324	4.842439	0.305665	6.31	139.9293	134.7164
1996	269	4.483210	0.306006	6.83	97.7006	111.7227
1997	292	4.707430	0.307828	6.54	122.2573	143.3418
1998	298	4.345582	0.328798	7.57	85.1385	97.8490
1999	392	4.365553	0.310756	7.12	86.8559	106.3227
2000	365	3.431722	0.308052	8.98	34.1383	57.0123
2001	359	3.485862	0.314301	9.02	36.0375	71.1986
2002	328	3.825815	0.304916	7.97	50.6284	69.8942
2003	329	3.860149	0.304605	7.89	52.3968	87.8553
2004	426	4.237672	0.304857	7.19	76.4296	124.5725
2005	374	4.589341	0.304706	6.64	108.6399	151.3088
2006	315	4.684825	0.305637	6.52	119.5246	152.6025
2007	363	4.117101	0.302631	7.35	67.7483	95.8576
2008	263	4.526899	0.316073	6.98	102.0637	154.5548
2009	273	4.273499	0.308399	7.22	79.2175	120.5502
2010	375	3.483863	0.305963	8.78	35.9655	146.8808
2011	383	3.980935	0.305071	7.66	59.1238	86.6303
2012	344	4.708989	0.302138	6.42	122.4481	143.7823
2013	436	3.841601	0.305921	7.96	51.4340	130.5284
2014	414	3.496452	0.306505	8.77	36.4212	151.3372

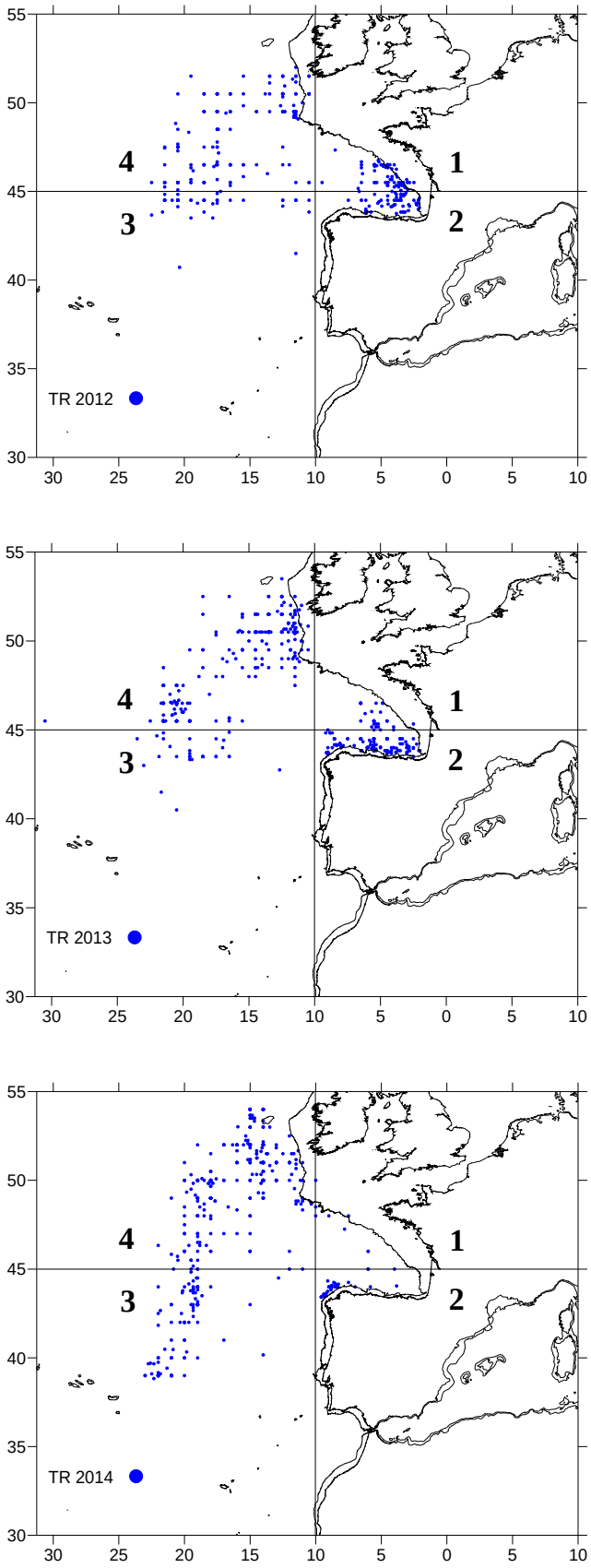

Figure 1. Annual spatial distribution of troll trips sampled to collect nominal CPUE´s information during 2012-2014. Levels of spatial factor Zone (1,2,3,4) used in the model.

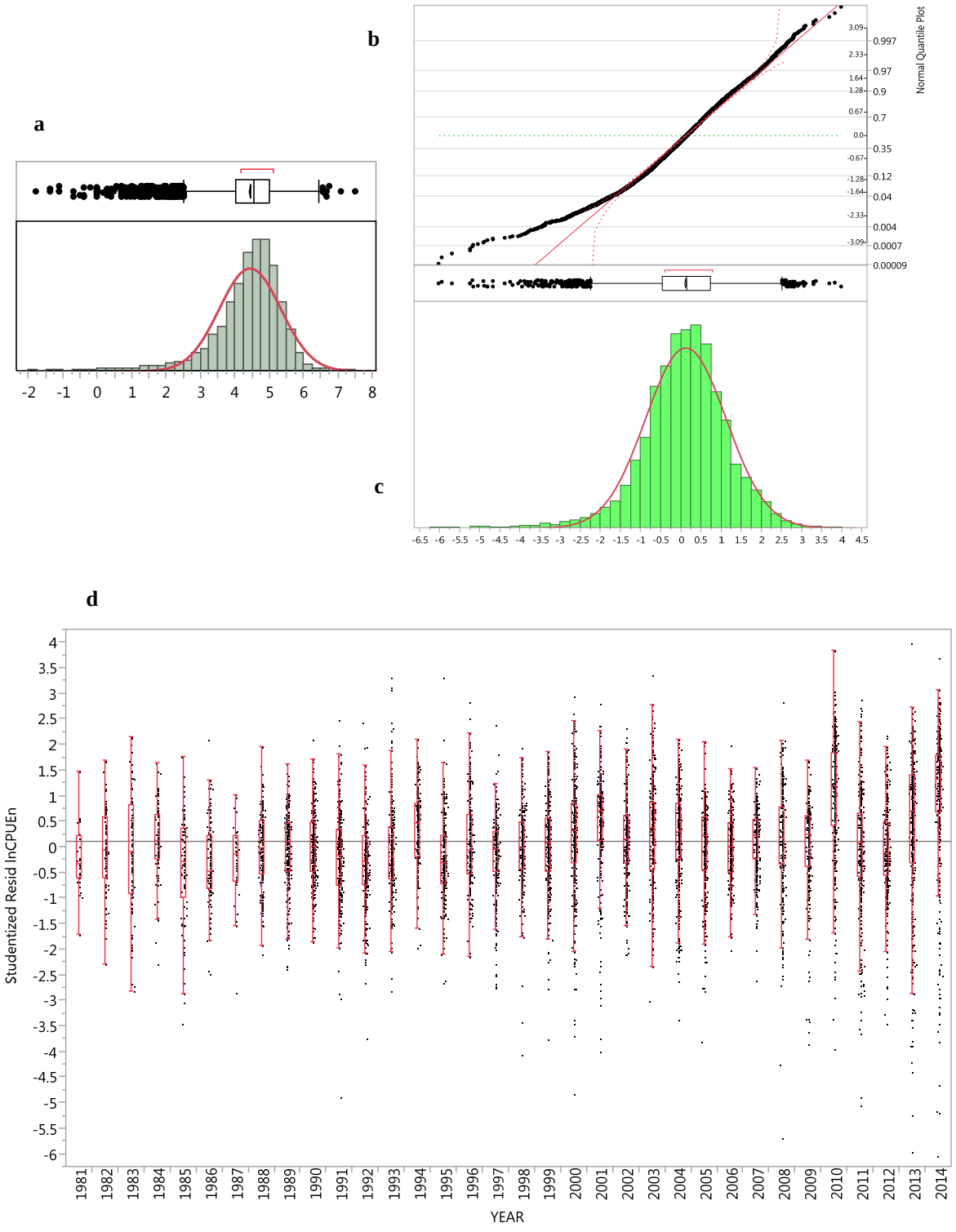

Figure 2. Model diagnostics plots from lognormal error distribution with main effects of Year, Quarter, Zone categories and Year by Quarter and Year by Zone random effects interaction, a) density and frequency distribution of log nominal CPUE troll 1981-2014, b) quantiles of standardized residuals, c) histogram of standardized residuals, d) Standardized residuals by year.

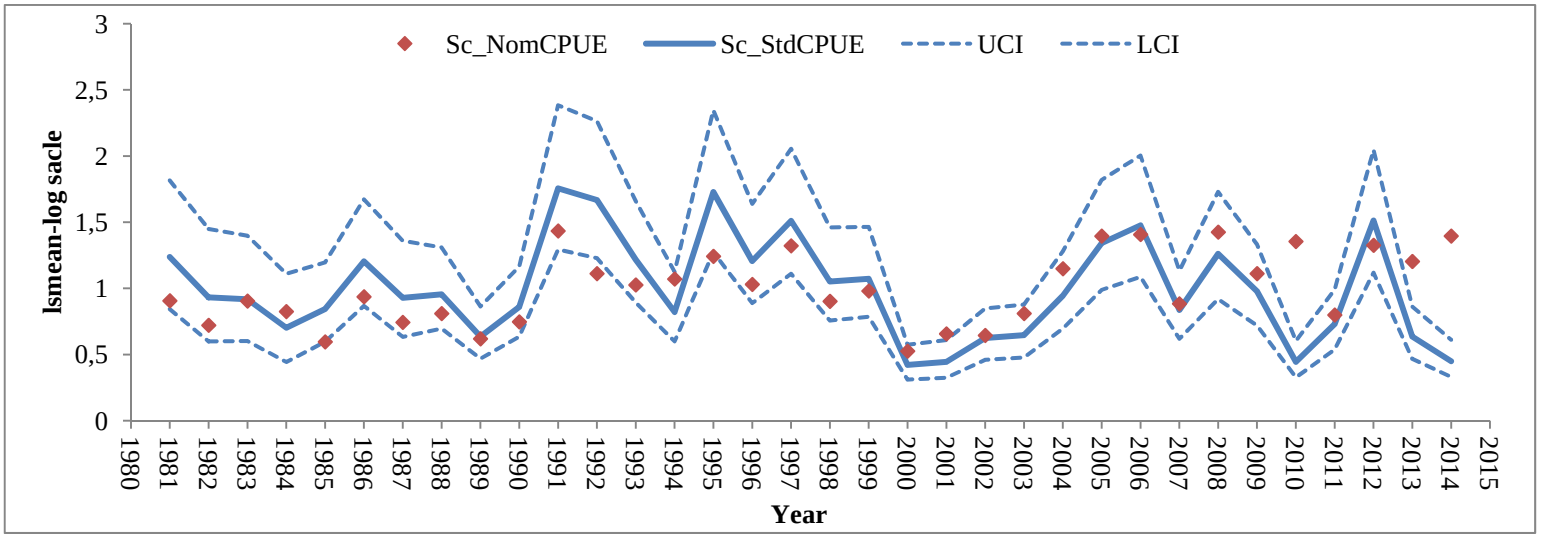

Figure 3. Estimated CPUEn (log-scale), low and upper confidence intervals of response variable from Spanish troll fleet, 1981-2014.

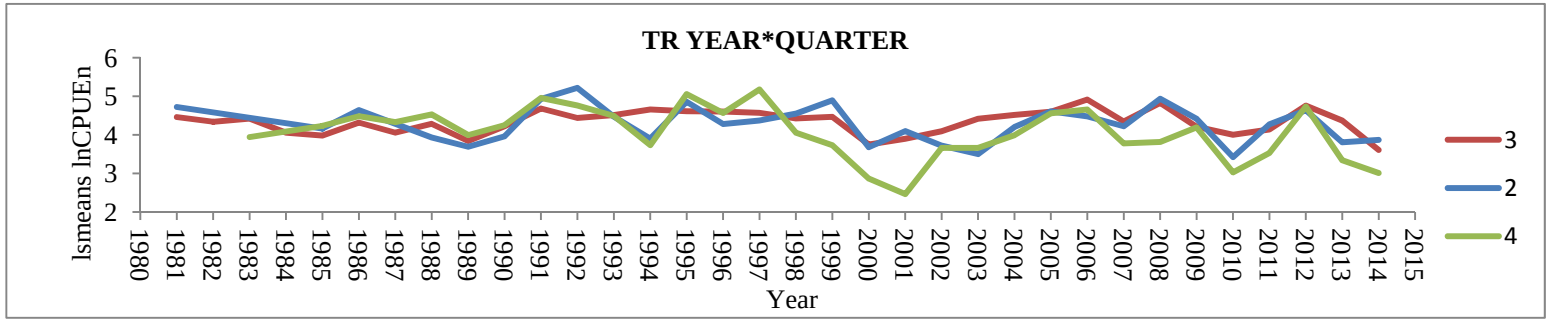

Figure 4. Estimated CPUEn (log-scale) by quarter from Spanish troll fleet, 1981-2014.