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STANDARDIZED NORTH EAST ATLANTIC ALBACORE (*THUNNUS ALALUNGA*) CPUEs FROM THE SPANISH BAITBOAT FLEET, BY QUARTER, FOR THE PERIOD 1981-2011

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SUMMARY

*Nominal catch in number of fish per unit effort (CPUEs) of North Atlantic albacore (*Thunnus alalunga*) caught by the Spanish baitboat fleet in the North eastern Atlantic were collected by individual trip for the period 1981-2011 and analyzed by generalized linear model (GLM) .The year and quarter interaction factor was included to obtain year-quarterly CPUE series to use in Multifan-CL model fit. The model had a log-normal error distribution with constant variance.*

RÉSUMÉ

La prise nominale en nombre de poisson par unité d'effort (CPUE) de germon de l'Atlantique Nord (Thunnus alalunga) capturé par la flottille de canneurs espagnols dans l'Atlantique Nord-Est a été recueillie par sortie individuelle pour la période 1981-2011. Celle-ci a été analysée au moyen d'un modèle linéaire généralisé (GLM). Le facteur d'interaction année et trimestre a été inclus afin d'obtenir des séries de CPUE annuelle-trimestrielle à utiliser dans l'ajustement du modèle Multifan-CL. Le modèle avait une distribution d'erreur lognormale avec une variance constante.

RESUMEN

La captura nominal en número por unidad de esfuerzo (CPUE) del atún blanco del Atlántico norte capturado por la flota española de cebo vivo, recogidas en mareas individuales durante el período de 1981 a 2011, fueron analizadas con un Modelo Generalizado Lineal (GLM). El factor de interacción año y trimestre fue incluido en el análisis para obtener la CPUE estandarizada por año y trimestre para su utilización en el ajuste del modelo Multifan-CL. El modelo tenía una distribución de error lognormal con una varianza constante.

KEYWORDS

Thunnus alalunga*, Albacore, Standardization, Quarterly CPUEs, Baitboat fleet, GLM, North Atlantic*

1. Introduction

The North Atlantic albacore stock has been assessed since 2007 (Anon. 2008), by applying the method MULTIFAN-CL (Fournier *et al*., 1998) among others assessment methods. This model is applied to catch, effort and length frequency data compiled for all the fisheries in the North Atlantic Ocean. Accordingly to the 2013 work plan elaborated for the 2013 assessment session it is required to prepare several statistics and set 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 bait boat fishery by quarter and year were updated and standardized to calculate the corresponding standardized fishing effort for this fishery (Ortiz de Zárate and Ortiz de Urbina, 2008; 2010).

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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 bait boat fishery operating in the Bay of Biscay and adjacent North east Atlantic area during the period 1981 to 2011. To derive the quarterly based standardized CPUEs, the interaction term year * quarter, was modelled by means of the Generalized Linear Modelling (GLM) approach assuming the log-normal error distribution model in the analysis.

The time series of standardized bait boat CPUE's by quarter/year from 1981 to 2011 are presented to be used in the Multifan-CL model analysis to estimate the state of the population of North Atlantic albacore stock in the 2013 assessment session.

2. Materials and Methods

Data collected from the Spanish bait boat fishery comprises a total of 2723 trips compiled from 1981 through 2011. Information on trips from commercial bait boats was recorded at landing ports through interviews of skippers and the catch landed by commercial categories was randomly sampled to the nearest centimeter (FL= 35–120 cm range) on each single trip surveyed. Each record contains information on: date of landing, number of fishing days, area of effort , catch in number, catch in weight (k), likewise information on size of catches landed by commercial categories was obtained through random sampling, measuring the fish to the nearest centimeter (FL= 35–120 cm range). In **Table 1**, is summarized the sampling coverage in number of fish, in relation to the total catch in number of fish, for the period from 2000 to 2011.

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 broad sense, however it shows inter annual variability depending on availability of the resource (Ortiz de Zárate and Barreiro, 2010; Ortiz de Zárate *et al*., 2011; 2012; 2013). The stratification of the fishing area concerning trips location, is the same as in previous analyses (Ortiz de Zárate and Cramer, 2001; Ortiz de Zárate and Ortiz de Urbina, 2008; 2010) and it was defined as the explanatory variable ZONE factor with four levels (1=NE, 2=SE, SW =3 and 4=NW) in the Generalized Linear Model applied in the CPUE´S analyses (**Figure 1)**. The number of trips for the whole period comprising 1981 to 2011 were summarized in relation to the spatial and temporal strata. Total CPUE's observations were included in the analyses and are presented in **Table 2**. All the observations are positive trips and the nominal catch rate expressed in number of fish per fishing day was log transformed. Frequency distribution of the log transformed response variable for years 1981 to 2011, is shown in **Figure 2.**

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

Additionally, this factor was included in the model as year*time interaction fixed factor to derive the yearly standardized CPUE´s by quarter. Therefore the set of fixed factors: Year, Zone, Quarter that significantly explained the observed variability of the response variable (Ortiz de Zárate and Ortiz de Urbina, 2008; 2010) and an interaction term [Year*time] were included as explanatory variables in the formulated model as follows:

Model formulation

$\log(\text{CPUEn}) = \mu + Yi + Zk + \text{QUARTER}l + Yi * \text{QUARTER}l + \varepsilon_{ikl}$

where

μ= overall mean

Y = year factor; levels: 1981-2007

Z = 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 GLM procedure of S-PLUS 2000 statistical software (Professional release 2) which includes the contrast treatment option to estimate the coefficients relative to the first level of each factor in the model. Also another run was done using GLM code R version 2.12.1

Year*time least squares means (LSmeans) were bias corrected using the algorithm of Lo et al., (1992) and back-transformed estimates of CPUE´s calculated. Standarized catch rates in number of fish per fishing day (CPUEn) were estimated for the interaction term year*time strata of the model.

3. Results and Discussion

The model fit and the summary statistics of the ANOVA Type I significance test for fixed factors are shown in **Table 3a** and **3b**, respectively. As shown, the model accounted for 23.58 % of the variability of the observed log-CPUE when counting for the year*quarter term.

Diagnostics plots of the model are shown in **Figure 3**. Plots of standardized residuals, plots of residuals against predicted log CPUE values, response variable against predictor variables and the normalized cumulative residuals (or QQ-residual plots) are represented. Some negative residuals on the tail of the normal distribution are appreciated, that don´t fit well the normal standard distribution. Those observations represent a number of trips with very low number of fish (i.e. 2 fish) caught. Nevertheless the log catch rates of the lognormal model suggests a reasonably overall fit for the time series analysed.

The quarterly standardized nominal catch rates (CPUEn) and estimated coefficients of variation for the model fit are presented in **Table 4.** Likewise, time series of the standardized CPUE (log-scale), nominal CPUE (log-scale) and the respective 95% low and high confidence intervals of the response variable along with a lowest trend fit to show evolution of the response variable, are shown in **Figure 4.**

Acknowledgments

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Table 1. Summary of sampling coverage in number of fish obtained from monitoring of bait boat fleet, years 2000 to 2011.

Baitboat	No. Sample	No. Catch	Percentage	Mean %
2000	15231	1726156	0.88	
2001	14157	488788	2.90	
2002	10729	505709	2.12	
2003	13362	1299360	1.03	
2004	15881	1172419	1.35	
2005	39315	1107560	3.55	
2006	20186	1923541	1.05	1.51
2007	14060	969233	1.45	
2008	6273	853732	0.73	
2009	5652	498845	1.13	
2010	6429	722769	0.89	
2011	10468	965334	1.08	

Table 2. Summary of observations by Zone and Quarter analysed in the model.

Quarter	No. OBS	ZONE	No. OBS
2	12	NE	866
3	2270	SE	1588
4	441	SW	228
		NW	41
Total	**2723**		**2723**

Table 3.a. Summary of fits for the YEAR*QUARTER model

Model QUARTER*YEAR	DF	Residual SE	Adj R-Square
	2655	0.8793	0.2358

Table 3.b. ANOVA Type I test for fixed factors in Model YEAR*QUARTER

Source	DF	Type I SS	Mean Square	F Value	Pr(>F)
YEAR	30	282.166	9.40553	12.1640	< 2.20E-16
TRIM	2	187.021	93.51071	120.9356	< 2.20E-16
ZONE	3	22.381	7.46039	9.6484	< 2.20E-16
YEAR*TRIM	32	209.606	6.55020	8.4712	< 2.20E-16
Residuals	2655	2052.919	0.77323		

Table 4. Quarterly Standardized CPUEs estimated from lsmeans and standard error and log nominal CPUE in number of fish per fishing day. BB fleet, 1981-2011.

YEAR	Quarter	lsmean	SE	lower.CL	upper.CL	CV (%)	Standardized CPUEn	lower.CL	upper.CL	Nominal lnCPUEn
1981	2	NA	NA	NA	NA	NA	NA	NA	NA	NA
1981	3	4,8584	0,1921	4,4818	5,2350	3,9533	189,6147	130,1092	276,3354	4,8441
1981	4	4,2175	0,6236	2,9948	5,4402	14,7850	99,8914	29,4112	339,2673	4,3070
1982	2	NA	NA	NA	NA	NA	NA	NA	NA	NA
1982	3	4,8331	0,1562	4,5268	5,1394	3,2322	184,8715	136,0946	251,1304	4,8465
1982	4	4,8656	0,6232	3,6437	6,0876	12,8077	190,9887	56,2756	648,1792	4,8736
1983	2	4,2976	0,8805	2,5710	6,0241	20,4887	108,2185	19,2514	608,3305	4,2239
1983	3	5,2062	0,1637	4,8851	5,5272	3,1446	268,4695	194,7509	370,0922	5,2536
1983	4	5,0192	0,2119	4,6038	5,4347	4,2211	222,6928	146,9879	337,3889	4,9637
1984	2	NA	NA	NA	NA	NA	NA	NA	NA	NA
1984	3	4,6347	0,1776	4,2864	4,9830	3,8328	151,6078	107,0150	214,7824	4,6740
1984	4	NA	NA	NA	NA	NA	NA	NA	NA	NA
1985	2	NA	NA	NA	NA	NA	NA	NA	NA	NA
1985	3	4,9696	0,1370	4,7011	5,2382	2,7558	211,9231	162,0131	277,2080	4,9496
1985	4	5,0634	0,3615	4,3546	5,7722	7,1391	232,7498	114,5658	472,8510	5,0985
1986	2	NA	NA	NA	NA	NA	NA	NA	NA	NA
1986	3	4,8015	0,1425	4,5220	5,0810	2,9687	179,1231	135,4456	236,8851	4,8518
1986	4	4,9290	0,2012	4,5344	5,3235	4,0821	203,4748	137,1404	301,8950	4,9695
1987	2	NA	NA	NA	NA	NA	NA	NA	NA	NA
1987	3	5,2716	0,1561	4,9654	5,5778	2,9620	286,6231	211,0283	389,2973	5,3083
1987	4	4,8954	0,2813	4,3437	5,4470	5,7468	196,7583	113,3332	341,5931	4,9360
1988	2	NA	NA	NA	NA	NA	NA	NA	NA	NA
1988	3	5,1678	0,1298	4,9132	5,4223	2,5124	258,3570	200,2882	333,2614	5,1566
1988	4	5,2773	0,1808	4,9228	5,6319	3,4261	288,2765	202,2265	410,9421	5,2559
1989	2	NA	NA	NA	NA	NA	NA	NA	NA	NA
1989	3	4,9571	0,0880	4,7845	5,1296	1,7755	209,2738	176,1023	248,6935	5,0000
1989	4	4,8704	0,1453	4,5855	5,1553	2,9827	191,9013	144,3336	255,1458	4,8987

Table 4. Cont

YEAR	Quarter	lsmean	SE	lower.CL	upper.CL	CV (%)	Standardized CPUEn	lower.CL	upper.CL	Nominal lnCPUEn
1990	2	NA	NA	NA	NA	NA	NA	NA	NA	NA
1990	3	5,6878	0,1280	5,4369	5,9387	2,2499	434,5905	338,1458	558,5428	5,6745
1990	4	4,8298	0,2388	4,3616	5,2980	4,9437	184,2599	115,3717	294,2810	4,8027
1991	2	NA	NA	NA	NA	NA	NA	NA	NA	NA
1991	3	5,3286	0,1209	5,0914	5,5657	2,2697	303,4334	239,3692	384,6440	5,2978
1991	4	4,7065	0,2673	4,1823	5,2308	5,6802	162,8983	96,4386	275,1585	4,6277
1992	2	NA	NA	NA	NA	NA	NA	NA	NA	NA
1992	3	5,3389	0,1202	5,1031	5,5746	2,2522	306,5697	242,1776	388,0830	5,2981
1992	4	3,6855	0,2962	3,1047	4,2663	8,0370	58,6800	32,8281	104,8901	3,6481
1993	2	NA	NA	NA	NA	NA	NA	NA	NA	NA
1993	3	5,4471	0,1182	5,2154	5,6787	2,1692	341,5999	270,9557	430,6632	5,3920
1993	4	5,0093	0,4420	4,1425	5,8760	8,8241	220,4966	92,6781	524,5980	4,9356
1994	2	NA	NA	NA	NA	NA	NA	NA	NA	NA
1994	3	5,4998	0,1379	5,2295	5,7702	2,5068	360,1185	274,8123	471,9053	5,5505
1994	4	5,1403	0,2316	4,6862	5,5943	4,5052	251,3482	159,6122	395,8092	5,0666
1995	2	NA	NA	NA	NA	NA	NA	NA	NA	NA
1995	3	5,3894	0,1184	5,1572	5,6215	2,1970	322,4488	255,6395	406,7177	5,3879
1995	4	4,9003	0,3959	4,1240	5,6765	8,0789	197,7195	90,9740	429,7163	4,8266
1996	2	6,1705	0,8862	4,4327	7,9083	14,3627	704,1900	123,8723	4003,1877	6,0398
1996	3	5,4487	0,1073	5,2384	5,6591	1,9685	342,1767	277,2757	422,2693	5,4559
1996	4	NA	NA	NA	NA	NA	NA	NA	NA	NA
1997	2	NA	NA	NA	NA	NA	NA	NA	NA	NA
1997	3	5,5057	0,1541	5,2034	5,8080	2,7997	362,2307	267,7426	490,0646	5,4980
1997	4	4,6993	0,1778	4,3506	5,0480	3,7842	161,7229	114,1122	229,1980	4,6507
1998	2	6,6931	0,8862	4,9553	8,4309	13,2411	1187,6291	208,9127	6751,4478	6,5624
1998	3	5,6322	0,1237	5,3896	5,8749	2,1969	411,0970	322,5329	523,9804	5,6048
1998	4	5,3016	0,6232	4,0796	6,5235	11,7545	295,3539	87,0272	1002,3758	5,3095

Table 4. Cont

YEAR	Quarter	lsmean	SE	lower.CL	upper.CL	CV (%)	Standardized CPUEn	lower.CL	upper.CL	Nominal lnCPUEn
1999	2	NA	NA	NA	NA	NA	NA	NA	NA	NA
1999	3	5,5394	0,1053	5,3330	5,7458	1,9004	374,6485	304,7715	460,5467	5,5342
1999	4	3,4905	0,3355	2,8327	4,1483	9,6110	48,2827	25,0097	93,2129	3,4168
2000	2	NA	NA	NA	NA	NA	NA	NA	NA	NA
2000	3	5,8294	0,0936	5,6459	6,0129	1,6055	500,6795	416,7353	601,5335	5,8417
2000	4	3,5890	0,2818	3,0365	4,1416	7,8513	53,2834	30,6638	92,5885	3,5154
2001	2	NA	NA	NA	NA	NA	NA	NA	NA	NA
2001	3	4,8099	0,0902	4,6331	4,9867	1,8747	180,6411	151,3659	215,5783	4,8046
2001	4	4,1680	0,8805	2,4414	5,8946	21,1256	95,0675	16,9120	534,4046	4,0943
2002	2	NA	NA	NA	NA	NA	NA	NA	NA	NA
2002	3	4,8203	0,1002	4,6238	5,0168	2,0789	182,5221	149,9614	222,1523	4,7690
2002	4	3,7704	0,1852	3,4072	4,1335	4,9119	63,8760	44,4249	91,8438	3,6967
2003	2	NA	NA	NA	NA	NA	NA	NA	NA	NA
2003	3	5,5251	0,0946	5,3397	5,7106	1,7121	369,3406	306,8120	444,6130	5,5011
2003	4	4,2263	0,2390	3,7576	4,6949	5,6554	100,7723	63,0669	161,0203	4,1759
2004	2	5,0981	0,5082	4,1015	6,0946	9,9691	240,9637	88,9504	652,7624	5,0054
2004	3	5,4486	0,0928	5,2667	5,6306	1,7033	342,1401	285,2141	410,4279	5,4437
2004	4	4,3832	0,2308	3,9306	4,8357	5,2658	117,8899	74,9761	185,3660	4,4417
2005	2	NA	NA	NA	NA	NA	NA	NA	NA	NA
2005	3	5,3894	0,0810	5,2305	5,5482	1,5035	322,4497	275,0798	377,9770	5,4085
2005	4	4,3596	0,1688	4,0285	4,6906	3,8726	115,1389	82,6893	160,3226	4,3093
2006	2	5,4576	0,3619	4,7480	6,1672	6,6306	345,2129	169,7934	701,8651	5,3839
2006	3	6,2238	0,0867	6,0538	6,3937	1,3925	742,7401	626,6582	880,3242	6,2110
2006	4	4,2245	0,2394	3,7551	4,6939	5,6668	100,5959	62,9089	160,8598	4,1509

Table 4. Cont

YEAR	Quarter	lsmean	SE	lower.CL	upper.CL	CV (%)	Standardized CPUEn	lower.CL	upper.CL	Nominal lnCPUEn
2007	2	NA	NA	NA	NA	NA	NA	NA	NA	NA
2007	3	5,6952	0,0889	5,5209	5,8695	1,5609	437,8005	367,7654	521,1726	5,6720
2007	4	4,3295	0,2015	3,9345	4,7246	4,6536	111,7346	75,2681	165,8687	4,2653
2008	2	NA	NA	NA	NA	NA	NA	NA	NA	NA
2008	3	5,4884	0,1112	5,2702	5,7065	2,0269	356,0102	286,2376	442,7903	5,5198
2008	4	3,9783	0,2818	3,4258	4,5309	7,0830	78,6425	45,2576	136,6541	3,9047
2009	2	NA	NA	NA	NA	NA	NA	NA	NA	NA
2009	3	5,4289	0,1069	5,2192	5,6386	1,9695	335,4528	272,0044	413,7009	5,4411
2009	4	4,6977	0,2477	4,2120	5,1834	5,2731	161,4651	99,3404	262,4410	4,6492
2010	2	NA	NA	NA	NA	NA	NA	NA	NA	NA
2010	3	5,4415	0,1024	5,2407	5,6422	1,8818	339,6923	277,8975	415,2278	5,4947
2010	4	4,1929	0,1595	3,8803	4,5056	3,8029	97,4677	71,2974	133,2442	4,1292
2011	2	NA	NA	NA	NA	NA	NA	NA	NA	NA
2011	3	5,4079	0,0888	5,2339	5,5820	1,6413	328,4962	276,0225	390,9455	5,3993
2011	4	6,2358	0,1430	5,9554	6,5162	2,2935	751,7345	567,8971	995,0831	6,1660

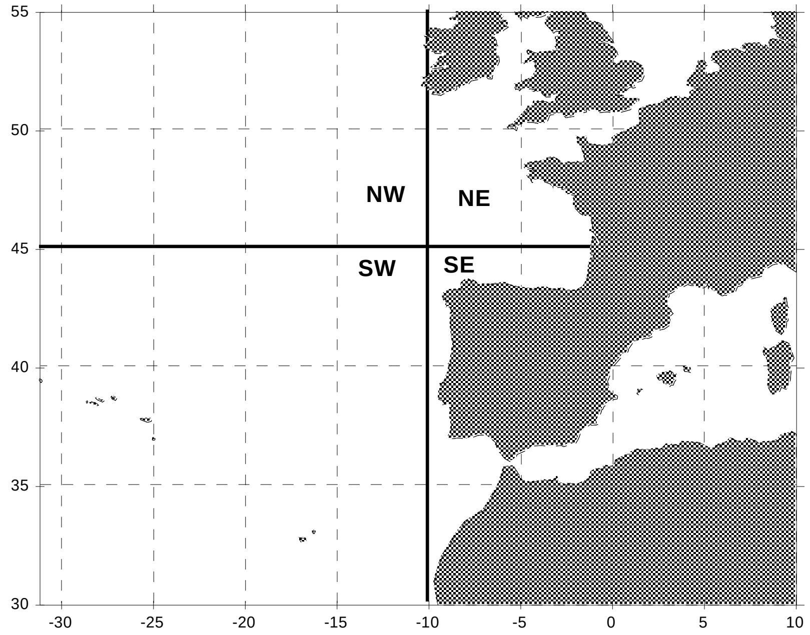

Figure 1. Area stratification used in the analysis of Atlantic albacore bait boat fishery CPUE observations: 1981-2011. Factor ZONE with 4 levels

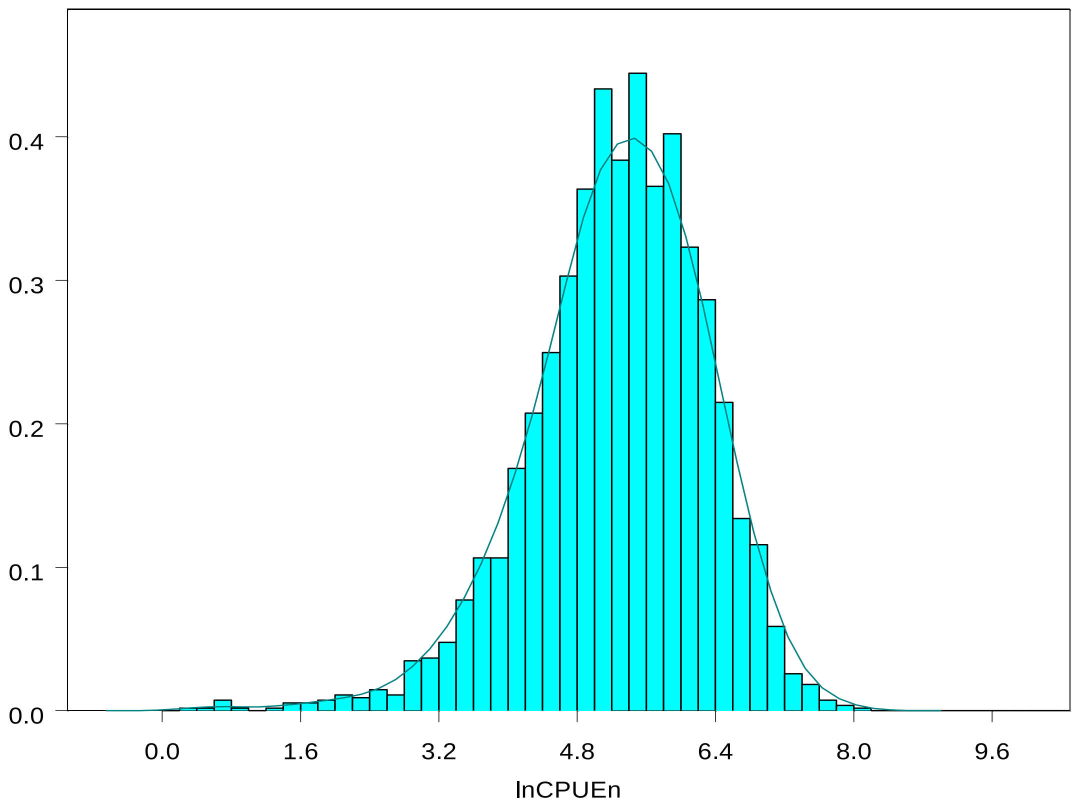

Figure 2. Density and frequency distribution of total observed nominal CPUE (log-scale) in number fish per fishing day from bait boat fleet for 1981-2011 period

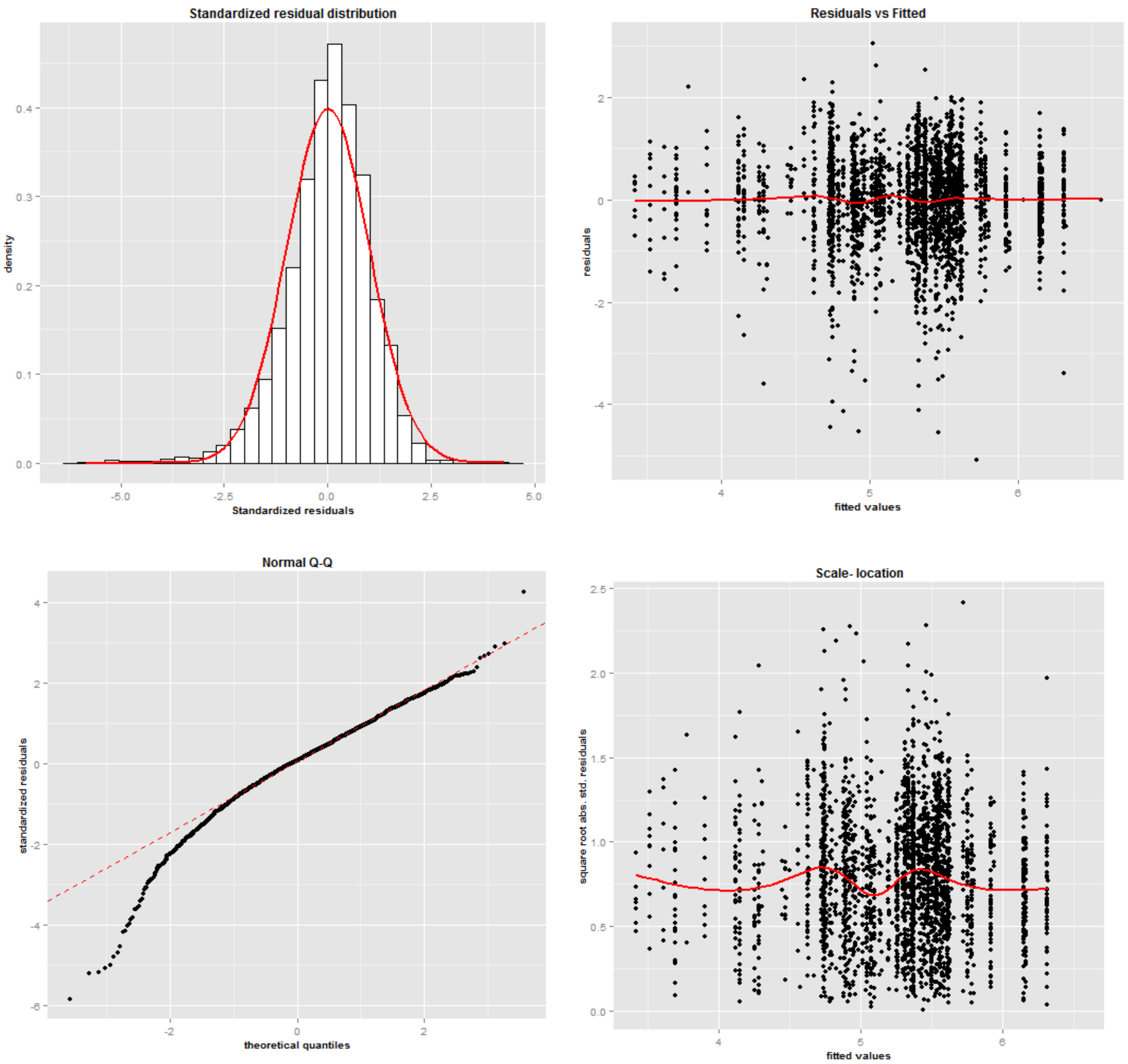

Figure 3. Model fit diagnostics (clockwise from top left). Standardized residual, residual *v* fitted values; quantiles of standard normal, sqrt(abs(residuals) *v* fitted;). Log- Normal error model

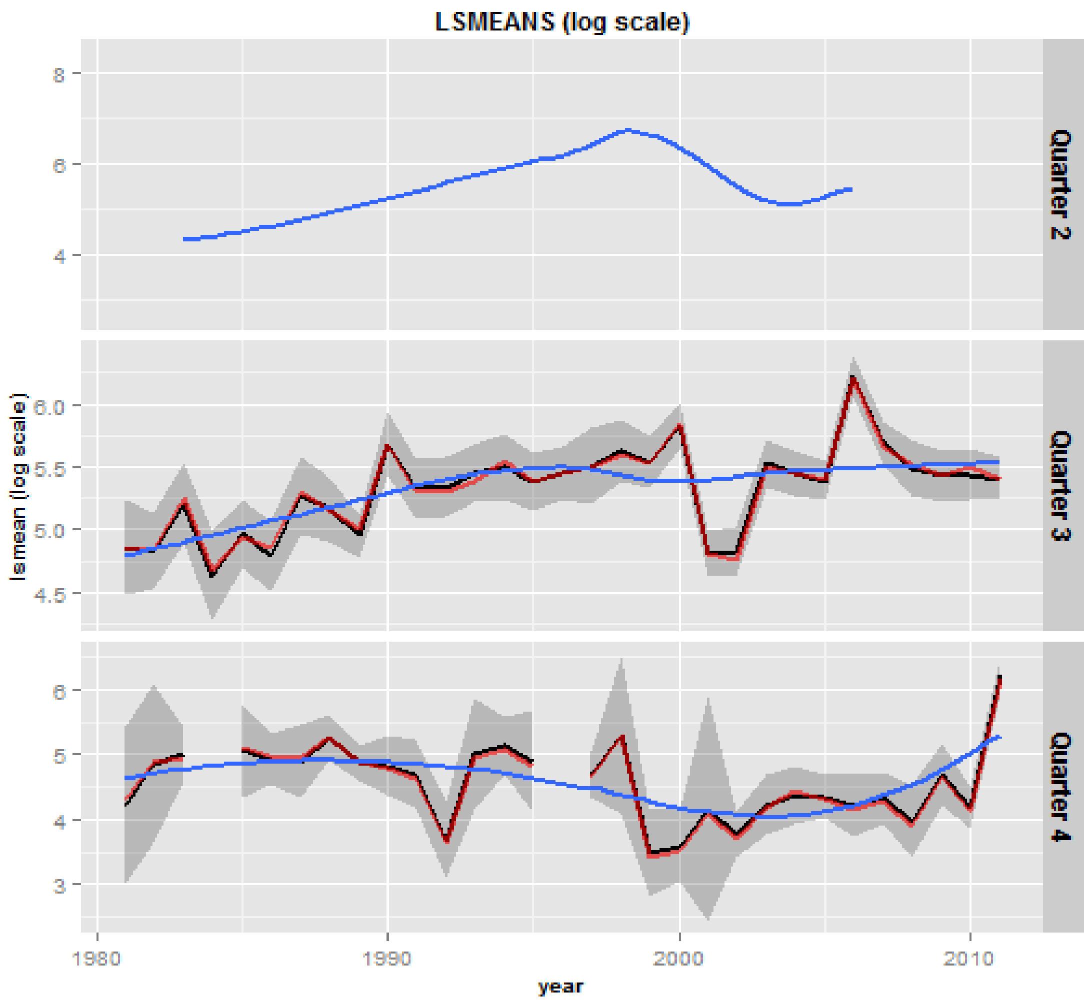

Figure 4. Observed bait boat CPUEn (log-scale) represented by red line, estimated CPUEn (log-scale) by black line, confidence interval of response variable by grey area and lowest fit by blue line to show trend in response variable. Years 1981-2011 by quarter