PRELIMINARY UPDATE OF CATCH RATES OF LARGE BLUEFIN TUNA (*THUNNUS THYNNUS*) FROM THE U.S. PELAGIC LONGLINE FISHERY (1987-2013) ACCOUNTING FOR WEAK HOOK IMPLEMENTATION

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SUMMARY

An updated index of abundance of bluefin tuna was constructed from logbooks from the U.S. pelagic longline fishery in the U.S. Gulf of Mexico for1987-2013. The index is an update of the index presented for the 2012 assessment and was estimated to evaluate recent abundance trends. The index was constructed using a repeated measures procedure to account for the variance in catch rates between vessels, and was standardized using Generalized Linear Mixed Models and a delta lognormal approach. In 2011 vessels were required to use a 'weak' hook that bent due to pressure from a large fish as a means of reducing bycatch of Bluefin tuna. Experiments have determined that these hooks result in a 46% (23-62%CI) reduction in the catch rates of bluefin tuna. Indices for2011, 2012 and 2013 were adjusted upwards by a factor of 1.108,1.54 and 1.54, respectively to account for this expected reduction in CPUE. Adjusted index values for 2012 were among the highest in the time series and indicate an increasing CPUE in recent years.

RÉSUMÉ

Un indice d'abondance actualisé du thon rouge a été créé à partir des carnets de pêche de la pêcherie palangrière pélagique des États-Unis opérant dans le golfe du Mexique entre 1987 et 2013. Il s'agit d'une actualisation de l'indice présenté pour l'évaluation de 2012 et il a été estimé pour évaluer les tendances récentes de l'abondance. L'indice a été élaboré à l'aide d'une procédure de mesures répétées pour tenir compte de la variance dans les taux de capture entre les navires, et il a été standardisé au moyen de modèles mixtes linéaires généralisés et d'une approche delta-lognormale. En 2011, les navires ont dû utiliser un hameçon "faible" qui se plierait avec la pression exercé par un gros poisson comme moyen de réduire les prises accessoires de thon rouge. Des expériences ont démontré que ces hameçons entraînent une réduction de 46% (23-62% CI) des taux de capture du thon rouge. Les indices de 2011, 2012 et 2013 ont été ajustés à la hausse par un facteur de 1,108, 1,54 et 1,54, respectivement afin de tenir compte de cette réduction escomptée dans la CPUE. Les valeurs des indices ajustés pour 2012 étaient parmi les plus élevées dans les séries temporelles et elles indiquent une hausse de la CPUE au cours de ces dernières années.

RESUMEN

Se calculó un índice de abundancia actualizado de atún rojo a partir de los informes de los cuadernos de pesca de las pesquerías palangrera pelágica estadounidense en el Golfo de México para el periodo 1987-2013. El índice es una actualización del índice presentado para la evaluación de 2012 y se estimó para evaluar las tendencias de abundancia recientes. El índice se obtuvo utilizando un procedimiento de mediciones repetidas para tener en cuenta la variación en las tasas de capturas entre los buques, y se estandarizó mediante modelos lineales mixtos generalizados y un enfoque delta lognormal. En 2011, se requirió a los buques que utilizasen un anzuelo más flojo diseñado para enderezarse por la presión de un ejemplar grande, como medio para reducir la captura fortuita de atún rojo. Los experimentos han determinado que estos anzuelos tienen como resultado una reducción del 46% (23-62% CI) en las tasas de captura de atún rojo. Los índices para 2011, 2012 y 2013 se ajustaron al alza con factores de 1,108; 1,54 y 1,54, respectivamente, para tener en cuenta esta reducción prevista en la CPUE. Los valores de los índices ajustados para 2012 fueron unos de los más elevados de la serie temporal e indicaban un incremento en la CPUE en los últimos años.

KEYWORDS

Catch/effort, Abundance, Commercial longline, Bluefin tuna

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1. Introduction

This paper is a strict update of an index constructed from the US pelagic longline fishery in the Gulf of Mexico obtained from vessel logbooks. It is constructed with the same delta-lognormal model as Cass-Calay & Walter (2013) but with data updated through 2013. In the 2012 assessment, the year 2011 was removed from the index so the index only was through 2010. For the purposes of evaluating population trends we have included 2011 and the years 2012 and 2013, though the previous concerns that 2011 may represent anamolous effort remain. In 2011 the U.S. longline fleet operated very differently from previous years in that only 18 of the sets that met the filtering criteria caught bluefin tuna, and these were limited to vessels targeting swordfish in the southeastern part of the Gulf of Mexico which historically have low CPUE of BFT.

In this fishery, bluefin are considered incidental bycatch to this fishery, which primarily targets swordfish, bigeye and yellowfin tunas. Previous studies have used logbook data from this fishery to construct catch rate indices for the western stock of Atlantic bluefin (Cramer and Ortiz 2000; Cramer 2002; Cass-Calay 2007; Diaz and Cass-Calay 2009, Cass-Calay 2011). These indices were utilized during previous assessments of Atlantic bluefin tuna.

2. Materials and methods

Data used in this paper comes from vessel logbook data from the US Pelagic longline fishery operating in the US Gulf of Mexico. The main features of the U.S. pelagic longline fleet are described by Hoey and Bertolino (1988). Logbook records have been collected since 1986. Each logbook record contains trip information by fishing day or set, including: vessel ID, date and time, fishing location, catch in numbers and fishing effort (hooks per set). The majority of records describe a unique longline set, other types of records (fishing day) were excluded from the analysis. Because very few sets were reported in 1986, records from 1986 were excluded.

This index is intended to reference the spawning stock biomass of western bluefin tuna. Therefore, to minimize the inclusion of effort targeting species unlikely to co-occur with bluefin tuna and/or effort targeting bluefin tuna that are unlikely to spawn, the analysis dataset was restricted to sets occurring in the Gulf of Mexico (GOM) from January 1 to May 31 of each year. During this time period, vessels were substantially more likely to report bluefin tuna. Vessels were included in the analysis if they that caught, released or discarded at least one bluefin tuna during two or more years of the time series (N = 180). Sets from the Desoto closed area were removed prior to and post closure. Data exclusions exactly followed the previous index and data from pre-2010 was exactly the same as this index.

In this paper we use the same delta-lognormal model as in Cass-Calay & Walter (2013) and do not update model factors. The model uses a repeated measures approach where the variance in catch rates, by vessel, was modeled using "repeated measures" within the SAS PROC MIXED procedure (Littell *et al*., 1998). The two models used are shown, below:

PROPORTION POSITIVE SETS = YEAR + ZONE + MONTH + ZONE*MONTH + YEAR*MONTH + YEAR*ZONE

LOG(CPUE) = YEAR + MONTH + ZONE
+ the effect of the repeated measure VESSEL_ID with the covariance structure VESSEL_ID(YEAR)

Parameterization of each model was accomplished using a GLM procedure (GENMOD; Version 8.02 of the SAS System for Windows © 2000. SAS Institute Inc. Cary, NC, USA). For the lognormal models, the response variable, log(CPUE), was calculated as:

log(CPUE) = log(Number of Bluefin Tuna kept and discarded / 1000 Hooks)]

Following exclusions the dataset contained 39,010 records from 1987 through 2013. Of these, 4,161 (10.6%) reported catching bluefin tuna (landed, discarded or released).

Correcting for the putative effects of circle hooks on recreational catch rates

The mandatory use of 'weak' hooks in the Gulf of Mexico beginning on May 5, 2011 was designed to reduce the discards of Bluefin tuna. The weak hook model and make is Mustad 39988 Prior to and after implementation of this rule, NOAA Fisheries conducted extensive experimental trials to determine the effectiveness of the weak hooks at reducing the incidental capture of Bluefin tuna. The results of these trials indicate a 46% (23-62% 95CI) reduction in the catch rates of Bluefin tuna (Foster and Bergmann 2012). Hence it may be necessary to adjust the commercial longline CPUE to account for this reduction in catch rate.

To make this correction it was necessary to make several assumptions:

1. Weak hook effect is knife-edged starting in May 5, 2011. No weak hooks in fishery prior to this time and then 100% compliance after.
2. To account for the implementation in May 5, 2011, 20% of the correction was applied in 2011 as the index is calculated for months January-May.
3. The resulted in the index values being increased by a factor of 1.108, 1.54 and 1.54 in 2011, 2012 and 2013, respectively.

To account for the variance of the estimate of the weak hook effect the variance of the corrected index was the calculated from the product of two random variables:

$$\mathrm{Var}(XY) = \mu_Y^2\sigma_X^2 + \mu_X^2\sigma_Y^2 + 2\mu_X\mu_Y\rho\sigma_X\sigma_Y.$$

Where X is the index for a given year and Y is the weak hook effect, and are the mean and variances of each component and is the correlation between the two components. The two ratios were assumed to be independent so the last term becomes zero. The variance of the correction factor is 0.01 (Foster and Bergmann 2012, pers comm.) (i.e. the variance of the estimate of a 46% decrease was 0.01. Converting this to a factor to be multiplied by each index gives a value of 1.54= (1+1-0.46) which has the same variance. Hence the variance of the adjusted index in each year is obtained by the above equation.

3. Results and discussion

Diagnostic plots show almost the same results as Cass-Calay & Walter (2013) for the dependent variables (**Figure 1**), the proportion positive (**Figure 2**) and for the lognormal component (**Figure 3**). The index for the time period 1987-2010 was exactly the same as in Cass-Calay & Walter (2013) (**Table 2**, **Figure 3**). For the updated time period the unadjusted index shows a slight decline in 2011 with a steep increase in 2012 and then a very low value in 2013 (**Table 2**, **Figure 4**). Adjusting for the substantial expected reduction in CPUE increases, the 2011 data point decreases by very little but the 2012 value increases to among the highest in the time series. Furthermore there appears to be a general trend of increasing index values since 2006 which would not have been estimated to have been as high in the unadjusted indices. We should also note that the data values for 2013 may be preliminary and not include 100% of all vessel logbooks.

Overall, accounting for the effects of the weak hooks increases the index and slightly expands the confidence intervals of the index values. The effect of the weak hooks was estimated to be quite substantial and, anecdotally, there were reports of substantial numbers of bent and straightened hooks during the 2012 and 2013 fishing season, presumably due to Bluefin tuna.

It should also be noted that this analysis does not take into account any effects that the Deep Water Horizon oil spill that began in the Gulf of Mexico on April 20, 2010 and continued until July 2010 may have had on catch and effort. Also, as noted in Cass-Calay and Walter (2012) management-related factors may have affected catch rates and should be carefully considered when this index is revised for the next stock assessment (**Figure 5**).

References

Cass-Calay, S.L. 2007. Standardized catch rates of large bluefin tuna (*Thunnus thynnus*) from the U.S. pelagic longline fishery in the Gulf of Mexico and off the Florida east coast during 1987-2005. Collect. Vol. Sci. Pap. ICCAT, 60(4): 1070-1086.

Cass-Calay, S.L. 2011. Standardized catch rates of large bluefin tuna (*Thunnus thynnus*) from the U.S. pelagic longline fishery in the Gulf of Mexico during 1987-2009. Collect. Vol. Sci. Pap. ICCAT, 66(3): 1257-1267.

Cass-Calay, S.L. and Walter, J. 2013. Standardized catch rates of large bluefin tuna (*Thunnus thynnus*) from the U.S. pelagic longline fishery in the Gulf of Mexico during 1987-2010. Collect. Vol. Sci. Pap. ICCAT, 69(2): 992-1004.

Cramer, J. 2002, Standardized catch rates for large bluefin tuna, *Thunnus thynnus*, from the U.S. pelagic longline fishery in the Gulf of Mexico and off the Florida east coast. Collect. Vol. Sci. Pap. ICCAT, 55(3): 1115-1122.

Cramer, J. and Ortiz, M. 2000, Standardized catch rates for large bluefin tuna, *Thunnus thynnus*, from the U.S. pelagic longline fishery in the Gulf of Mexico and off the Florida east coast. Collect. Vol. Sci. Pap. ICCAT, 52(3): 1070-1077.

Diaz, G.A. and Cass-Calay, S.L. 2009. Standardized catch rates of bluefin tuna (*Thunnus thynnus*) for the U.S. pelagic longline vessels in the Gulf of Mexico 1987-2007. Collect. Vol. Sci. Pap. ICCAT, 64(2): 417-448. 996.

Foster, D. and C. Bergman. 2012 Update Gulf of Mexico Weak Hook Research (Preliminary results) Presentation to the Fall 2012 HMS advisory panel. September 19 - 21, 2012. http://www.nmfs.noaa.gov/sfa/hms/Advisory%20Panels/AP2012/Fall/Agenda.htm.

Hoey, J.J. and Bertolino, A. 1988. Review of the U.S. fishery for swordfish, 1978 to 1986. Collect. Vol. Sci. Pap. ICCAT, 27: 256-266.

Littell, R.C., Henry, P.R. and Ammerman, C.B. 1998, Statistical analysis of repeated measures data using SAS procedures. J. Anim. Sci. 76: 1216-1231.

Table 1. Table of sets, hooks, number of positive sets and number of bluefin tuna (sum of kept and discarded).

YEAR	*SETS*	*HOOKS*	*POS SETS*	*BFT*
1987	1558	842,229	293	491
1988	1893	995,181	213	298
1989	1857	798,697	218	400
1990	1519	686,243	188	262
1991	1319	614,091	309	471
1992	1756	1,035,960	206	279
1993	1173	876,711	90	113
1994	1082	802,006	83	112
1995	1217	903,225	63	80
1996	1476	1,081,226	68	72
1997	1414	1,036,780	53	65
1998	1288	1,023,082	67	97
1999	1825	1,430,720	160	227
2000	1727	1,321,443	167	400
2001	1433	1,058,471	124	166
2002	1569	1,213,618	142	198
2003	1881	1,429,509	212	313
2004	2149	1,645,196	303	431
2005	2127	1,672,806	196	267
2006	1070	816,436	81	100
2007	1447	1,095,130	164	233
2008	1097	842,312	177	328
2009	1227	940,584	157	252
2010	1111	836,237	134	184
2011	303	164,635	18	24
2012	1415	1,038,953	217	304
2013	1077	762,459	58	77

Table 2. Table of number of nominal and standardized index of Bluefin CPUE from US pelagic longline index in the Gulf of Mexico.

Year	Nsets	nominal CPUE	% pos	std cpue	LCI	UCI	cv	2013 adj. weak hook	Adj LCI	Adj UCI	adjust ment factor
1987	1558	2.56	19%	3.29	1.72	6.27	0.33	3.16	1.657	6.034	1
1988	1893	1.44	11%	1.56	0.78	3.13	0.36	1.50	0.750	3.012	1
1989	1857	2.02	12%	2.48	1.27	4.83	0.34	2.39	1.224	4.652	1
1990	1519	1.70	12%	1.91	0.95	3.84	0.36	1.84	0.914	3.695	1
1991	1319	3.58	23%	3.30	1.72	6.33	0.33	3.18	1.656	6.089	1
1992	1756	1.28	12%	0.81	0.39	1.70	0.38	0.78	0.372	1.637	1
1993	1173	0.55	8%	0.45	0.21	0.99	0.41	0.44	0.198	0.957	1
1994	1082	0.52	8%	0.34	0.15	0.78	0.44	0.32	0.140	0.746	1
1995	1217	0.31	5%	0.32	0.14	0.74	0.44	0.31	0.131	0.715	1
1996	1476	0.24	5%	0.18	0.08	0.44	0.45	0.18	0.076	0.419	1
1997	1414	0.25	4%	0.34	0.15	0.75	0.41	0.32	0.146	0.719	1
1998	1288	0.34	5%	0.36	0.16	0.81	0.42	0.35	0.156	0.783	1
1999	1825	0.60	9%	0.62	0.30	1.26	0.37	0.59	0.291	1.209	1
2000	1727	1.20	10%	0.90	0.44	1.83	0.37	0.86	0.424	1.757	1
2001	1433	0.72	9%	0.51	0.23	1.15	0.42	0.49	0.219	1.109	1
2002	1569	0.78	9%	0.48	0.21	1.10	0.43	0.46	0.201	1.056	1
2003	1881	0.81	11%	0.87	0.44	1.76	0.36	0.84	0.419	1.693	1
2004	2149	0.93	14%	0.79	0.39	1.59	0.36	0.76	0.377	1.534	1
2005	2127	0.59	9%	0.60	0.29	1.25	0.38	0.58	0.276	1.200	1
2006	1070	0.45	8%	0.42	0.18	0.98	0.44	0.40	0.174	0.940	1
2007	1447	0.81	11%	0.56	0.25	1.25	0.42	0.54	0.238	1.204	1
2008	1072	1.53	16%	1.28	0.62	2.65	0.38	1.23	0.595	2.552	1
2009	1151	1.02	13%	1.07	0.50	2.33	0.40	1.03	0.477	2.241	1
2010	1070	0.88	12%	0.98	0.46	2.06	0.39	0.94	0.446	1.980	1
2011	303	0.57	6%	0.80	0.29	2.23	0.56	0.86	0.303	2.418	1.108
2012	1327	0.90	13%	1.32	0.64	2.72	0.32	1.96	1.049	3.658	1.54
2013	1077	0.39	5%	0.46	0.20	1.10	0.41	0.69	0.313	1.514	1.54

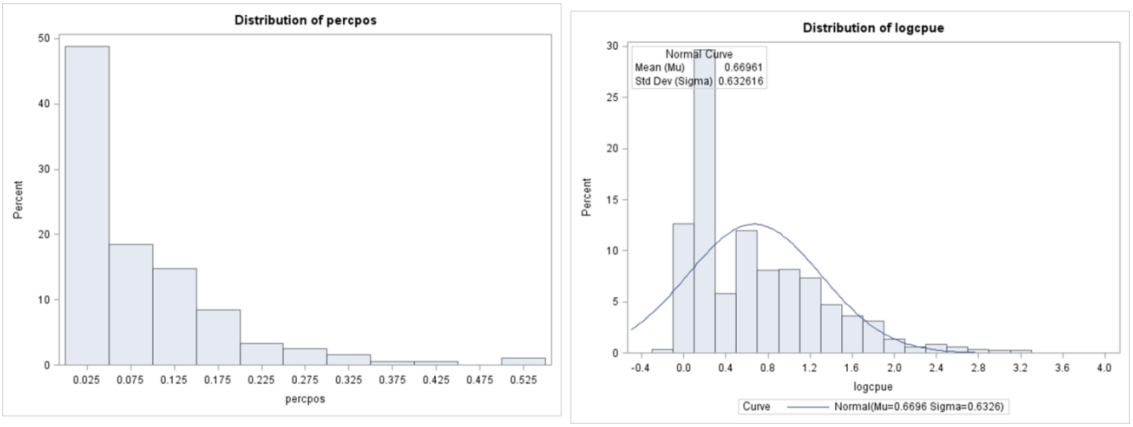

Figure 1. Distribution of proportion positive trips and histogram of log (CPUE).

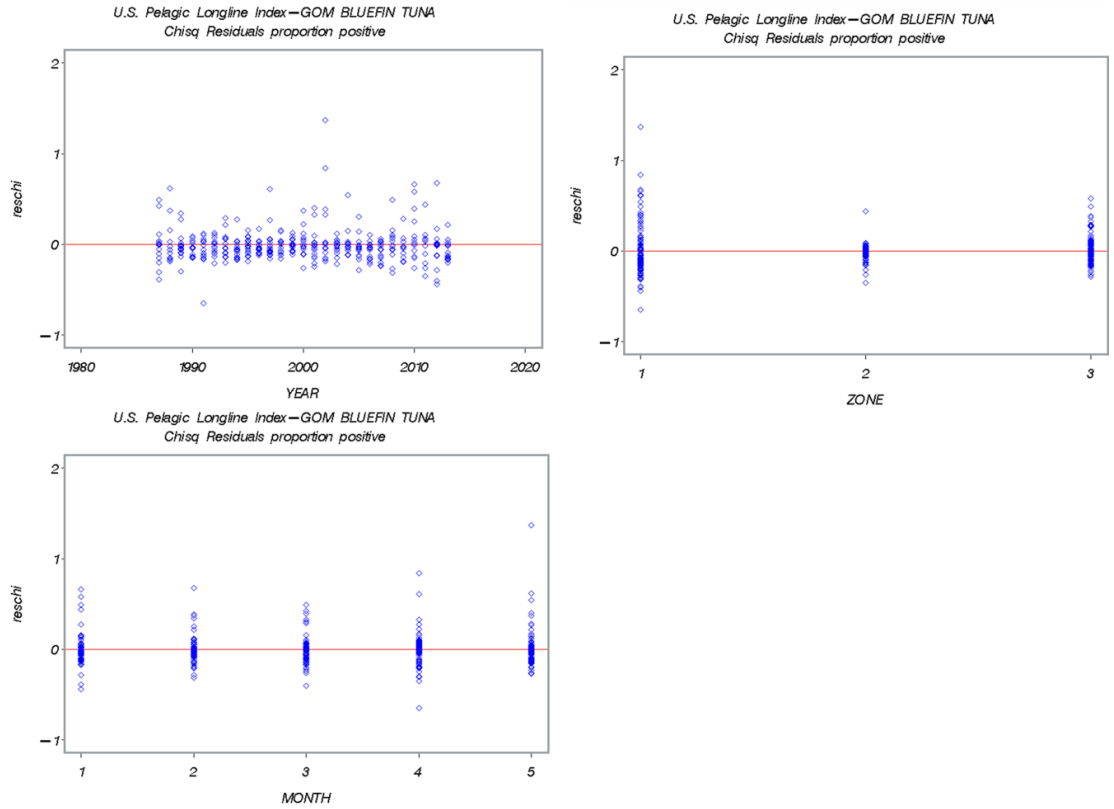

Figure 2. Chi-square residuals by year, zone and month for proportion positive.

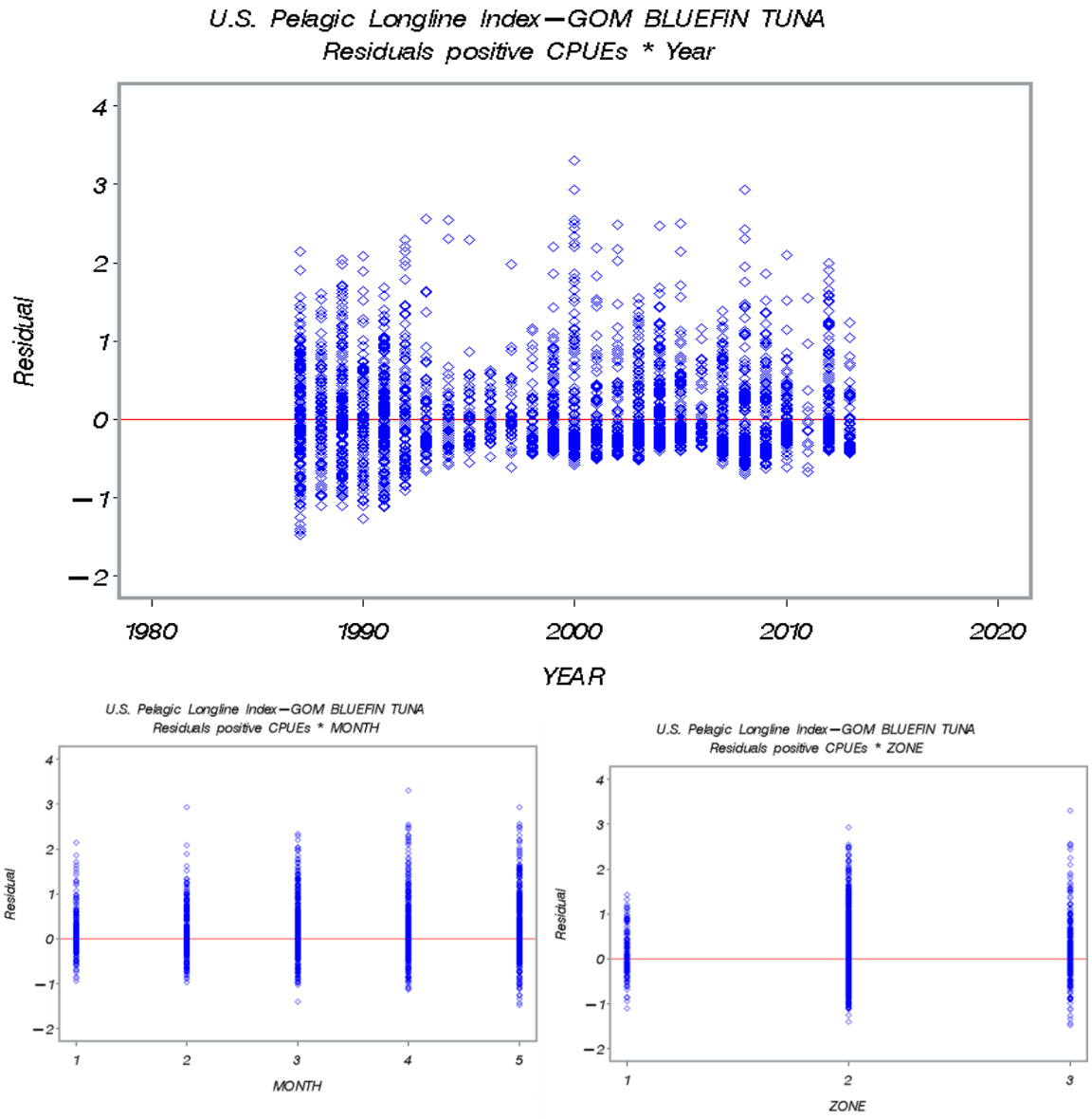

Figure 3. Chi-square residuals by year, zone and month for log (CPUE).

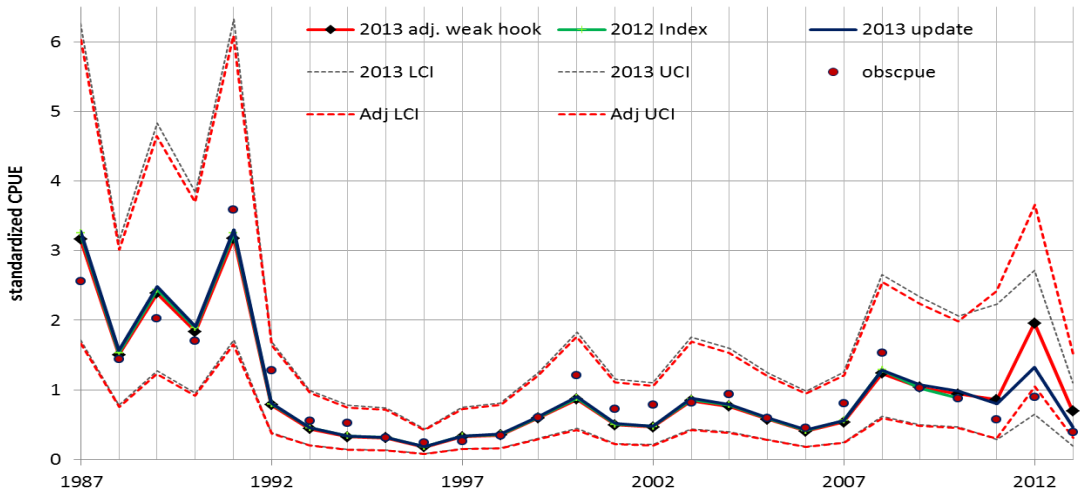

Figure 4. Standardized updated index with 2012 index for reference and index adjusted for weak hook effects in 2011, 2012 and 2013.