STANDARDIZED CATCH RATES OF VERMILION SNAPPER, *RHOMBOPLITES AURORUBENS*, FROM THE UNITED STATES HEADBOAT FISHERY IN THE GULF OF MEXICO DURING 1986-2004

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Introduction

Rod and reel catch and effort from party (head) boats in the Gulf of Mexico have been monitored by the National Marine Fisheries Service (NMFS) Southeast Zone Headboat Survey (conducted by the NMFS Beaufort Laboratory). Standardized catch rates of vermilion snapper (*Rhomboplites aurorubens*) have been developed by Schirripa (2000) and Brown and Cass-Calay (2001). The available catch per unit effort (CPUE) series, from 1986 - 2004, was used here to develop abundance indices for vermilion snapper.

Material and Methods

The NMFS Southeast Zone Headboat Survey collects data on the catch and effort for a vessel trip. This includes information on the landing date and location, vessel identification, the number of anglers, a single fishing location (10' x 10' rectangle of latitude and longitude) for the entire trip, the type/duration of the trip (half/three-quarter/full/multi-day, day/night, morning/afternoon), and catch by species in number and weight.

Catch rate was calculated in number of fish per angler-hour. For trips less than or equal to one day in duration, the number of hours fished was assigned as the midpoint of the range of fishing hours assigned to the trip duration type. For the multi-day trips, an assumption that 12 hours were fished per day was used (the length of the trip in days was recorded).

The geographic distribution of vermilion snapper catches (1986-1999) was examined by Brown and Cass-Calay (2001) and is shown in Figure 1, with each symbol scaled to reflect the average catch rate at that location. Based upon this distribution, two zones (EAST and WEST) having relatively high catch rates were defined. Data from 2000-2004 were examined and found to follow similar distribution patterns. The analysis was therefore restricted to data from these two zones, as was done by Brown and Cass-Calay (2001), since the expectation of catching vermilion

snapper on a given trip was markedly higher from within the zones. This approach was intended to reduce variance and to minimize the potential biases of year-to-year fluctuations in the proportion of total effort occurring within these zones.

The data were further restricted to trips targeting or likely to catch vermilion snapper based upon the species composition of the catch. This was accomplished by applying the method of Stephens and MacCall (2004) within each zone to define species associated with vermilion snapper in the catch and to select trips with such a species composition. This approach was taken in lieu of defining a sub-fleet of vermilion-targeting vessels, as was done by Brown and Cass-Calay (2001), and resulted in a greater number of vessels as well as total observations in the analysis data set. However, differences changes in annual nominal catch rates were modest (Figure 2).

Historical regulatory changes in the fishery could potentially have influenced the catch rates recorded in the Headboat Survey, particularly since only kept fish were recorded. A minimum size of 8 inches total length (TL) was implemented on February 21 1990, followed by an increase in the minimum size limit to 10 inches TL on January 29 1998 (Table 1). In addition, an aggregate bag limit of 20 fish per angler was effective on January 15, 1997. Based upon the size distribution of headboat catches during 1986-1989, it was assumed that the 8 inch TL minimum size had only a minimal effect upon discard rates, since fish smaller than this size represented only 2.3% of the kept catch. However, 43.4% of the kept fish were less than 10 inches TL, so the size limit implemented in 1998 could be expected to have caused a substantial change in the rate of discards. For this reason, the data were separated into two time periods (1986-1997 and 1998-2004) since catch rates across the entire time period would not be comparable. Any potential impact of the 20 fish bag limit was largely addressed by this same split, although one year of implementation occurred during the first time period (1997). During 1986-1996, 2% of the trips reported more than 20 vermilion snapper kept per angler. In 1997, only 0.2% of the trips reported more than 20 vermilion snapper kept per angler.

The process of calculating the indices of abundance from this data involves the standardization of yearly changes in catch rate, accounting for the influence of those factors which have a significant influence. Factors which were considered as possible influences on catch rates included year, zone, vessel, month, season (WINTER=Dec.-Feb., SPRING=Mar.-May, etc.), trip category (TRIPCAT: half day/3qtr-full day/multi day), and whether the fishing occurred during the day or night (DAYNIGHT: day/night/unknown) or during an open or closed red snapper season (RedSnapper_SEASON). The factor RedSnapper_SEASON was only considered for the 1998-2004 time period, since the red snapper season closures did not begin until November 27 1997.

The Lo method (Lo et al. 1992) was used to develop standardized indices; with that method separate analyses are conducted of the positive catch rates and the proportions of the observed trips which were successful. This technique has been employed in calculating abundance indices for bluefin tuna, *Thunnus thynnus*, (Ortiz *et al.* 1999,Turner *et al.* 1999, Brown *et al.* 1999), wherein a delta-lognormal model approach was used; this used a delta distribution with an assumed binomial error distribution for the proportion of positive observations (trips), and assumed a lognormal error distribution for the catch rates on successful trips. The present

analyses also applied a delta-lognormal approach. Brown and Cass-Calay (2001) utilized the delta-Poisson model approach of Brown and Turner (2001), differing from the delta-lognormal approach in that a Poisson error distribution is assumed for the catches on successful trips, with the natural log of the angler-hours fished as an offset term. The choice of a delta-lognormal approach was taken in the current analyses because the positive catch rates were determined to be distributed log-normally; the delta-Poisson approach might also have been appropriate but was not investigated.

Parameterization of the model was accomplished using a Generalized Linear Model (GLM) structure: The proportion of successful (i.e. positive observations) trips per stratum was assumed to follow a binomial distribution where the estimated probability was a linearized function of fixed factors. The logit function linked the linear component and the assumed binomial distribution. Similarly, the logged catch per angler-hour on positive trips was assumed to follow a normal distribution where the estimated rate was a function of similar fixed factors.

A stepwise approach was used to quantify the relative importance of the main factors explaining the variance in catch rates. That is, first the Null model was run, in which no factors were entered in the model. These results reflect the distribution of the nominal data. Each potential factor was then tested one at a time. The results were then ranked from greatest to least reduction in deviance per degree of freedom when compared to the Null model. The factor which resulted in the greatest reduction in deviance per degree of freedom was then incorporated into the model, provided two conditions were met: 1) the effect of the factor was determined to be significant at at least the 5% level based upon a χ^2 (Chi-Square) test, and 2) the deviance per degree of freedom was reduced by at least 1% from the less complex model. This process was repeated, adding factors (including factor interactions) one at a time at each step, until no factor met the criteria for incorporation into the final model.

Brown and Cass-Calay (2001) had determined that there was a significant year interaction effect with zone. As this indicated the yearly pattern differed between zones, separate models were calculated for each zone. This approach was maintained in the current analyses.

The product of the standardized proportion positives and the standardized positive catch rates was used to calculate overall standardized catch rates. For comparative purposes, each relative index of abundance was obtained dividing the standardized catch rates by the mean value in each series.

Results and Discussion

The stepwise construction of the WEST zone model (1986-1997) is shown in Table 2 for the proportion positive analysis and in Table 3 for the positive catch rate analysis. Diagnostics of the model fits are shown in Figure 2. The construction of the EAST zone model (1986-1997) is shown in Tables 4 and 5, with diagnostics of the model fits shown in Figure 3.

The stepwise construction of the WEST zone model (1998-2004) is shown in Table 6 for the proportion positive analysis and in Table 7 for the positive catch rate analysis. Diagnostics of

the model fits are shown in Figures 4. The construction of the EAST zone model (1998-2004) is shown in Tables 8 and 9, with diagnostics of the model fits shown in Figure 5.

The index values for the WEST zone are shown in Table 10 and in Figures 6a and 6b; for the EAST zone, the values are shown in Table 11 and in Figures 7a and 7b. The index values calculated by Brown and Cass-Calay (2001) model are compared to current results (for the years 1986-1997) in Figures 6a and 7a.

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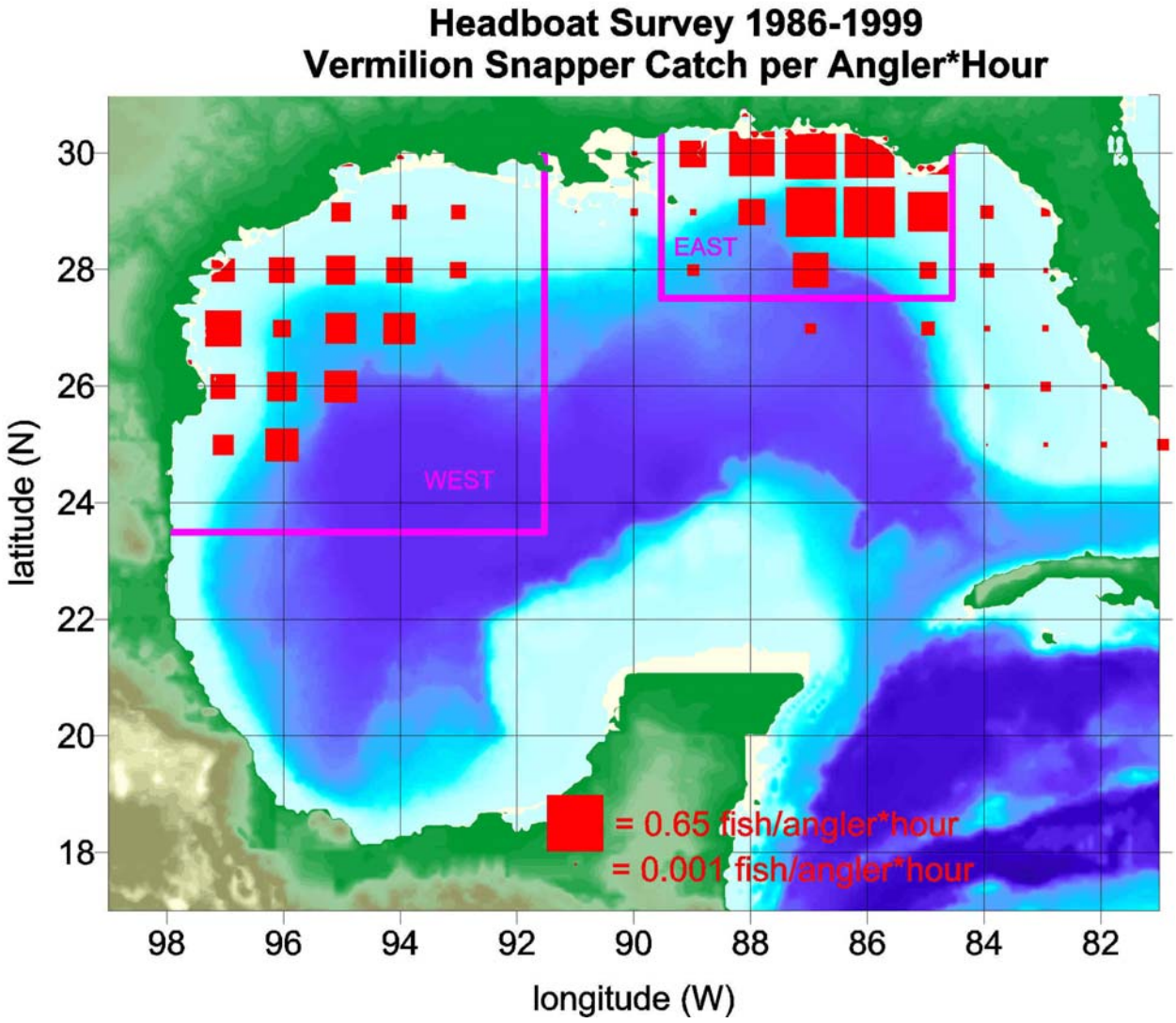

FIGURE 1: The geographic distribution of vermilion snapper catches (1986-1999). Each symbol is scaled to reflect the average catch rate within that 1 by 1 square. Catch rates from locations for which total effort is below 1500 angler*hours are not shown. [reproduced from Brown and Cass-Calay (2001)]

TABLE 1. Relevant Vermilion snapper regulations	
Effective Date	Action
February 21, 1990	Establish minimum size of 8 inches TL
January 15, 1997	Put in 20-fish aggregate bag limit
January 29, 1998	Raise minimum size to 10 inches TL

TABLE 2: Results of the stepwise procedure to develop the proportion positive catch rate model for the WEST indices 1986-1997.

There are no explanatory factors in the base model.

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	8772	10274.0	1.1712		-5137.0		
VESSEL	8759	8514.7	0.9721	17.00	-4257.4	1759.27	0.00000
AREA	8770	9797.5	1.1172	4.62	-4898.8	476.48	0.00000
DAYNIGHT	8770	9966.8	1.1365	2.97	-4983.4	307.17	0.00000
TRIPCAT	8770	10141.6	1.1564	1.27	-5070.8	132.34	0.00000
YEAR	8761	10170.2	1.1608	0.89	-5085.1	103.79	0.00000
MONTH	8761	10174.7	1.1614	0.84	-5087.4	99.27	0.00000
SEASON	8769	10221.3	1.1656	0.48	-5110.7	52.66	0.00000

The explanatory factors in the base model are: VESSEL

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	8759	8514.7	0.9721		-4257.4		
YEAR	8748	8425.4	0.9631	0.92	-4212.7	89.29	0.00000
TRIPCAT	8757	8435.3	0.9633	0.91	-4217.7	79.41	0.00000
DAYNIGHT	8757	8457.5	0.9658	0.65	-4228.7	57.26	0.00000
MONTH	8748	8488.2	0.9703	0.19	-4244.1	26.49	0.00548
SEASON	8756	8511.7	0.9721	0.00	-4255.8	3.05	0.38421
AREA	8759	8514.7	0.9721	0.00	-4257.4	0.00	.

FINAL MODEL: VESSEL+YEAR

TABLE 3: Results of the stepwise procedure to develop the positive catch rate model for the WEST indices 1986-1997.

There are no explanatory factors in the base model.

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	6383	10712.1	1.6782		-10710.6		
VESSEL	6370	9053.0	1.4212	15.32	-10173.5	1074.30	0.00000
AREA	6381	10205.7	1.5994	4.70	-10556.0	309.22	0.00000
YEAR	6372	10478.0	1.6444	2.02	-10640.1	141.07	0.00000
DAYNIGHT	6381	10614.8	1.6635	0.88	-10681.5	58.29	0.00000
MONTH	6372	10615.1	1.6659	0.73	-10681.6	58.09	0.00000
SEASON	6380	10650.6	1.6694	0.53	-10692.2	36.78	0.00000
TRIPCAT	6381	10708.4	1.6782	0.00	-10709.5	2.21	0.33098

The explanatory factors in the base model are: VESSEL

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	6370	9053.0	1.4212		-10173.5		
YEAR	6359	8852.6	1.3921	2.04	-10102.0	142.91	0.00000
DAYNIGHT	6368	8979.4	1.4101	0.78	-10147.4	52.11	0.00000
MONTH	6359	8969.6	1.4105	0.75	-10143.9	59.10	0.00000
SEASON	6367	8995.2	1.4128	0.59	-10153.0	40.93	0.00000
TRIPCAT	6368	9046.0	1.4205	0.05	-10171.0	4.94	0.08463
AREA	6370	9053.0	1.4212	0.00	-10173.5	0.00	.

The explanatory factors in the base model are: VESSEL YEAR

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	6359	8852.6	1.3921		-10102.0		
DAYNIGHT	6357	8772.8	1.3800	0.87	-10073.1	57.83	0.00000
MONTH	6348	8760.8	1.3801	0.87	-10068.8	66.54	0.00000
SEASON	6356	8785.2	1.3822	0.72	-10077.6	48.84	0.00000
TRIPCAT	6357	8843.7	1.3912	0.07	-10098.8	6.41	0.04055
AREA	6359	8852.6	1.3921	0.00	-10102.0	0.00	.

FINAL MODEL: VESSEL+YEAR

TABLE 4: Results of the stepwise procedure to develop the proportion positive catch rate model for the EAST indices 1986-1997.

There are no explanatory factors in the base model.

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	18389	7162.4	0.3895		-3581.2		
VESSEL	18374	6852.8	0.3730	4.24	-3426.4	309.58	0.00000
YEAR	18378	7013.7	0.3816	2.02	-3506.9	148.65	0.00000
TRIPCAT	18387	7019.5	0.3818	1.98	-3509.7	142.87	0.00000
DAYNIGHT	18387	7097.7	0.3860	0.89	-3548.8	64.70	0.00000
MONTH	18378	7105.1	0.3866	0.74	-3552.5	57.31	0.00000
SEASON	18386	7133.1	0.3880	0.39	-3566.6	29.24	0.00000

The explanatory factors in the base model are: VESSEL

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	18374	6852.8	0.3730		-3426.4		
YEAR	18363	6706.8	0.3652	2.07	-3353.4	145.99	0.00000
MONTH	18363	6807.8	0.3707	0.60	-3403.9	44.95	0.00000
TRIPCAT	18372	6820.4	0.3712	0.46	-3410.2	32.42	0.00000
SEASON	18371	6834.9	0.3720	0.24	-3417.4	17.90	0.00046
DAYNIGHT	18372	6838.8	0.3722	0.19	-3419.4	13.98	0.00092

The explanatory factors in the base model are: VESSEL YEAR

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	18363	6706.8	0.3652		-3353.4		
MONTH	18352	6655.2	0.3626	0.71	-3327.6	51.56	0.00000
TRIPCAT	18361	6676.5	0.3636	0.44	-3338.2	30.31	0.00000
SEASON	18360	6684.3	0.3641	0.32	-3342.2	22.47	0.00005
DAYNIGHT	18361	6699.2	0.3649	0.10	-3349.6	7.64	0.02198

FINAL MODEL: VESSEL+YEAR

TABLE 5: Results of the stepwise procedure to develop the positive catch rate model for the EAST indices 1986-1997.

There are no explanatory factors in the base model.

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	17493	21913.8	1.2527		-26793.2		
VESSEL	17478	17488.8	1.0006	20.12	-24820.3	3945.87	0.00000
TRIPCAT	17491	19712.4	1.1270	10.04	-25867.2	1852.01	0.00000
YEAR	17482	20096.5	1.1496	8.23	-26036.0	1514.41	0.00000
DAYNIGHT	17491	21429.7	1.2252	2.20	-26597.9	390.73	0.00000
MONTH	17482	21564.3	1.2335	1.53	-26652.6	281.24	0.00000
SEASON	17490	21817.6	1.2474	0.42	-26754.8	76.92	0.00000

The explanatory factors in the base model are: VESSEL

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	17478	17488.8	1.0006		-24820.3		
YEAR	17467	15822.1	0.9058	9.47	-23944.3	1752.05	0.00000
TRIPCAT	17476	17040.0	0.9751	2.55	-24592.9	454.74	0.00000
MONTH	17467	17166.3	0.9828	1.78	-24657.5	325.53	0.00000
SEASON	17475	17397.6	0.9956	0.50	-24774.6	91.44	0.00000
DAYNIGHT	17476	17434.4	0.9976	0.30	-24793.1	54.49	0.00000

The explanatory factors in the base model are: VESSEL YEAR

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	17467	15822.1	0.9058		-23944.3		
TRIPCAT	17465	15382.5	0.8808	2.77	-23697.8	492.95	0.00000
MONTH	17456	15477.0	0.8866	2.12	-23751.4	385.74	0.00000
SEASON	17464	15723.7	0.9004	0.60	-23889.7	109.10	0.00000
DAYNIGHT	17465	15779.5	0.9035	0.26	-23920.7	47.14	0.00000

The explanatory factors in the base model are: VESSEL YEAR TRIPCAT

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	17465	15382.5	0.8808		-23697.8		
MONTH	17454	14979.3	0.8582	2.56	-23465.5	464.59	0.00000
SEASON	17462	15260.3	0.8739	0.78	-23628.0	139.50	0.00000
DAYNIGHT	17463	15380.1	0.8807	0.00	-23696.5	2.68	0.26141

The explanatory factors in the base model are: VESSEL YEAR TRIPCAT MONTH

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	17454	14979.3	0.8582		-23465.5		
SEASON	17454	14979.3	0.8582	0.00	-23465.5	0.00	.
DAYNIGHT	17452	14978.6	0.8583	-0.01	-23465.1	0.83	0.66032

FINAL MODEL: VESSEL+YEAR+TRIPCAT+MONTH

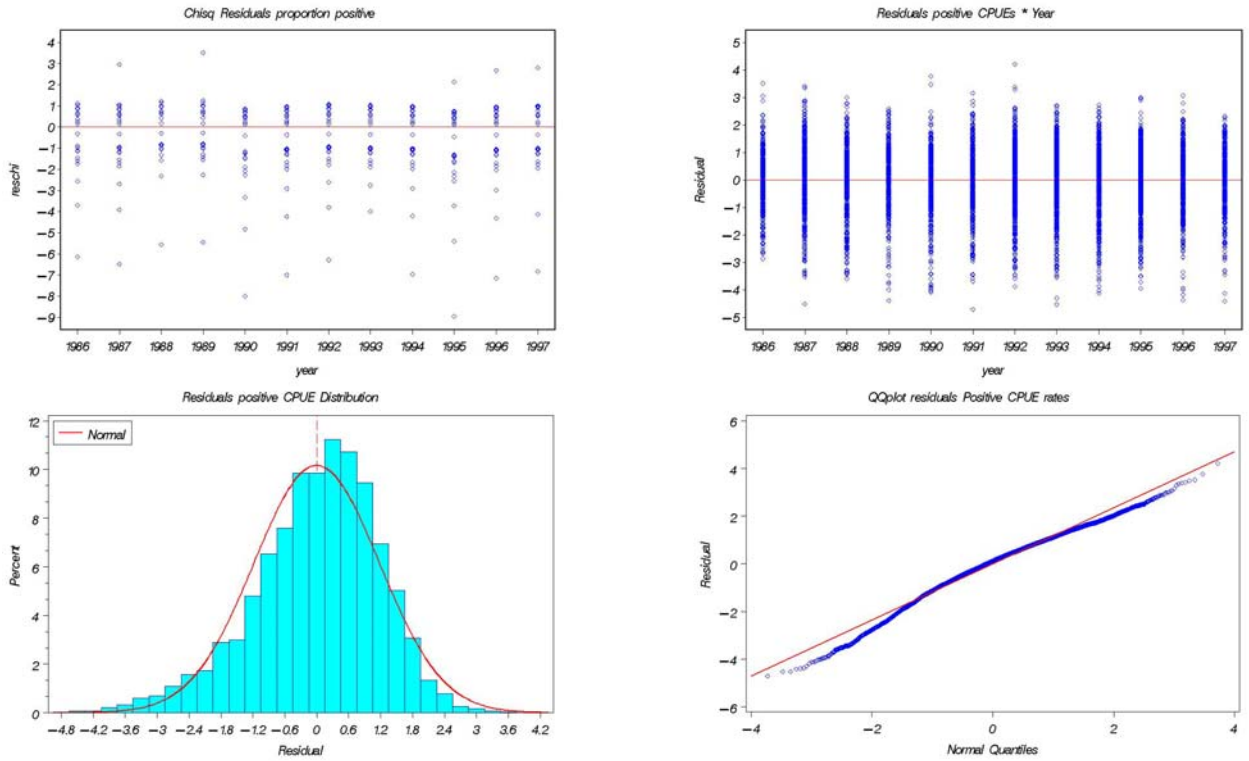

Figure 2. Diagnostic plots for the delta lognormal model fit to the WEST 1986-1997

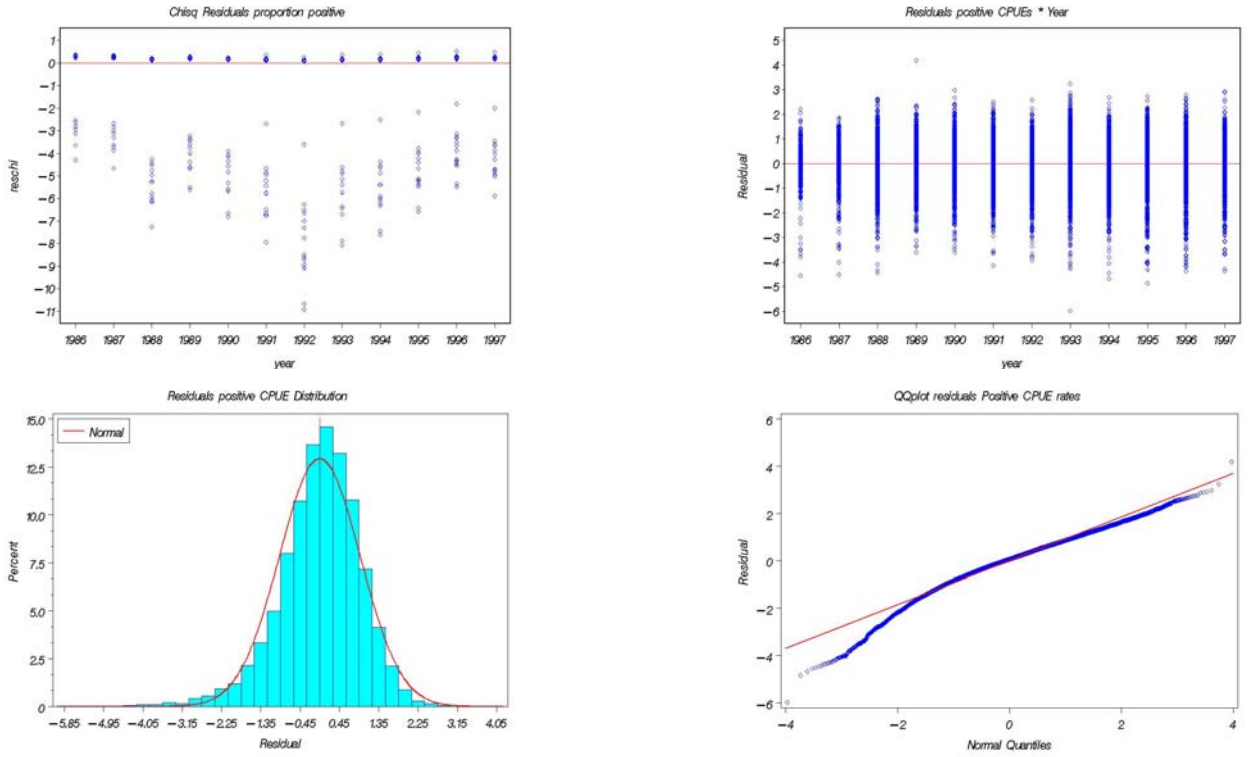

Figure 3. Diagnostic plots for the delta lognormal model fit to the EAST 1986-1997.

TABLE 6: Results of the stepwise procedure to develop the proportion positive catch rate model for the WEST indices 1998-2004.

There are no explanatory factors in the base model.

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	4563	5530.9	1.2121		-2765.4		
VESSEL	4548	4296.3	0.9447	22.06	-2148.2	1234.52	0.00000
AREA	4561	4971.7	1.0900	10.07	-2485.8	559.18	0.00000
DAYNIGHT	4561	5292.1	1.1603	4.27	-2646.0	238.75	0.00000
MONTH	4552	5479.7	1.2038	0.69	-2739.8	51.16	0.00000
TRIPCAT	4561	5507.8	1.2076	0.37	-2753.9	23.06	0.00001
YEAR	4557	5505.0	1.2080	0.34	-2752.5	25.89	0.00023
REDSNAPPER_SEASON	4562	5523.4	1.2107	0.11	-2761.7	7.45	0.00634
SEASON	4560	5525.6	1.2118	0.03	-2762.8	5.26	0.15346

The explanatory factors in the base model are: VESSEL

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	4548	4296.3	0.9447		-2148.2		
MONTH	4537	4218.6	0.9298	1.57	-2109.3	77.74	0.00000
REDSNAPPER_SEASON	4547	4268.6	0.9388	0.62	-2134.3	27.70	0.00000
YEAR	4542	4273.2	0.9408	0.41	-2136.6	23.16	0.00075
SEASON	4545	4278.0	0.9413	0.36	-2139.0	18.33	0.00038
TRIPCAT	4546	4282.5	0.9420	0.28	-2141.2	13.87	0.00097
DAYNIGHT	4546	4291.1	0.9439	0.08	-2145.5	5.27	0.07155
AREA	4548	4296.3	0.9447	0.00	-2148.2	0.00	.

The explanatory factors in the base model are: VESSEL MONTH

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	4537	4218.6	0.9298		-2109.3		
TRIPCAT	4535	4204.3	0.9271	0.29	-2102.2	14.25	0.00080
YEAR	4531	4201.5	0.9273	0.27	-2100.7	17.11	0.00887
DAYNIGHT	4535	4211.1	0.9286	0.13	-2105.6	7.46	0.02398
REDSNAPPER_SEASON	4536	4217.3	0.9297	0.01	-2108.6	1.32	0.25053
SEASON	4537	4218.6	0.9298	0.00	-2109.3	0.00	.
AREA	4537	4218.6	0.9298	0.00	-2109.3	0.00	.

FINAL MODEL: VESSEL+MONTH+YEAR

TABLE 7: Results of the stepwise procedure to develop the positive catch rate model for the WEST indices 1998-2004.

There are no explanatory factors in the base model.

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	3220	5521.3	1.7147		-5438.3		
VESSEL	3205	4704.9	1.4680	14.39	-5180.6	515.42	0.00000
MONTH	3209	5367.6	1.6727	2.45	-5392.9	90.94	0.00000
REDSNAPPER_SEASON	3219	5389.6	1.6743	2.36	-5399.5	77.77	0.00000
YEAR	3214	5423.6	1.6875	1.59	-5409.6	57.56	0.00000
DAYNIGHT	3218	5463.6	1.6978	0.98	-5421.4	33.84	0.00000
SEASON	3217	5480.8	1.7037	0.64	-5426.5	23.76	0.00003
AREA	3218	5491.0	1.7063	0.49	-5429.5	17.77	0.00014
TRIPCAT	3218	5516.8	1.7143	0.02	-5437.0	2.68	0.26228

The explanatory factors in the base model are: VESSEL

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	3205	4704.9	1.4680		-5180.6		
REDSNAPPER_SEASON	3204	4513.2	1.4086	4.04	-5113.6	133.98	0.00000
MONTH	3194	4510.5	1.4122	3.80	-5112.7	135.90	0.00000
YEAR	3199	4566.2	1.4274	2.77	-5132.5	96.36	0.00000
SEASON	3202	4647.8	1.4515	1.12	-5161.0	39.34	0.00000
DAYNIGHT	3203	4673.2	1.4590	0.61	-5169.8	21.74	0.00002
TRIPCAT	3203	4701.4	1.4678	0.01	-5179.5	2.37	0.30505
AREA	3205	4704.9	1.4680	0.00	-5180.6	0.00	.

The explanatory factors in the base model are: VESSEL REDSNAPPER_SEASON

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	3204	4513.2	1.4086		-5113.6		
YEAR	3198	4369.1	1.3662	3.01	-5061.4	104.52	0.00000
MONTH	3193	4442.7	1.3914	1.22	-5088.3	50.70	0.00000
DAYNIGHT	3202	4480.7	1.3994	0.66	-5102.0	23.25	0.00001
SEASON	3201	4496.5	1.4047	0.28	-5107.7	11.92	0.00766
AREA	3204	4513.2	1.4086	0.00	-5113.6	0.00	.
TRIPCAT	3202	4511.5	1.4090	-0.02	-5113.0	1.22	0.54409

The explanatory factors in the base model are: VESSEL REDSNAPPER_SEASON YEAR

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	3198	4369.1	1.3662		-5061.4		
MONTH	3187	4267.5	1.3390	1.99	-5023.5	75.77	0.00000
DAYNIGHT	3196	4334.5	1.3562	0.73	-5048.6	25.61	0.00000
SEASON	3195	4343.2	1.3594	0.50	-5051.8	19.14	0.00026
AREA	3198	4369.1	1.3662	0.00	-5061.4	0.00	.
TRIPCAT	3196	4368.4	1.3668	-0.05	-5061.1	0.53	0.76672

The explanatory factors in the base model are: VESSEL REDSNAPPER_SEASON YEAR MONTH

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	3187	4267.5	1.3390		-5023.5		
DAYNIGHT	3185	4232.8	1.3290	0.75	-5010.3	26.35	0.00000
SEASON	3187	4267.5	1.3390	0.00	-5023.5	0.00	.
AREA	3187	4267.5	1.3390	0.00	-5023.5	0.00	.
TRIPCAT	3185	4266.8	1.3397	-0.05	-5023.2	0.55	0.75989

FINAL MODEL: VESSEL+REDSNAPPER_SEASON+YEAR+MONTH

TABLE 8: Results of the stepwise procedure to develop the proportion positive catch rate model for the EAST indices 1998-2004.

There are no explanatory factors in the base model.

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	13437	9535.8	0.7097		-4767.9		
VESSEL	13417	8586.1	0.6399	9.82	-4293.1	949.68	0.00000
TRIPCAT	13435	9336.1	0.6949	2.08	-4668.0	199.73	0.00000
YEAR	13431	9361.8	0.6970	1.78	-4680.9	173.98	0.00000
DAYNIGHT	13435	9450.7	0.7034	0.88	-4725.3	85.13	0.00000
MONTH	13426	9461.3	0.7047	0.70	-4730.6	74.54	0.00000
SEASON	13434	9512.7	0.7081	0.22	-4756.4	23.08	0.00004
REDSNAPPER_SEASON	13436	9535.8	0.7097	-0.01	-4767.9	0.02	0.88873

The explanatory factors in the base model are: VESSEL

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	13417	8586.1	0.6399		-4293.1		
MONTH	13406	8478.9	0.6325	1.17	-4239.5	107.21	0.00000
TRIPCAT	13415	8495.3	0.6333	1.04	-4247.7	90.84	0.00000
YEAR	13411	8506.6	0.6343	0.88	-4253.3	79.51	0.00000
SEASON	13414	8541.5	0.6368	0.50	-4270.8	44.60	0.00000
DAYNIGHT	13415	8546.9	0.6371	0.44	-4273.4	39.27	0.00000
REDSNAPPER_SEASON	13416	8582.0	0.6397	0.04	-4291.0	4.09	0.04311

The explanatory factors in the base model are: VESSEL MONTH

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	13406	8478.9	0.6325		-4239.5		
TRIPCAT	13404	8362.8	0.6239	1.36	-4181.4	116.17	0.00000
YEAR	13400	8385.7	0.6258	1.06	-4192.8	93.24	0.00000
DAYNIGHT	13404	8428.2	0.6288	0.58	-4214.1	50.70	0.00000
SEASON	13406	8478.9	0.6325	0.00	-4239.5	0.00	.
REDSNAPPER_SEASON	13405	8478.7	0.6325	-0.01	-4239.4	0.19	0.66175

The explanatory factors in the base model are: VESSEL MONTH TRIPCAT

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	13404	8362.8	0.6239		-4181.4		
YEAR	13398	8272.0	0.6174	1.04	-4136.0	90.75	0.00000
SEASON	13404	8362.8	0.6239	0.00	-4181.4	0.00	.
REDSNAPPER_SEASON	13403	8362.7	0.6239	-0.01	-4181.4	0.01	0.92411
DAYNIGHT	13402	8362.5	0.6240	-0.01	-4181.2	0.27	0.87312

The explanatory factors in the base model are: VESSEL MONTH TRIPCAT YEAR

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	13398	8272.0	0.6174		-4136.0		
SEASON	13398	8272.0	0.6174	0.00	-4136.0	0.00	.
REDSNAPPER_SEASON	13397	8271.5	0.6174	-0.00	-4135.7	0.54	0.46419
DAYNIGHT	13396	8271.7	0.6175	-0.01	-4135.8	0.32	0.85076

FINAL MODEL: VESSEL+MONTH+TRIPCAT+YEAR

TABLE 9: Results of the stepwise procedure to develop the positive catch rate model for the EAST indices 1998-2004.

There are no explanatory factors in the base model.

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	11905	20780.0	1.7455		-20209.4		
VESSEL	11885	13429.1	1.1299	35.27	-17610.5	5197.81	0.00000
TRIPCAT	11903	18791.4	1.5787	9.55	-19610.6	1197.64	0.00000
DAYNIGHT	11903	19657.1	1.6514	5.39	-19878.7	661.44	0.00000
YEAR	11899	19857.7	1.6689	4.39	-19939.1	540.52	0.00000
MONTH	11894	20403.1	1.7154	1.72	-20100.4	217.98	0.00000
REDSNAPPER_SEASON	11904	20495.9	1.7218	1.36	-20127.5	163.89	0.00000
SEASON	11902	20551.2	1.7267	1.08	-20143.5	131.82	0.00000

The explanatory factors in the base model are: VESSEL

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	11885	13429.1	1.1299		-17610.5		
YEAR	11879	12591.6	1.0600	6.19	-17227.2	766.63	0.00000
TRIPCAT	11883	13121.3	1.1042	2.28	-17472.5	276.08	0.00000
MONTH	11874	13293.1	1.1195	0.92	-17549.9	121.17	0.00000
DAYNIGHT	11883	13306.3	1.1198	0.90	-17555.8	109.35	0.00000
SEASON	11882	13371.6	1.1254	0.40	-17585.0	51.09	0.00000
REDSNAPPER_SEASON	11884	13413.6	1.1287	0.11	-17603.7	13.69	0.00022

The explanatory factors in the base model are: VESSEL YEAR

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	11879	12591.6	1.0600		-17227.2		
TRIPCAT	11877	12247.1	1.0312	2.72	-17062.0	330.30	0.00000
MONTH	11868	12428.9	1.0473	1.20	-17149.7	154.89	0.00000
DAYNIGHT	11877	12457.6	1.0489	1.05	-17163.5	127.43	0.00000
SEASON	11876	12533.5	1.0554	0.44	-17199.6	55.10	0.00000
REDSNAPPER_SEASON	11878	12584.8	1.0595	0.05	-17223.9	6.47	0.01099

The explanatory factors in the base model are: VESSEL YEAR TRIPCAT

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	11877	12247.1	1.0312		-17062.0		
MONTH	11866	12082.3	1.0182	1.25	-16981.4	161.27	0.00000
SEASON	11874	12181.9	1.0259	0.51	-17030.3	63.55	0.00000
REDSNAPPER_SEASON	11876	12246.7	1.0312	-0.00	-17061.8	0.42	0.51688
DAYNIGHT	11875	12246.3	1.0313	-0.01	-17061.6	0.79	0.67255

The explanatory factors in the base model are: VESSEL YEAR TRIPCAT MONTH

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	11866	12082.3	1.0182		-16981.4		
REDSNAPPER_SEASON	11865	12078.5	1.0180	0.02	-16979.5	3.75	0.05278
SEASON	11866	12082.3	1.0182	0.00	-16981.4	0.00	.
DAYNIGHT	11864	12080.8	1.0183	-0.00	-16980.6	1.51	0.46909

FINAL MODEL: VESSEL+YEAR+TRIPCAT+MONTH

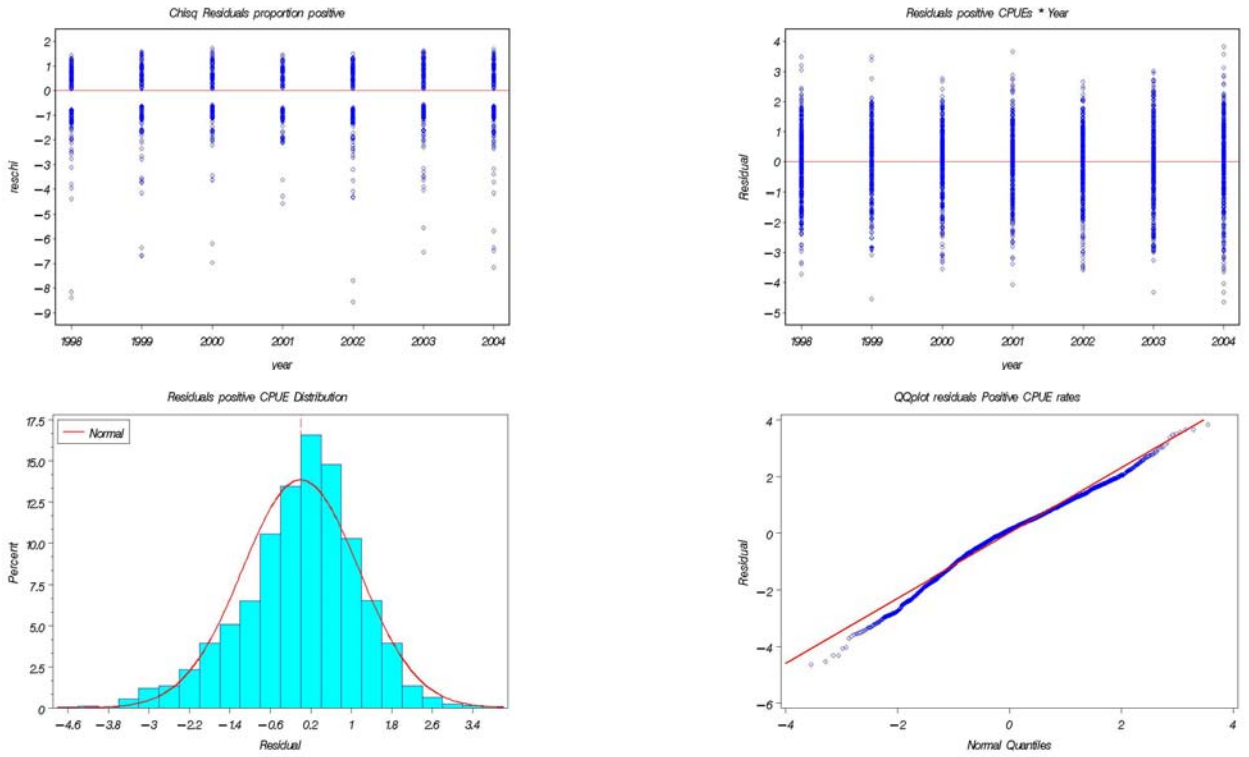

Figure 4. Diagnostic plots for the delta lognormal model fit to the WEST 1998-2004.

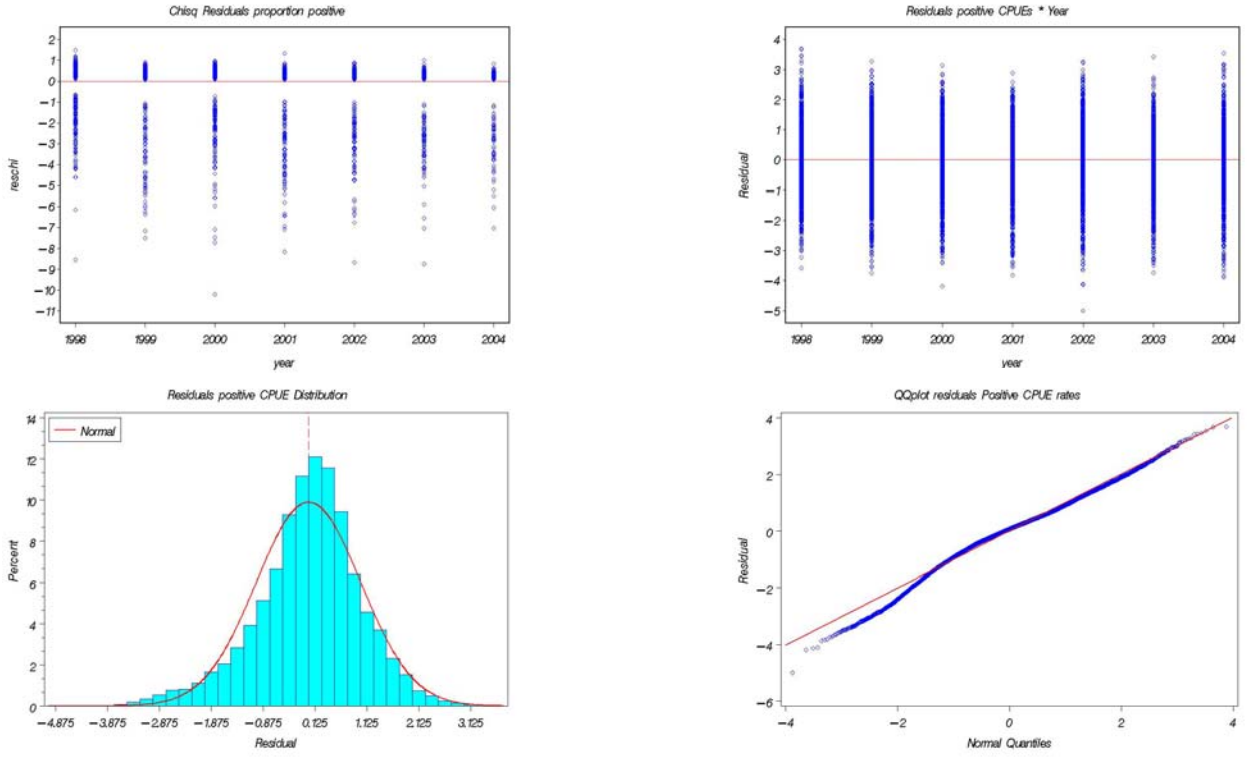

Figure 5. Diagnostic plots for the delta lognormal model fit to the EAST 1998-2004.

TABLE 10: Relative Abundance Indices for VERMILION SNAPPER in the WESTERN Gulf of Mexico				
YEAR	**INDEX**	**LCI**	**UCI**	**CV**
1986	1.267	1.053	1.524	0.093
1987	0.974	0.833	1.139	0.078
1988	0.803	0.665	0.971	0.095
1989	1.048	0.867	1.268	0.095
1990	1.595	1.375	1.851	0.074
1991	0.926	0.78	1.099	0.086
1992	0.811	0.689	0.953	0.081
1993	0.836	0.719	0.972	0.075
1994	1.015	0.88	1.17	0.071
1995	1.058	0.926	1.208	0.066
1996	0.802	0.683	0.943	0.081
1997	0.865	0.728	1.027	0.086
1998	0.952	0.795	1.139	0.09
1999	0.604	0.483	0.756	0.112
2000	0.736	0.6	0.901	0.102
2001	1.284	1.086	1.518	0.084
2002	1.192	1.016	1.398	0.08
2003	0.867	0.726	1.035	0.089
2004	1.366	1.155	1.616	0.084

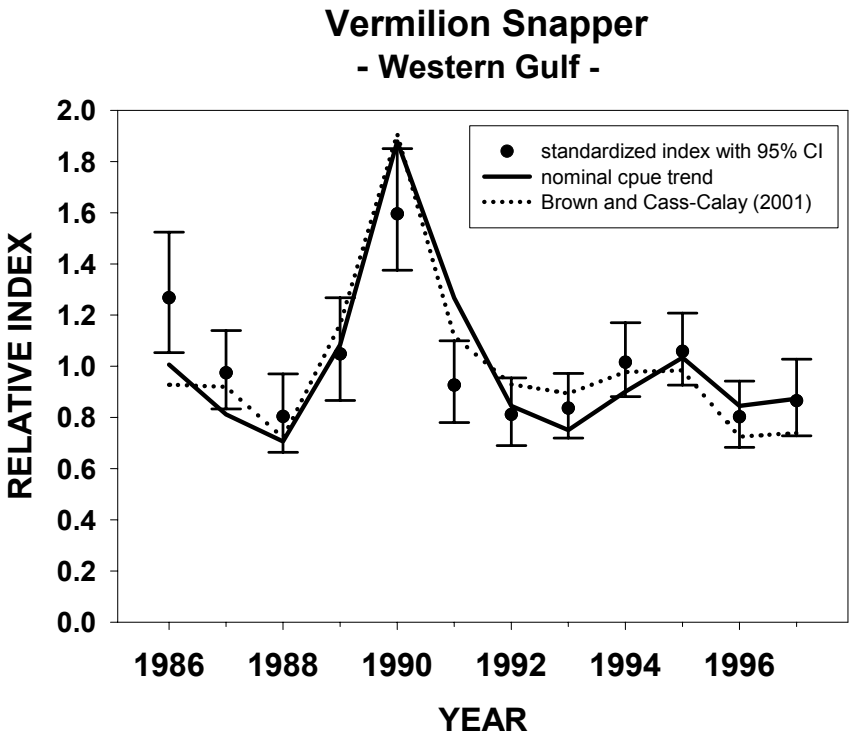

FIGURE 6a: Relative abundance indices for vermilion snapper in the Gulf of Mexico **(WEST 1986-1997)** with approximate 95% confidence intervals.

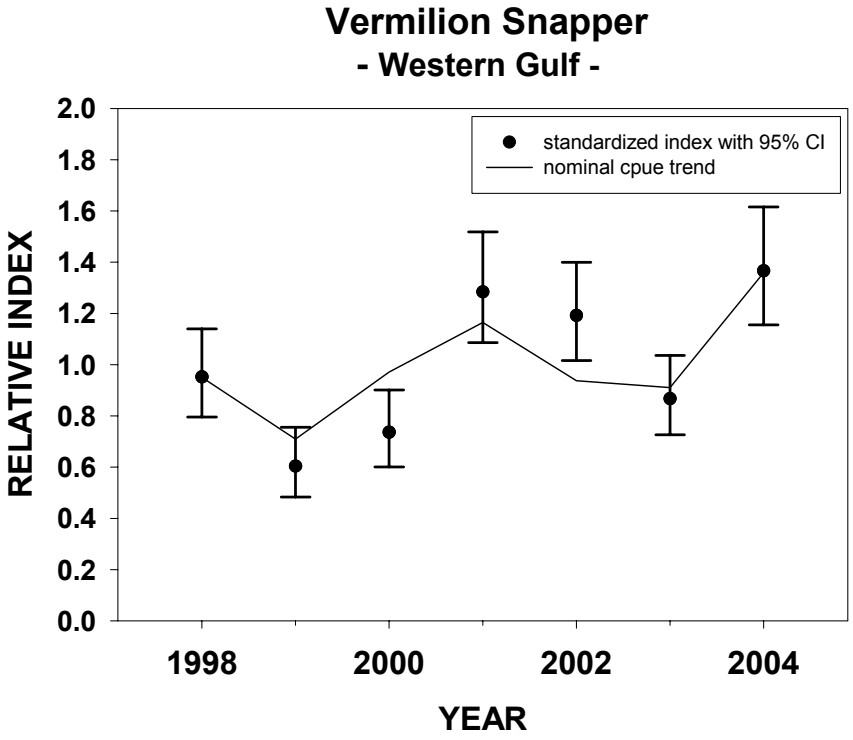

FIGURE 6b: Relative abundance indices for vermilion snapper in the Gulf of Mexico **(WEST 1998-2004)** with approximate 95% confidence intervals.

TABLE 11: Relative Abundance Indices for VERMILION SNAPPER in the EASTERN Gulf of Mexico

YEAR	INDEX	LCI	UCI	CV
1986	0.844	0.736	0.969	0.069
1987	0.796	0.709	0.894	0.058
1988	1.29	1.202	1.385	0.035
1989	0.776	0.717	0.841	0.04
1990	1.071	0.998	1.149	0.035
1991	1.323	1.236	1.415	0.034
1992	1.709	1.606	1.819	0.031
1993	1.128	1.06	1.2	0.031
1994	0.968	0.907	1.034	0.033
1995	0.958	0.892	1.028	0.035
1996	0.546	0.504	0.591	0.04
1997	0.591	0.546	0.639	0.039
1998	0.443	0.373	0.526	0.086
1999	0.978	0.875	1.093	0.056
2000	0.954	0.846	1.075	0.06
2001	1.042	0.934	1.162	0.055
2002	1.035	0.926	1.158	0.056
2003	1.26	1.132	1.402	0.053
2004	1.288	1.155	1.437	0.054

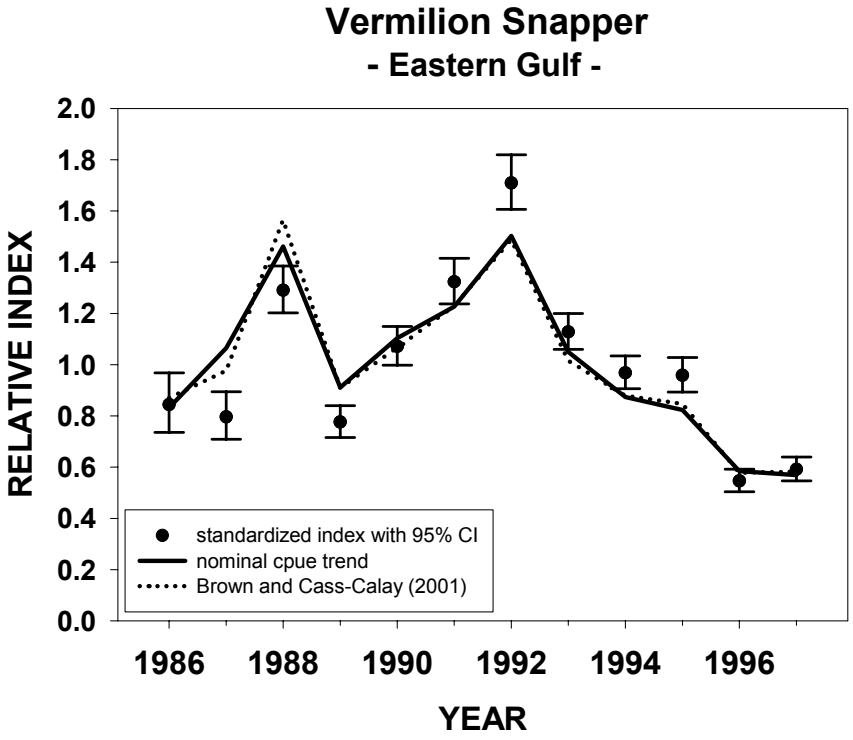

FIGURE 7a: Relative abundance indices for vermilion snapper in the Gulf of Mexico **(EAST 1986-1997)** with approximate 95% confidence intervals.

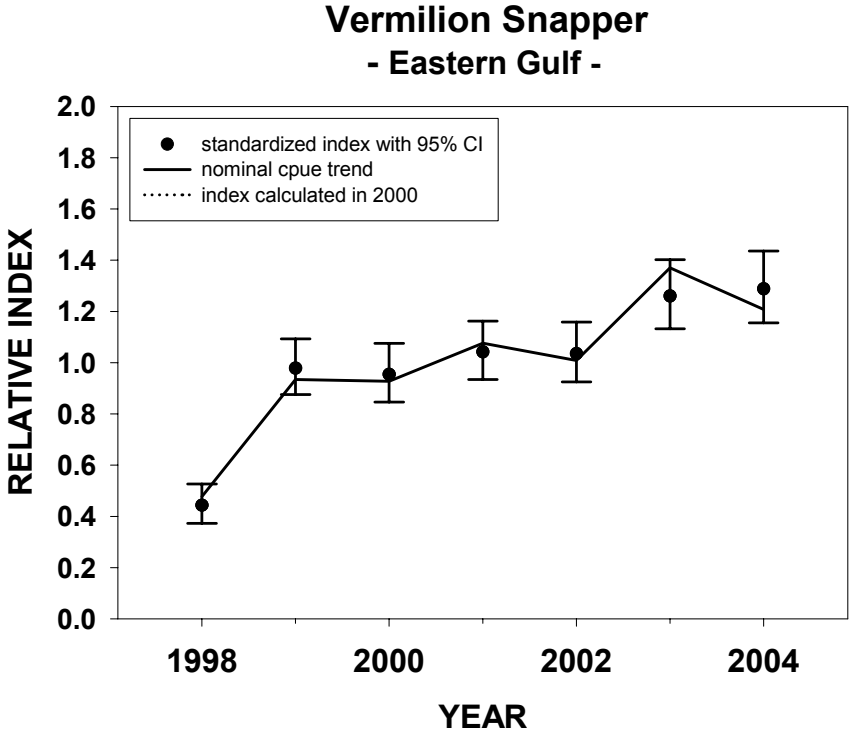

FIGURE 7b: Relative abundance indices for vermilion snapper in the Gulf of Mexico **(EAST 1998-2004)** with approximate 95% confidence intervals.