STANDARDIZED CATCH RATES OF RED GROUPER (EPINEPHELUS MORIO) FROM THE U.S. HEADBOAT FISHERY IN THE GULF OF MEXICO, 1986-2005

Shannon L. Cass-Calay[1]

SUMMARY

Two indices of abundance of red grouper from the United States headboat fishery in the Gulf of Mexico are presented for the period 1986-2005. Both were constructed using a "repeated measures" procedure to account for the variance in catch rates between vessels, and were standardized using Generalized Linear Mixed Models, and a delta-lognormal approach. The first index is for the period 1986-1990, during the 18" minimum size limit off Florida. The second index is for the period 1990-2005, during the period of the 20" federal minimum size limit. The indices suggest a recent increase in the catch rates of red grouper, nearly doubling since 2002. Estimated catch per unit effort in 2005 was the highest on record.

KEY WORDS

Catch/effort, abundance, headboat, multivariate analyses

Sustainable Fisheries Division Contribution No. SFD-2006-036

[1] U.S. Department of Commerce, NOAA Fisheries, Southeast Fisheries Science Center, Miami Laboratory, 75 Virginia Beach Drive, Miami, Florida 33149 U.S.A. Email: Shannon.Calay@noaa.gov

1. INTRODUCTION

Rod and reel catch and effort from party (head) boats in the Gulf of Mexico have been monitored by the NMFS Southeast Zone Headboat Survey (conducted by the NMFS Beaufort Laboratory) since 1986. The Headboat Survey collects data on the catch and effort for a vessel trip. Reported information includes landing date and location, vessel identification, the number of anglers, fishing location, trip duration and/or type (half/three-quarter/full/multi-day, day/night, morning/afternoon), and catch by species in number and weight. These data were used to construct standardized catch rate indices for red grouper in the U.S. Gulf of Mexico.

2. MATERIALS AND METHODS

Two revised indices were developed based on the recommendations of the SEDAR12-DW plenary using data from the NMFS Southeast Zone Headboat Survey. The first index was constructed for the period 1/1/1986-2/20/1990, and reflects the fishery during the FL 18" minimum size limit. The second index was constructed for the period 2/21/1990-12/31/2005 (excluding shallow water grouper closures). Based upon the typical geographic distribution of red grouper, three zones were defined off the Florida and Alabama coasts (NWFL-AL, FL Middle Grounds and SWFL). The analyses were restricted to data from these three zones. The Stephens and MacCall (2004) species association approach was used to identify trips that were likely to have fished in red grouper habitat based on the composition of other species landed. Only trips selected by the Stephens and MacCall (2004) approach were included in the analysis datasets.

The following factors were examined as possible influences on the proportion positive trips, and the catch rates on positive trips:

- YEAR
- SEASON (Dec-Feb, Mar-May, Jun-Aug, Sep-Nov)
- TRIPCAT (1/2 day, ¾ day, full day, multi-day)
- DAY/NIGHT (day trip, night trip, mixed)
- AREA (SW FL, FL Middle Grounds, NWFL-AL)

VESSEL

The variation in catch rates by VESSEL was examined using a "repeated measures" approach (Little et al., 1998). The term "repeated measures" refers to multiple measurements taken over time on the same experimental unit (i.e. vessel). Specifying the repeated measure "VESSEL" and the subject "VESSEL(YEAR)" allows PROC MIXED to model the covariance structure of the data. This is particularly important because catch rates may vary by vessel ***and because*** catch rates on trips by a given vessel close in time can be more highly correlated that those far apart in time (Littell et al., 1998).

Catch rate (CPUE) on positive trips was calculated in number of fish per angler hour.

CPUE = number of fish / (anglers * hours fished)

The variable "Hours Fished" does not exist in the dataset. To estimate the number of hours fished, the following assumptions were necessary:

½ day trip = 5 hours fished
¾ day trip = 7 hours fished
1 day trip = 10 hours fished
1½ day trips = 15 hours fished
multiday trips = number of days * 10 hours fished

A forward stepwise regression procedure was used to determine the set of fixed factors and interaction terms that explained a significant portion of the observed variability. Factors and interaction terms were selected for final analysis if: 1) the percent reduction in deviance per degree of freedom explained by adding the factor exceeded one percent , 2) the χ^2 test was significant and 3) the Type-III test was significant for the specified model. In addition, a χ^2 analysis was preformed to test the significance of the reduction in deviance between each consecutive set of nested models (McCullagh and Nelder 1989).

Once a set of fixed factors was identified, the influence of the YEAR*FACTOR interactions were examined. YEAR*FACTOR interaction terms were included in the model as random effects. Selection of the final mixed model was based on the Akaike's Information Criterion (AIC), Schwarz's Bayesian Criterion (BIC), and a chi-square test of the difference between the –2 loglikelihood statistics between successive model formulations (Littell et al. 1996). The final delta-lognormal model was fit using the SAS macro GLIMMIX and the SAS procedure PROC MIXED (SAS Institute Inc. 1997) following the procedures described by Lo et al. (1992).

3. RESULTS AND DISCUSSION

To examine the effect of the imposition of the 20" minimum size limit on 2/21/1990, the size frequency of red grouper landed by the headboat fishery was examined. After the 20" size limit, the size frequency of red grouper landed by headboats shifted to larger fish (Figure 1). If fact, fish smaller that 19" are very rarely reported after 1990. Due to this change in the size distribution, the SEDAR12 data working group recommended that the headboat index be broken into two components: 1986-1990 (during the 18" minimum size off FL), and 1990-2005 (during the federal 20" minimum size limit).

The final models for the binomial and lognormal components were:

Minimum Size Limit 18" (1/1/1986-2/20/1990)

- PPT = YEAR + AREA + TRIPCAT
- LN(CPUE) = YEAR + AREA + SEASON + TRIPCAT + SEASON*AREA + VESSEL(YEAR)

Minimum Size Limit 20" (2/21/1990 - 12/31/2005)

- PPT = YEAR + TRIPCAT + AREA + YEAR*AREA
- LN(CPUE) = YEAR + AREA + VESSEL(YEAR)

During 1986 to 1990, the annual proportion of positive trips (PPT: trips that caught red grouper) varied without trend, ranging from 38% to 52% (Fig. 2A; Table 1). After the imposition of the 20" minimum size limit, PPT decreased to about 20%, before increasing to nearly 50% between 2002 and 2005 (Fig. 2B; Table 2). The estimated PPT in 2005 was the highest on record.

Nominal CPUE generally decreased during 1986-1990 (Fig 3A; Table 1). After 1990, CPUE increased in 1995, and then decreased until 2002. From 2002 to 2005, CPUE increased quickly, and consistently (Figure 3B, Table 2). The estimated CPUE in 2005 was the highest on record.

Diagnostic plots were constructed to examine the fit of the components of the delta-lognormal model. The frequency distributions of nominal catch rates are shown in Figures 4A and 4B. As expected, the distributions are very similar to the expected normal distribution. The distribution of residuals from the binomial model on proportion positive trips and the lognormal model on catch rates, by year is shown in Figure 5. The residuals are evenly distributed above and below zero, indicating an acceptable fit to the models. The cumulative normalized residuals (QQ-Plot) from the lognormal model are shown in Figure 6. The QQ-Plot indicates a small departure from the assumption of a normal distribution (Fig. 6, red line), particularly during the 1990-2005 period. Figure 7 illustrates the residuals of the lognormal model on catch rates, by vessel. In general, the residuals are evenly distributed above and below zero, indicating that the model is able to effectively account for variability in catch rates between vessels.

The delta-lognormal catch rate indices, with 95% confidence intervals, are shown in Figure 8 and summarized in Tables 1 and 2. The standardized abundance indices are roughly similar to the nominal CPUE series (Fig. 8). The indices suggest that catch rates were fairly constant from 1986-2001, but increased sharply from 2002 to 2005. The estimated CPUE in 2005 is the highest on record.

4. REFERENCES

LITTELL, R.C., G.A. Milliken, W.W. Stroup, and R.D Wolfinger. 1996. SAS® System for Mixed Models, Cary NC, USA:SAS Institute Inc., 1996. 663 pp.

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

LO, N.C., L.D. Jacobson, and J.L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. Can. J. Fish. Aquat. Sci. 49: 2515-2526.

MCCULLAGH, P. and J.A. Nelder. 1989. Generalized Linear Models edition. Chapman & Hall.

SAS Institute Inc. 1997, SAS/STAT® Software: Changes and Enhancements through Release 6.12. Cary, NC, USA: SAS Institute Inc., 1997. 1167 pp.

Table 1. Relative nominal CPUE, number of trips, number of positive trips, proportion positive trips (PPT) and abundance index statistics during the 18" minimum size limit.

YEAR	TRIPS	POSITIVE TRIPS	PPT	Relative Nominal CPUE	Relative Index	Lower 95% CI	Upper 95% CI	CV
1986	2814	1309	0.465	1.217	0.745	0.242	2.297	0.611
1987	2625	1362	0.519	1.118	1.184	0.462	3.036	0.498
1988	4137	1669	0.403	0.799	1.043	0.396	2.744	0.514
1989	4847	1812	0.374	0.922	1.218	0.473	3.140	0.501
1990	839	407	0.485	0.944	0.810	0.249	2.639	0.646

Table 2. Relative nominal CPUE, number of trips, number of positive trips, proportion positive trips (PPT) and abundance index statistics during the 20" minimum size limit.

YEAR	TRIPS	POSITIVE TRIPS	PPT	Relative Nominal CPUE	Relative Index	Lower 95% CI	Upper 95% CI	CV
1990	7353	1836	0.250	1.052	0.848	0.306	2.350	0.545
1991	7224	2120	0.293	1.099	0.942	0.345	2.571	0.535
1992	7547	1848	0.245	1.010	0.796	0.281	2.252	0.558
1993	7928	1823	0.230	0.713	0.764	0.279	2.088	0.536
1994	7386	1727	0.234	0.765	0.803	0.290	2.221	0.543
1995	5891	1199	0.204	2.092	0.919	0.333	2.537	0.542
1996	5728	908	0.159	1.116	0.742	0.257	2.142	0.570
1997	5648	800	0.142	0.721	0.569	0.195	1.664	0.578
1998	4905	792	0.161	0.999	0.635	0.218	1.847	0.575
1999	4473	932	0.208	0.419	0.631	0.223	1.785	0.557
2000	4406	1068	0.242	0.659	0.873	0.312	2.442	0.550
2001	4232	1049	0.248	0.539	0.844	0.311	2.289	0.531
2002	4210	963	0.229	0.439	0.927	0.343	2.506	0.530
2003	4344	1556	0.358	0.826	1.375	0.545	3.473	0.489
2004	4587	2106	0.459	1.446	2.014	0.824	4.923	0.470
2005	3951	1958	0.496	2.105	2.317	0.949	5.656	0.469

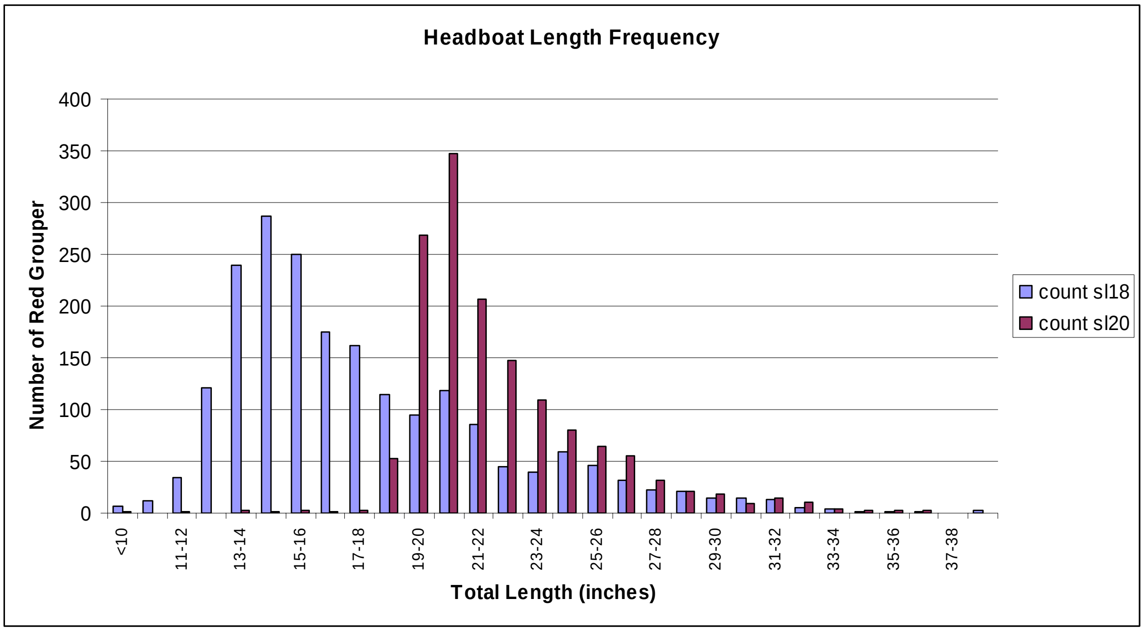

Figure 1. Size distribution red grouper landed by the Headboat fishery during the 18" minimum size limit (before 2/21/90) and during the 20" minimum size limit (after 2/21/90).

A) B)

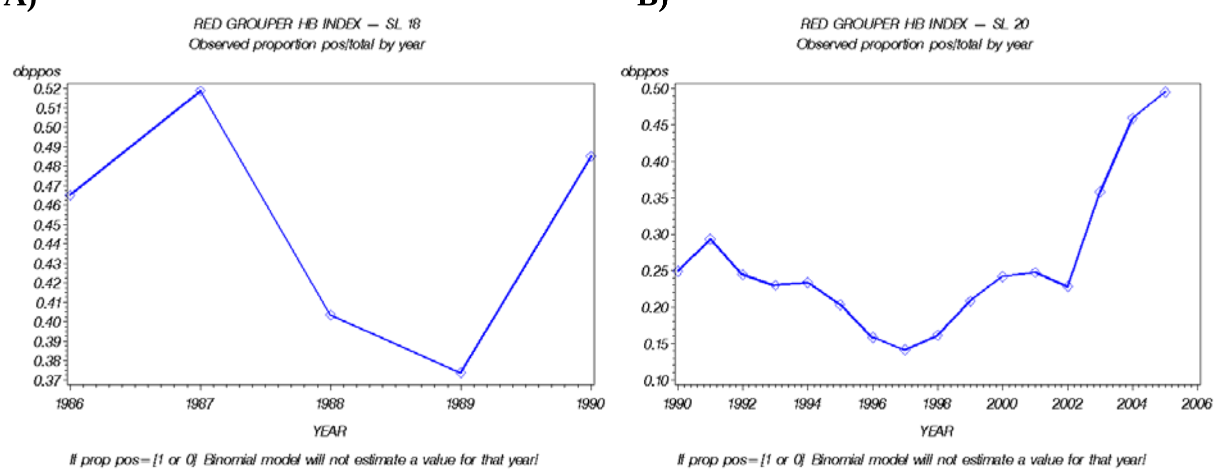

Figure 2. Proportion positive trips by year during the 18" (A) and 20" (B) minimum size limits.

A) B)

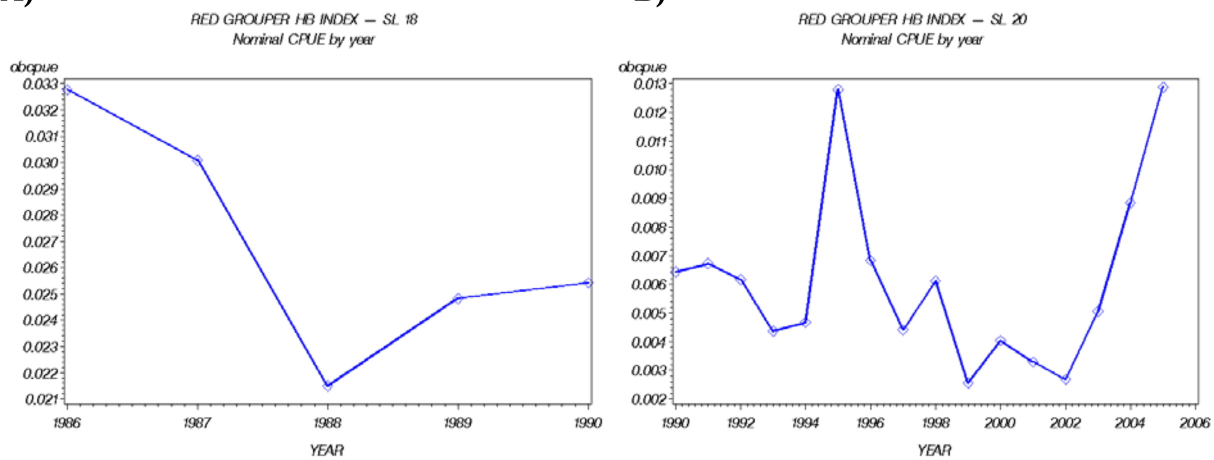

Figure 3. Nominal CPUE by year during the 18” (A) and 20” (B) minimum size limits.

A) B)

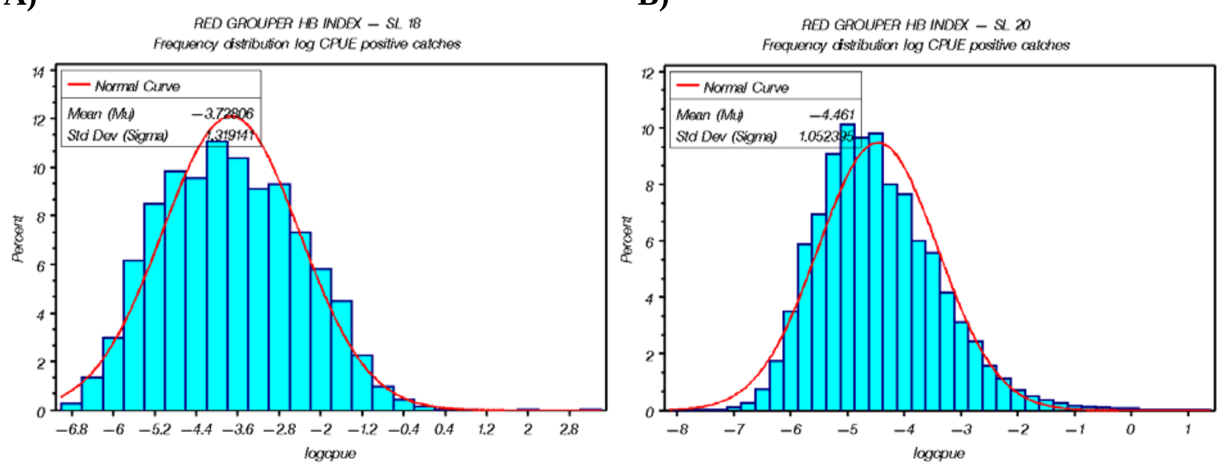

Figure 4. Frequency distribution of catch rates on positive trips during the 18” (A) and 20” (B) minimum size limits. The red line is the expected normal distribution.

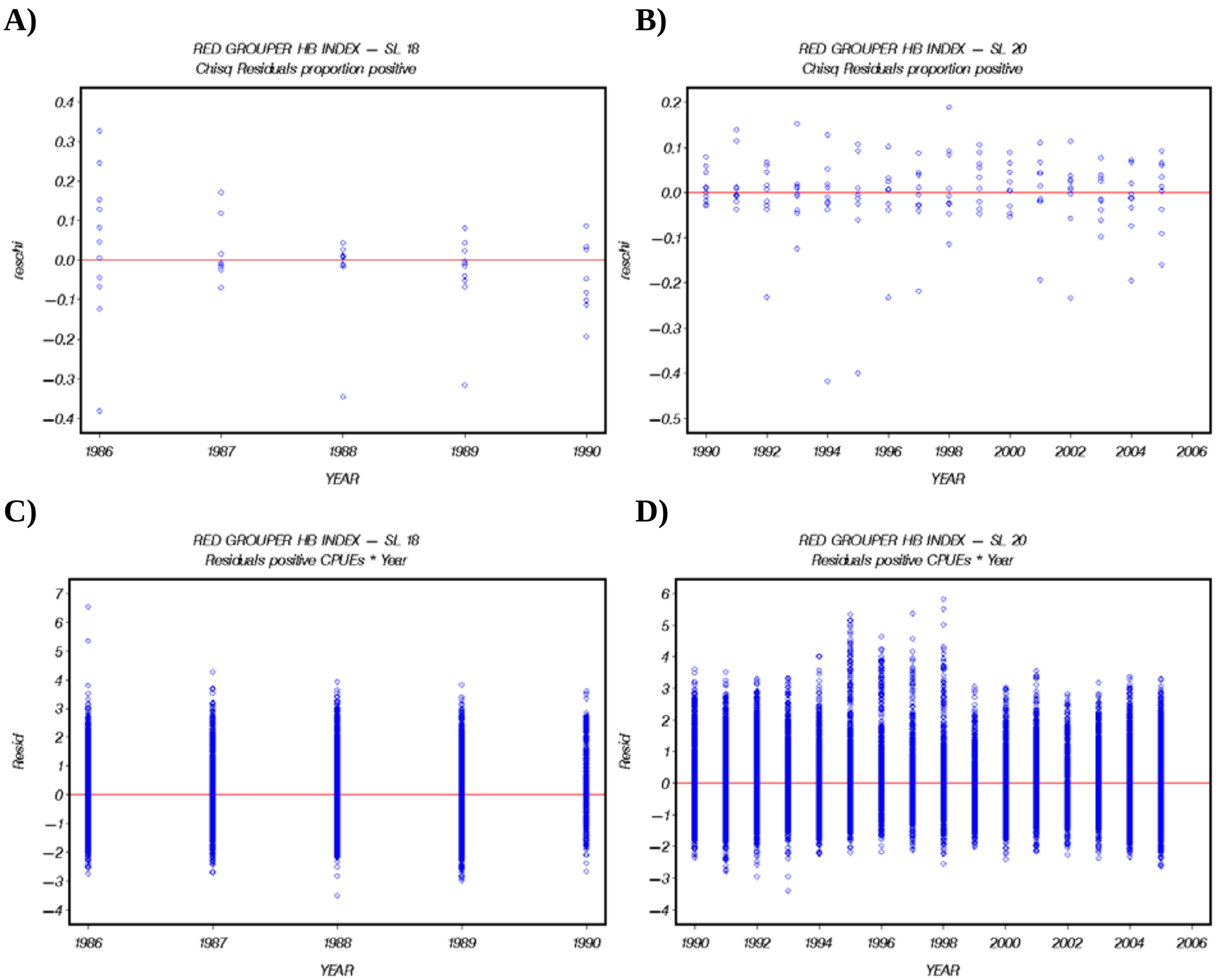

Figure 5. Diagnostic plots for the delta-lognormal model. The distribution of residuals from the binomial model on the proportion of positive set, by year during the 18"(**A**) and 20" (**B**) minimum size limit. The distribution of residuals from the lognormal model on catch rates, by year during the 18"(**C**) and 20" (**D**) minimum size limit.

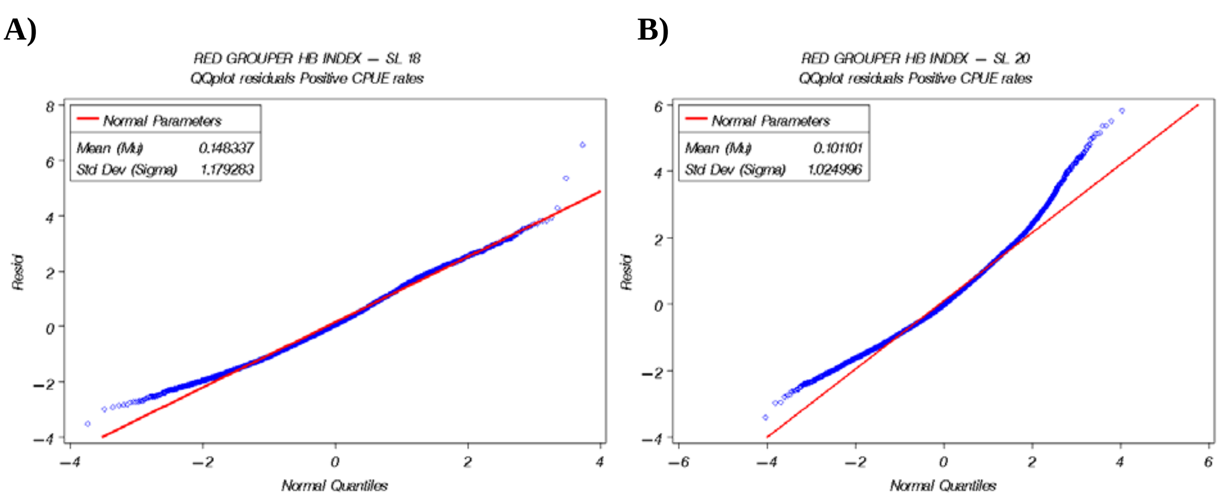

Figure 6. The cumulative normalized residuals (QQ-Plot) from the lognormal model on the catch rates of positive trips during the 18" (A) and 20" (B) minimum size limits. The red line is the expected normal distribution.

A) B)

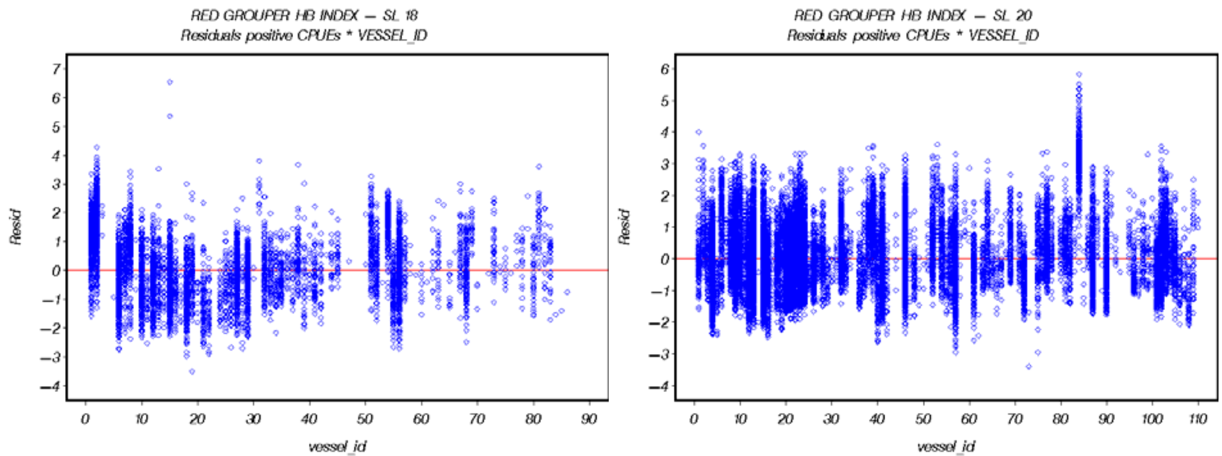

Figure 7. The distribution of residuals from the lognormal model on catch rates, by vessel ID, during the 18” (A) and 20” (B) minimum size limits. Vessels are coded with a numeric identifier.

A) B)

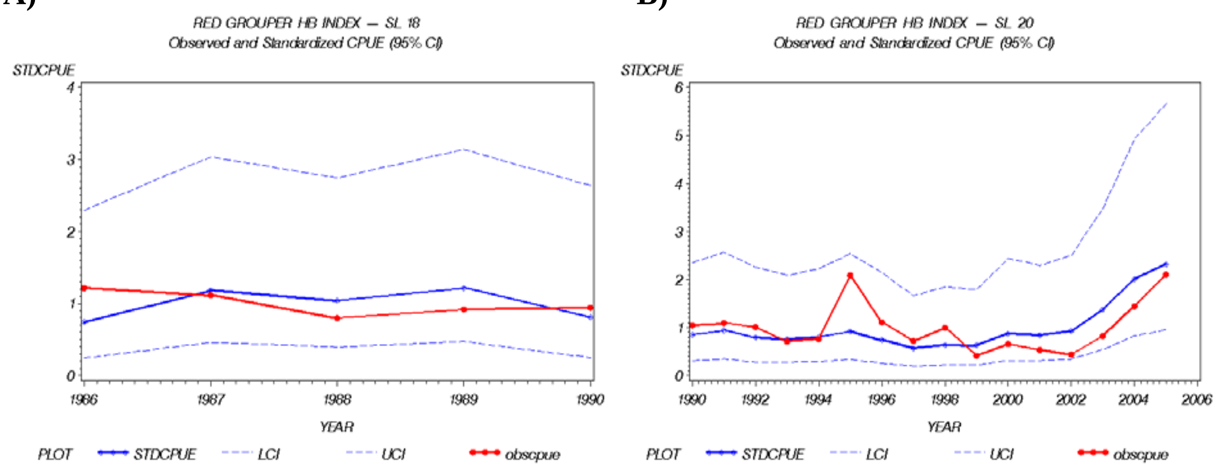

Figure 8. The standardized indices with 95% confidence intervals and nominal CPUE during the 18” (A) and 20” (B) minimum size limits.