STANDARDIZED CATCH RATE INDICES FOR GAG GROUPER (*MYCTEROPERCA MICROLEPIS*) LANDED BY THE COMMERCIAL LONGLINE FISHERY IN THE U.S. GULF OF MEXICO DURING 1993-2004

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(***Revised Feb 1st 2006***)

SUMMARY

Standardized catch rate indices (delta-lognormal) were constructed for the SEDAR10 data workshop (Charleston, N.C., January 2006). The indices were constructed using NMFS Gulf of Mexico Reef Fish Logbook data. An index was constructed for the entire time period (1993-2004), and for two subintervals divided at the date of initiation of the 24 inch size limit. The indices all indicate that gag grouper are increasing in abundance.

Revised indices were constructed following the recommendations of the SEDAR10 Data Workshop. The recommendations, conclusions and revised indices are discussed in Appendix 1. The revised indices are very similar to those presented during the workshop, and generally suggest increasing abundance of gag grouper.

KEY WORDS

Catch/effort, CPUE, abundance, commercial longline, gag, groupers

PLEASE READ THE SEDAR10-DW REPORT, AND APPENDIX 1 FOR SEDAR10-DW RECOMMENDATIONS, CONCLUSIONS AND REVISED RESULTS

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INTRODUCTION

Commercial vessels operating in the U. S. Gulf of Mexico have been monitored by the NMFS Gulf of Mexico Reef Fish Logbook Program since 1990. Catch and effort data from commercial longline trips occurring within the Gulf of Mexico were used to develop standardized catch rate indices for gag grouper. This document describes the development of the indices which are presented for the consideration of the SEDAR10-DW panel (Charleston, N.C., January 2006).

METHODS

Data Sources

The NMFS Gulf of Mexico Reef Fish Logbook Program collects catch and effort data by trip for permitted vessels that participate in fisheries managed by the Gulf of Mexico and South Atlantic Fishery Management Councils. The program began in 1990 with a complete census of commercial reef fish trips by vessels permitted in TX, LA, MS and AL. A 20% sample of vessels permitted in FL was required until 1993, when all permitted reef fish vessels were required to submit logs. We constructed catch rate indices for the period 1993-2004, because we have concerns that the data prior to 1993 is less reliable.

The logbook data base includes unique trip and vessel identifiers and information regarding trip date, gear class, fishing area (identical to shrimp statistical grid; Fig. 1), days at sea, fishing effort, species caught and landed weight. A vessel may fish in multiple areas using multiple gears on a single trip. However, while catch is reported by gear and area, effort is not. Instead total effort by gear is reported for each trip. Therefore it is not possible to calculate the catch per unit effort by area on trips that fished in more than one area. For this reason, trips that fished in multiple areas were excluded from the analysis.

Data collected for trips that fished during shallow water grouper or gag grouper closures were excluded. Closures occurred from February 15th to March 15th in 2001 through 2004, and from November 15th –December 31st 2004. In addition, data were restricted to those longline trips occurring within the U.S Gulf of Mexico areas 1 to 10. On average, >95% of the total annual landings of gag grouper occur in these areas.

Species Misidentification

There is concern that gag grouper is often misidentified as black grouper, particularly in South Florida and the Keys. To examine this problem, NOAA Trip Interview Program (TIP) observations of commercial longline landings were examined.[2] TIP species identifications are made by trained scientific observers. Therefore, the species identifications may be more reliable than those reported in the Reef Fish Logbook dataset. The proportion of gag and black groupers

[2] Ching-Ping Chih, Personal Communication. NOAA Fisheries, Miami Laboratory.

landed by commercial longliners that were identified as gag grouper by TIP scientific samplers is summarized by area in Table 1. These proportions were used to adjust the landings of gag grouper per trip in an attempt to account for gag grouper misidentified as "black grouper" in the logbook dataset using Equation 1:

$$Gag'(lbs) = \left[Gag(lbs) + Black(lbs)\right] * propGag_a \qquad \text{(Eq. 1)}$$

where *Gag'* is the adjusted weight of gag landed on a trip, *Gag* and *Black* are the weight of gag and black groupers landed on a trip, and *propGag* is the proportion of gag + black groupers that were identified as gag grouper by the TIP observers, by area *a*.

Index Development

Three indices were constructed. The first considered the entire time series (1993-2004) without considering the amended size limit (effective date June 19th, 2000). Indices two and three were constructed for periods with consistent size limits. Index two was constructed for the period of the 20" size limit (Jan 1993 to June 18th 2000), and index three was constructed for the 24" size limit (June 19th, 2000 to Dec. 2004).

For each index, the following factors were considered as possible influences on the proportion of trips that observed gag grouper, and the catch rates on positive trips.

FACTOR	INDEX	LEVELS	VALUES
	Entire Series	12	1993-2004
YEAR	Size Limit 20"	8	1993-2000
	Size Limit 24"	5	2000-2004
SEASON	ALL	4	WIN = (Dec-Feb) SPR = (Mar-May) SUM = (Jun-Aug) AUT = (Sep-Nov)
AREA	ALL	8	AREAS 1+2, 3, 4, 5, 6, 7, 8, 9+10
TRIP LENGTH	ALL	3	1-5 days; 6-10 days; > 10 days.

A delta-lognormal approach (Lo et al., 1992) was used to develop the standardized catch rate indices. This method combines separate generalized linear modeling (GLM) analyses of the proportion positive trips[3] (trips that observed gag grouper) and the catch rate on successful trips[4] to construct a single standardized index of abundance. 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, ln(CPUE), was calculated:

[3] Type-3 model, error = binomial, link = logit, response variable = success (where success = 1 if vermilion snapper catch > 0, else success = 0)
[4] Type-3 model, error = normal, link = identity, response variable = logCPUE (where catch ≠ 0 and effort = lines * hours fished).

$$\ln(CPUE) = \ln\left[\frac{Gag'(lbs)}{\left(sets * hooks/_{set}\right)}\right] \quad \text{(Eq. 2)}$$

where Gag' is the adjusted weight of gag grouper landed per trip (see Eq. 1). Although it contains more information, it is not advisable to use the response variable hook*hours due to confusion regarding the logbook variable “hours fished”. Most anglers record “total hours fished per trip”, but a significant portion report “average hours fished per set”. Although some errors can be corrected using deductive reasoning, many cannot. Therefore, rather than deleting these trips, the response variable “hooks” was adopted.

A forward stepwise approach was used during the construction of each GLM. First, a GLM model was fit on year. These results reflect the distribution of the nominal data. Next each potential factor was added to the null model individually, and the resulting reduction (%RED) in deviance per degree of freedom (DEV/DF) was examined. The factor that caused the greatest reduction in deviance per degree of freedom was added to the base model if the factor was significant based upon a Chi-Square test (PROBCHISQ≤0.05), and the reduction in deviance per degree of freedom was ≥1%. This model then became the base model, and the process was repeated, adding factors and two-way interaction terms individually until no factor or interaction met the criteria for incorporation into the final model. Higher order interaction terms were not examined.

The final delta-lognormal models were fitted using a SAS macro, GLIMMIX (glmm800MaOB.sas: Russ Wolfinger, SAS Institute). All factors were modeled as fixed effects except two-way interaction terms containing YEAR (e.g. YEAR*AREA). These were modeled as random effects. To facilitate visual comparison, a relative index and relative nominal CPUE series were calculated by dividing each value in the series by the mean value of the series.

RESULTS AND DISCUSSION

Index 1 (Entire time series):

A total of 18,864 longline trips were included in this analysis. Of these, 12,846 landed gag grouper (after adjustment for misidentification; Eq. 1). The final models for the binomial on proportion positive trips and the lognormal on CPUE were:

PPT= YEAR + TRIP_LENGTH + AREA + SEASON

LN(CPUE)= YEAR + AREA + TRIP_LENGTH + YEAR*AREA

The model construction and linear regression statistics are summarized in Table 2.

The proportion of trips that landed gag grouper varied from 0.61 to 0.75 (Fig. 2). Since 1995, the proportion of positive trips has generally increased to a maximum of 0.75 in 2004.

Annual nominal CPUE (made relative by dividing each value by the series mean) has increased significantly throughout the time series. In 2004, the nominal CPUE was nearly 4 times the minimum value observed in 1996 (Fig. 3). Diagnostic plots used to assess the goodness of fit were acceptable. The frequency distribution of the proportion of positive trips by the model factors was acceptable (ideally the distribution is uniform; Fig. 4). The distribution of the response variable (logCPUE) was nearly normal, as expected (Fig. 5). The fit of the lognormal model can also be assessed using a QQ-Plot (Fig. 6). According to this diagnostic, the model fit is quite good, with the model residuals close to the predicted outcome (red line; Fig. 6). The resulting delta-lognormal index is very similar to the nominal CPUE series. The index indicates generally increasing catch rates throughout the time series (Fig. 7). Index results, including confidence intervals and CVs are also summarized in Table 3.

Index 2 (20" Size Limit):

A total of 11,310 longline trips were included in the 20" size limit dataset. Of these, 7,499 landed gag grouper (after adjustment for misidentification; Eq. 1). The final models for the binomial on proportion positive trips and the lognormal on CPUE were:

PPT= YEAR + TRIP_LENGTH + AREA + YEAR*AREA

LN(CPUE)= YEAR + AREA + TRIP_LENGTH

The model construction and linear regression statistics are summarized in Table 4.

The proportion of trips that landed gag grouper varied from 0.61 to 0.71 (Fig. 8). Since 1995, the proportion of positive trips has generally increased. Annual nominal CPUE increased significantly from 1996 to 2000. In 2000, the nominal CPUE was nearly 3 times the minimum value observed in 1996 (Fig. 9). Diagnostic plots used to assess the goodness of fit were very similar to those described in the previous section (Figs. 10-12). The delta-lognormal index is very similar to the nominal CPUE series. The index indicates a gradual increase in catch rates throughout the time series (Fig. 13). Index results, including confidence intervals and CVs are also summarized in Table 5.

Index 3 (24" Size Limit):

A total of 7,554 longline trips were included in the 24" size limit dataset. Of these, 5,347 landed gag grouper (after adjustment for misidentification; Eq. 1). The final models for the binomial on proportion positive trips and the lognormal on CPUE were:

PPT= YEAR + TRIP_LENGTH + AREA + SEASON + AREA*TRIP_LENGTH + SEASON*AREA

LN(CPUE) =YEAR + AREA + TRIP_LENGTH + SEASON + AREA*TRIP_LENGTH + YEAR*SEASON

The model construction and linear regression statistics are summarized in Table 6.

The proportion of trips that landed gag grouper varied from 0.62 to 0.75, and generally increased throughout the time series (Fig. 14). Annual nominal CPUE also increased from 2000 to 2004, nearly doubling during that time (Fig. 15). Diagnostic plots used to assess the goodness of fit were very similar to those described in the previous section (Figs. 16-18). The delta-lognormal index is very similar to the nominal CPUE series. The index indicates a significant increase from 2000 to 2001, then a very modest increase thereafter (Fig. 19). Index results, including confidence intervals and CVs are also summarized in Table 7.

ACKNOWLEDGMENTS

Thanks to Drs. Ching-Ping Chih, and Steve Turner for their examination of, and recommendations regarding misidentification of black and gag groupers.

LITERATURE CITED

Lo, N.C., L.D. Jackson, 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.

Table 1. TIP observations of gag and black groupers, by area, and the proportion of the total (gag+black) that were identified as gag grouper.

AREA	OBS GAG	OBS BLACK	BLACK+GAG	PROP GAG
1	43	20	63	0.683
2	2283	1628	3911	0.584
3	4049	696	4745	0.853
4	8442	405	8847	0.954
5	12247	245	12492	0.980
6	8140	44	8184	0.995
7	438	0	438	1.000
8	580	0	580	1.000
9	59	0	59	1.000
10	78	0	78	1.000

Table 2. Linear regression statistics for the final GLM models on proportion positive trips (A) and (B) catch rates on positive trips (***Index 1***; Entire Time Series).

A)

Source	DF	%RED DEV/DF	Chi-Square	Pr > ChiSq
YEAR	11	N/A	245.36	<.0001
TRIP_LENGTH	2	13.44	2369.02	<.0001
AREA	7	6.20	1252.50	<.0001
SEASON	3	1.00	193.67	<.0001

B)

Source	DF	%RED DEV/DF	Chi-Square	Pr > ChiSq
YEAR	11	N/A	450.98	<.0001
AREA	7	3.79	409.56	<.0001
TRIP_LENGTH	2	1.89	223.43	<.0001
YEAR*AREA	77	1.52	274.25	<.0001

Table 3. Nominal CPUE, proportion positive trips (PPT) and index results (***Index 1***; Entire Time Series).

YEAR	Nominal CPUE	PPT	Obs	Positive Trips	Rel. Index	LCI	UCI	CV Index
1993	0.016	0.717	1027	736	0.557	0.177	1.752	0.623
1994	0.020	0.632	1352	854	0.364	0.095	1.400	0.757
1995	0.014	0.615	1225	753	0.537	0.172	1.676	0.619
1996	0.013	0.619	1789	1107	0.533	0.188	1.512	0.559
1997	0.015	0.646	1798	1162	0.565	0.205	1.558	0.542
1998	0.023	0.699	1656	1157	0.907	0.404	2.040	0.422
1999	0.024	0.698	1641	1146	0.817	0.342	1.949	0.456
2000	0.030	0.663	1693	1122	1.010	0.455	2.242	0.415
2001	0.045	0.707	1684	1191	1.614	0.855	3.044	0.325
2002	0.047	0.695	1622	1127	1.593	0.840	3.024	0.329
2003	0.045	0.721	1757	1267	1.671	0.908	3.075	0.312
2004	0.051	0.756	1620	1224	1.832	1.023	3.281	0.298

Table 4. Linear regression statistics for the final GLM models on proportion positive trips (A) and (B) catch rates on positive trips (***Index 2***; 20” Size Limit).

A)

Source	DF	%RED DEV/DF	Chi-Square	Pr > ChiSq
YEAR	7	N/A	25.34	0.0007
TRIP_LENGTH	2	12.03	1255.10	<.0001
AREA	7	5.03	541.64	<.0001
YEAR*AREA	49	1.03	174.80	<.0001

B)

Source	DF	%RED DEV/DF	Chi-Square	Pr > ChiSq
YEAR	7	N/A	198.38	<.0001
AREA	7	4.28	279.97	<.0001
TRIP_LENGTH	2	2.37	181.80	<.0001

Table 5. Nominal CPUE, proportion positive trips (PPT) and index results (***Index 2***; 20” Size Limit).

YEAR	Nominal CPUE	PPT	Obs	Positive Trips	Rel. Index	LCI	UCI	CV Index
1993	0.016	0.717	1027	736	0.884	0.454	1.721	0.343
1994	0.020	0.632	1352	854	0.570	0.255	1.275	0.419
1995	0.014	0.615	1225	753	0.761	0.381	1.522	0.357
1996	0.013	0.619	1789	1107	0.840	0.470	1.500	0.296
1997	0.015	0.646	1798	1162	0.855	0.491	1.488	0.282
1998	0.023	0.699	1656	1157	1.437	0.943	2.190	0.213
1999	0.024	0.698	1641	1146	1.164	0.716	1.892	0.247
2000	0.034	0.710	822	584	1.489	0.886	2.504	0.264

Table 6. Linear regression statistics for the final GLM models on proportion positive trips (A) and (B) catch rates on positive trips (***Index 3***; 24” Size Limit).

A)

Source	DF	%RED DEV/DF	Chi-Square	Pr > ChiSq
YEAR	4	N/A	55.16	<.0001
TRIP_LENGTH	2	15.85	933.66	<.0001
AREA	7	8.62	299.28	<.0001
SEASON	3	2.22	130.69	<.0001
AREA*TRIP_LENGTH	14	1.88	125.10	<.0001
SEASON*AREA	21	1.20	98.50	<.0001

B)

Source	DF	%RED DEV/DF	Chi-Square	Pr > ChiSq
YEAR	4	N/A	21.52	0.0003
AREA	7	4.52	197.96	<.0001
TRIP_LENGTH	2	1.27	50.89	<.0001
SEASON	3	1.24	80.49	<.0001
AREA*TRIP_LENGTH	14	1.14	81.11	<.0001
YEAR*SEASON	11	1.10	70.22	<.0001

Table 7. Nominal CPUE, proportion positive trips (PPT) and index results (***Index 3***; 24” Size Limit).

YEAR	Nominal CPUE	PPT	Obs	Positive Trips	Rel. Index	LCI	UCI	CV Index
2000	0.026	0.618	871	538	0.652	0.192	2.217	0.674
2001	0.045	0.707	1684	1191	1.011	0.415	2.465	0.469
2002	0.047	0.695	1622	1127	1.027	0.422	2.501	0.468
2003	0.045	0.721	1757	1267	1.138	0.485	2.668	0.446
2004	0.051	0.756	1620	1224	1.172	0.508	2.702	0.437

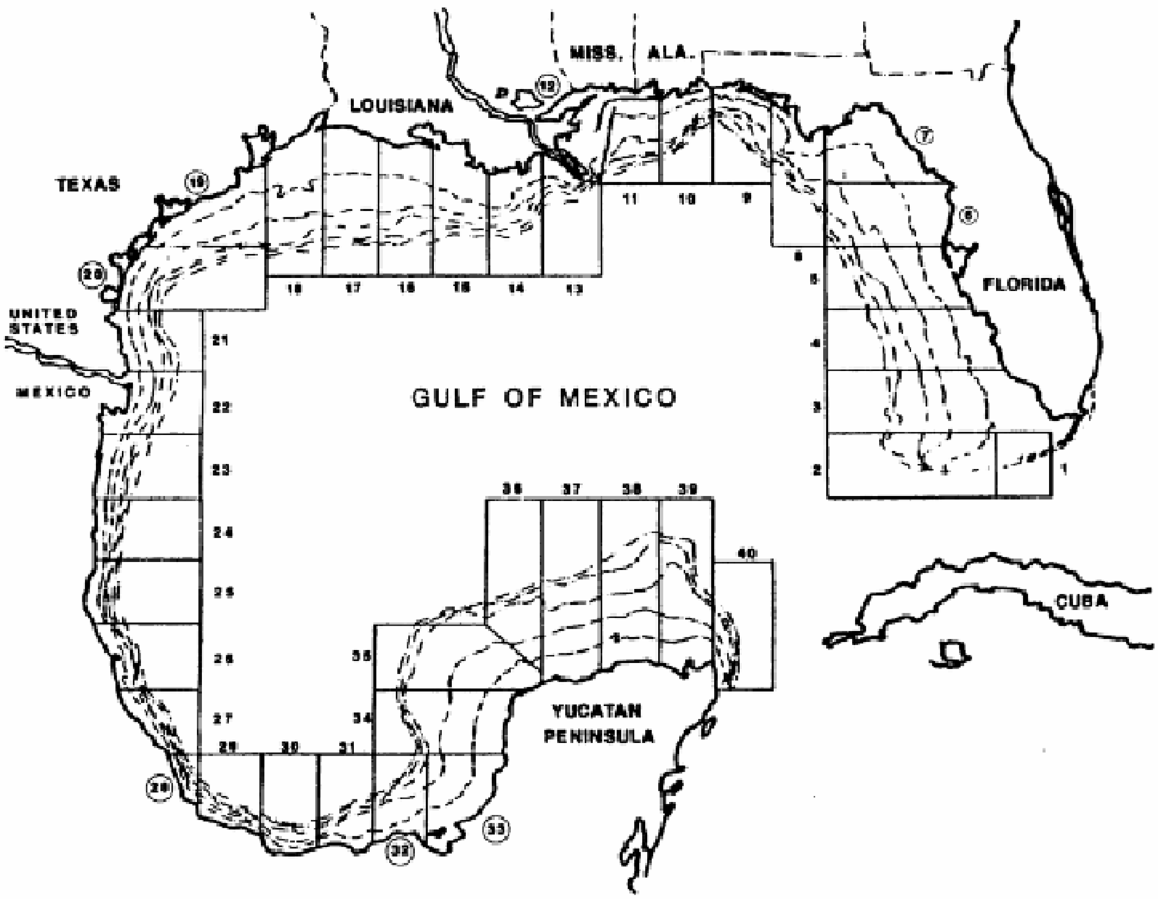

Figure 1. Gulf of Mexico with NMFS statistical grids.

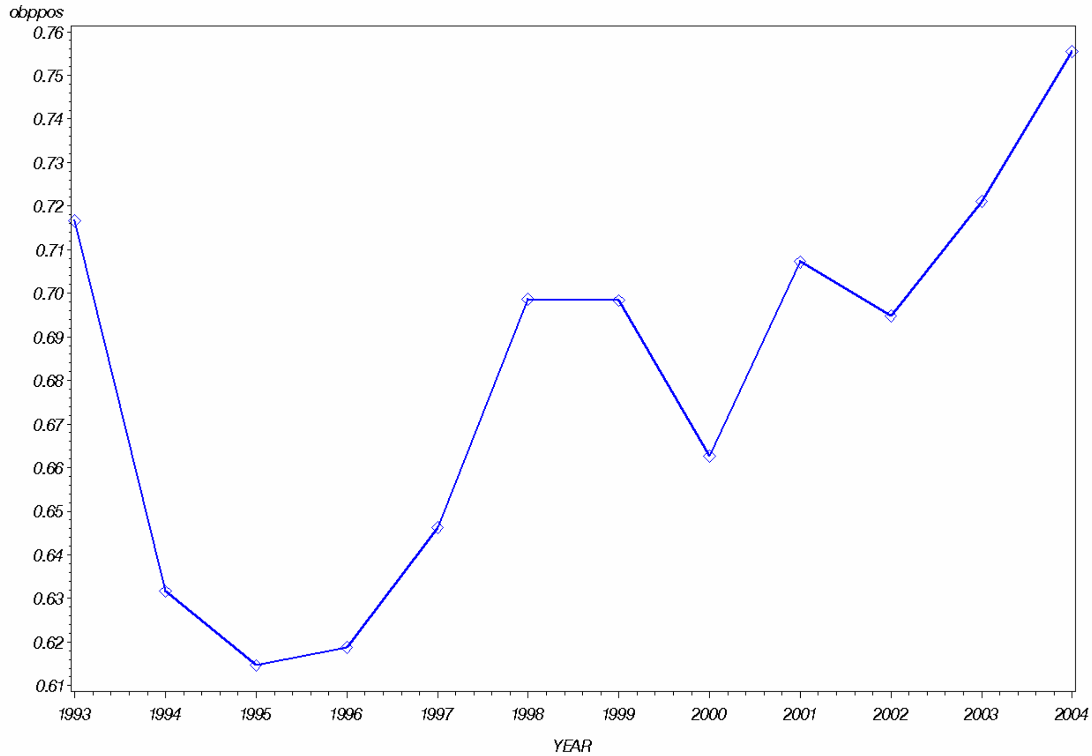

Figure 2. Annual trend in proportion of positive trips (***Index 1***; Entire Time Series).

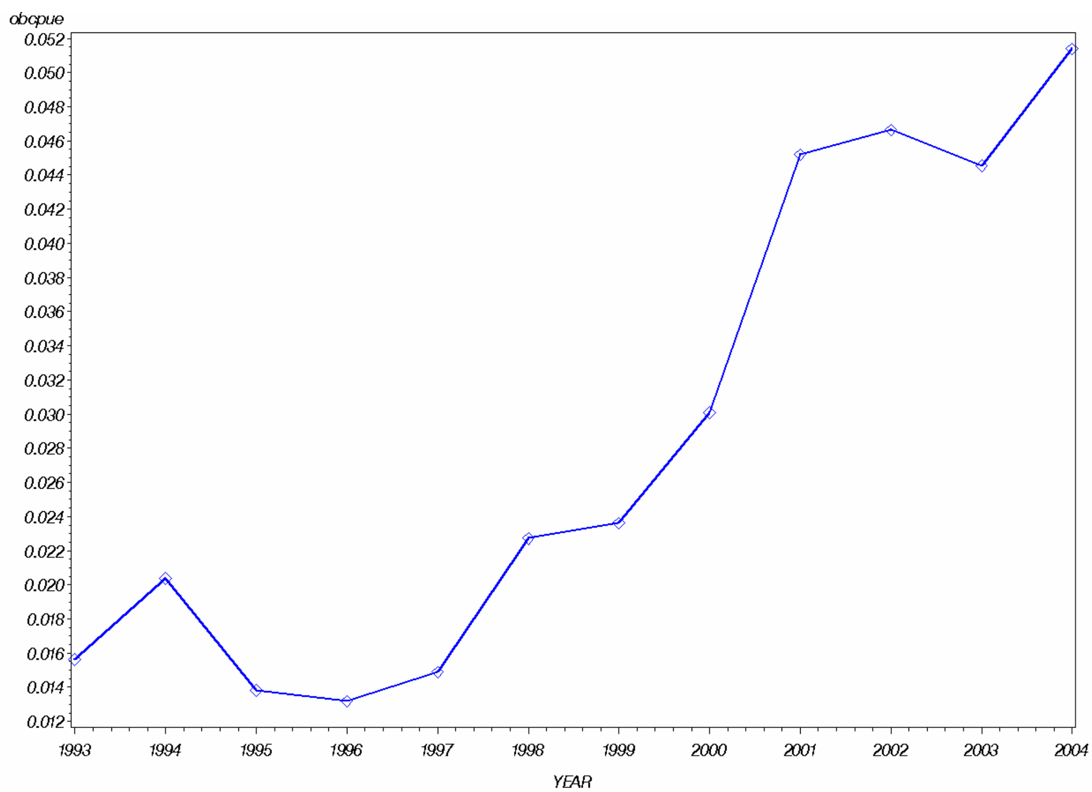

Figure 3. Annual trend in nominal CPUE (***Index 1***; Entire Time Series).

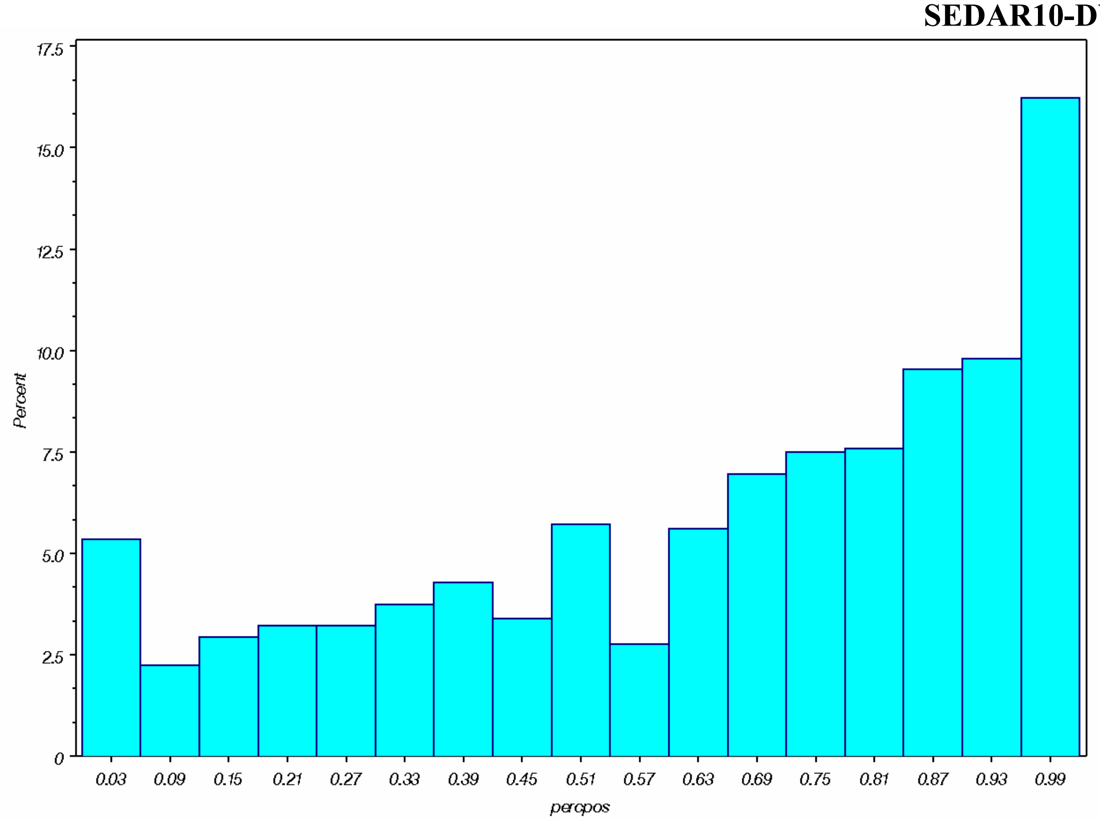

Figure 4. Frequency distribution of proportion positive catches by the factors YEAR, TRIP_LENGTH, AREA and SEASON (***Index 1***; Entire Time Series).

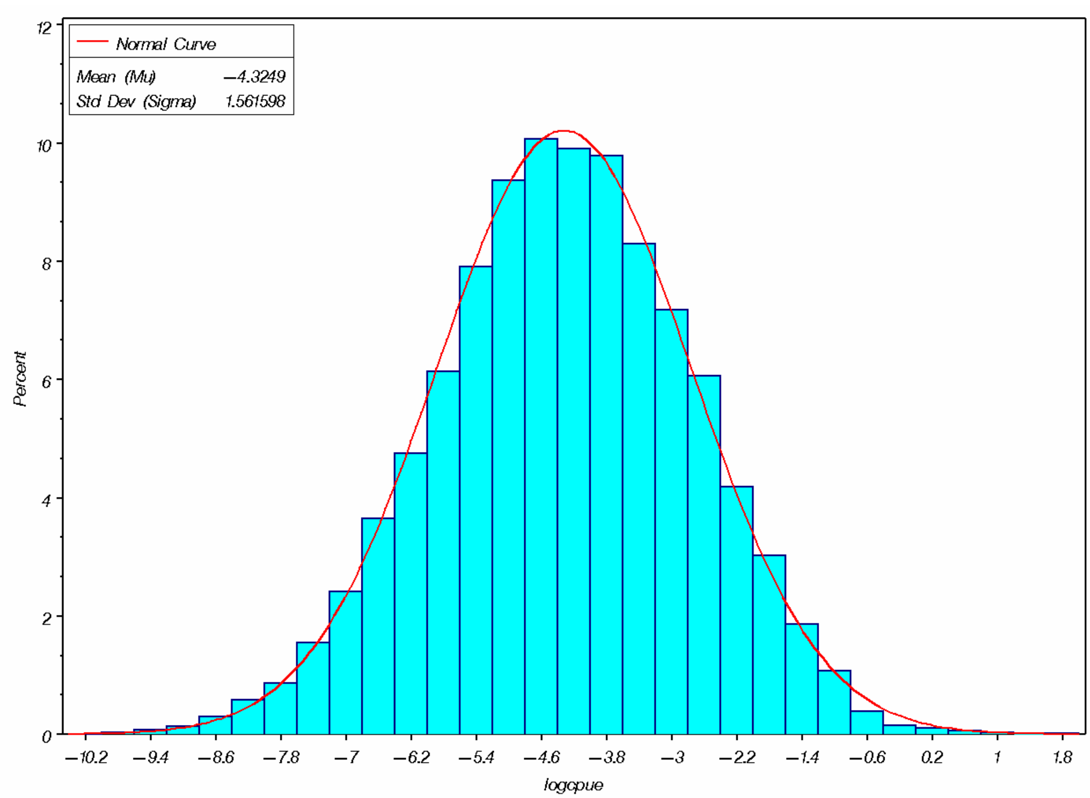

Figure 5. Frequency distribution of log(CPUE) on positive trips (***Index 1***; Entire Time Series).

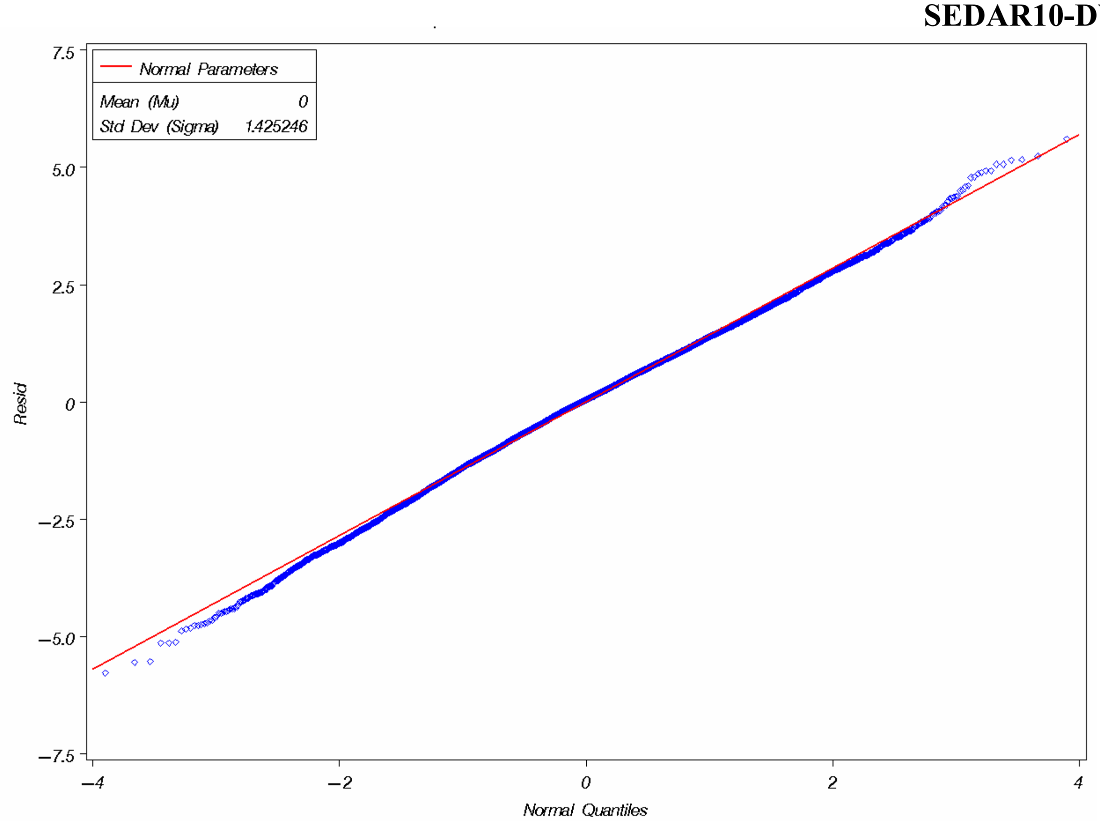

Figure 6. QQ plot of the fit of the lognormal model (***Index 1***; Entire Time Series).

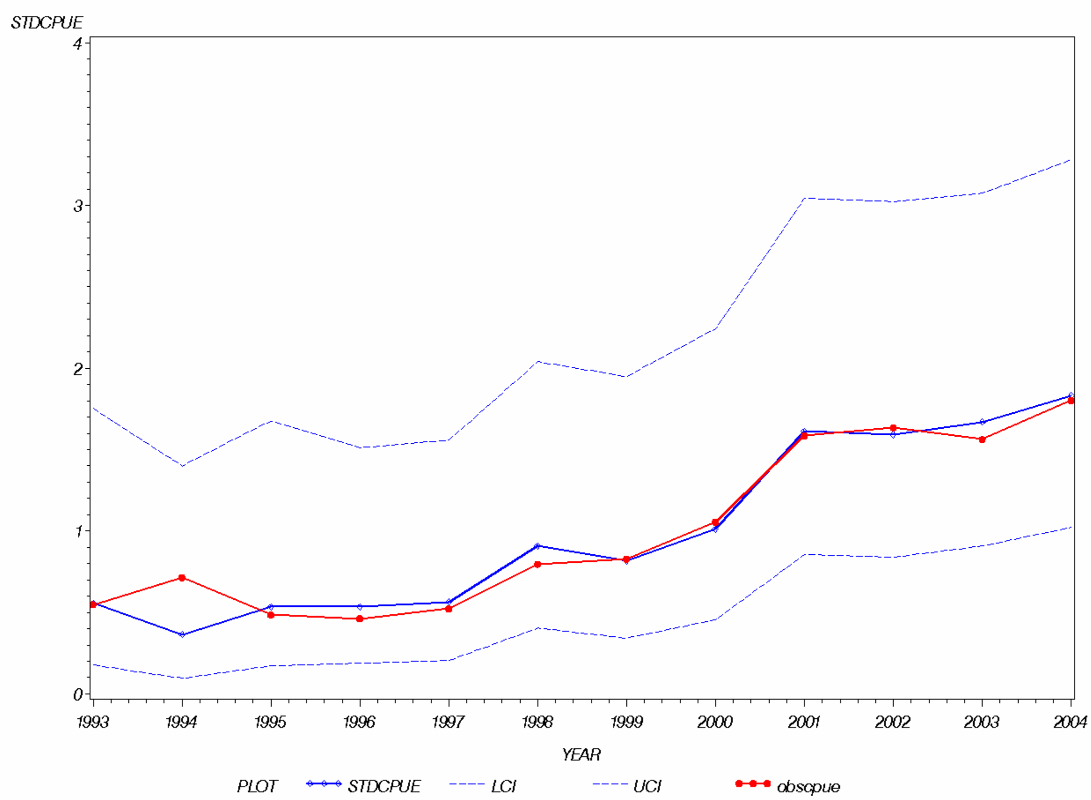

Figure 7. Relative nominal CPUE (red), relative standardized index (blue) and 95% confidence intervals (blue dotted) (***Index 1***; Entire Time Series).

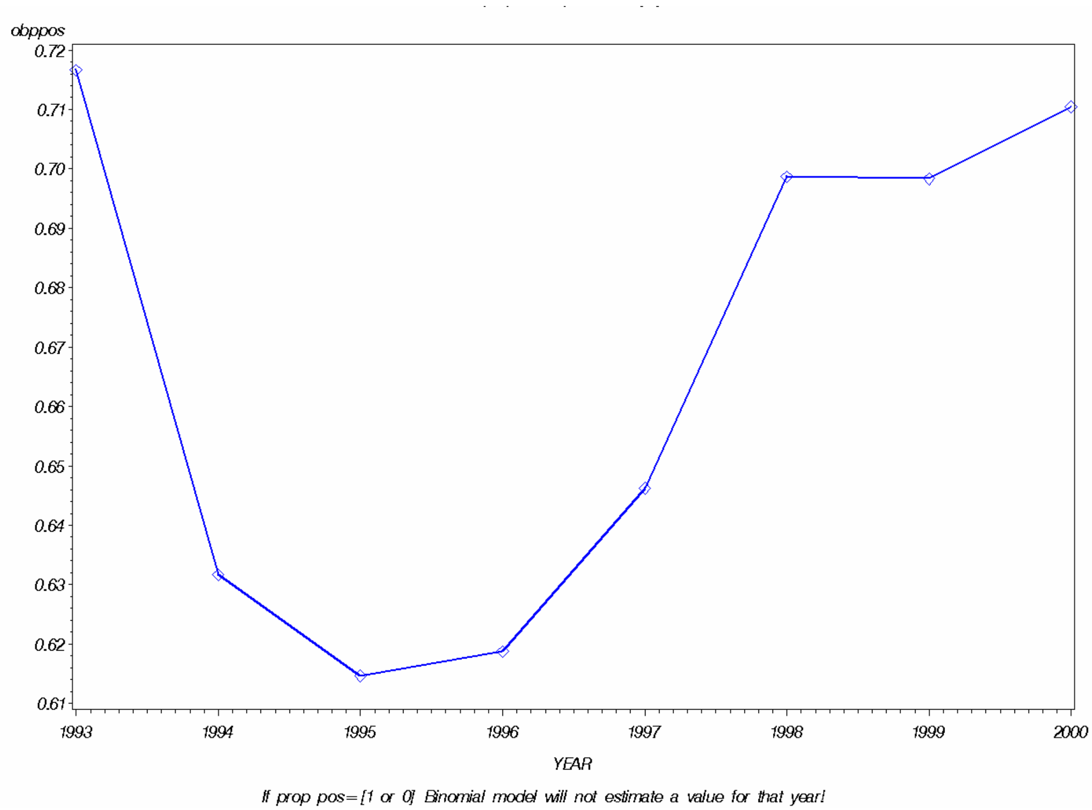

Figure 8. Annual trend in proportion of positive trips (***Index 2***; 20” Size Limit).

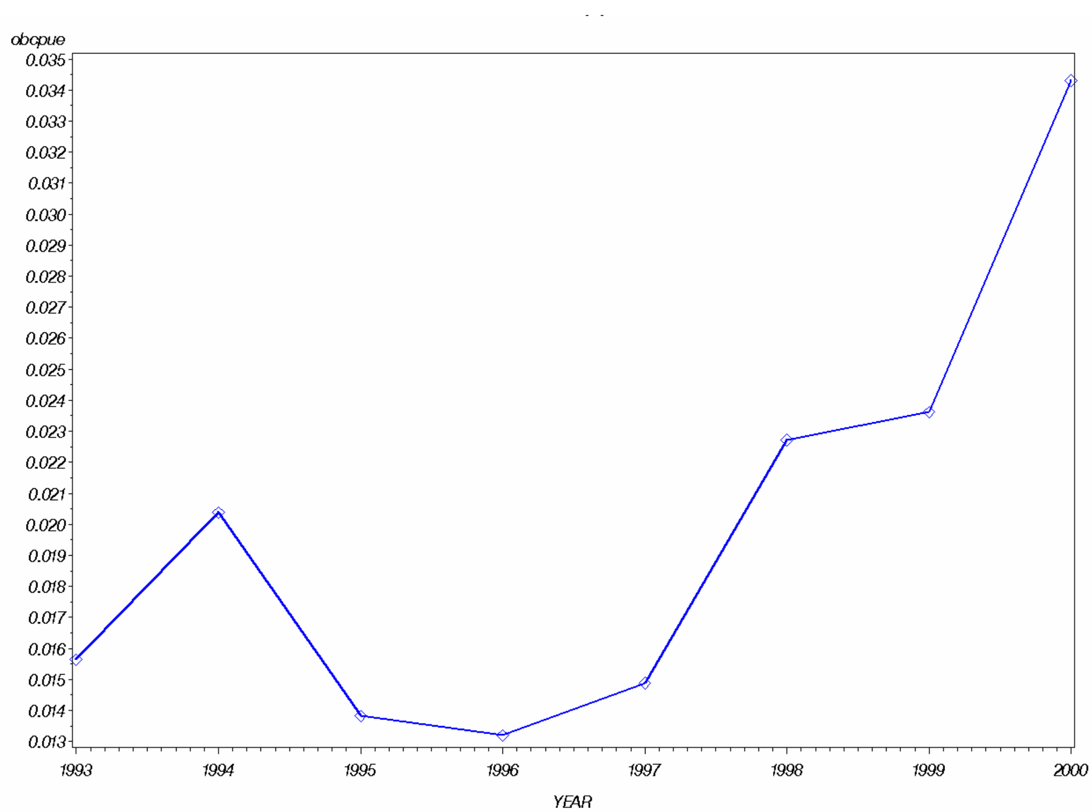

Figure 9. Annual trend in nominal CPUE (***Index 2***; 20” Size Limit).

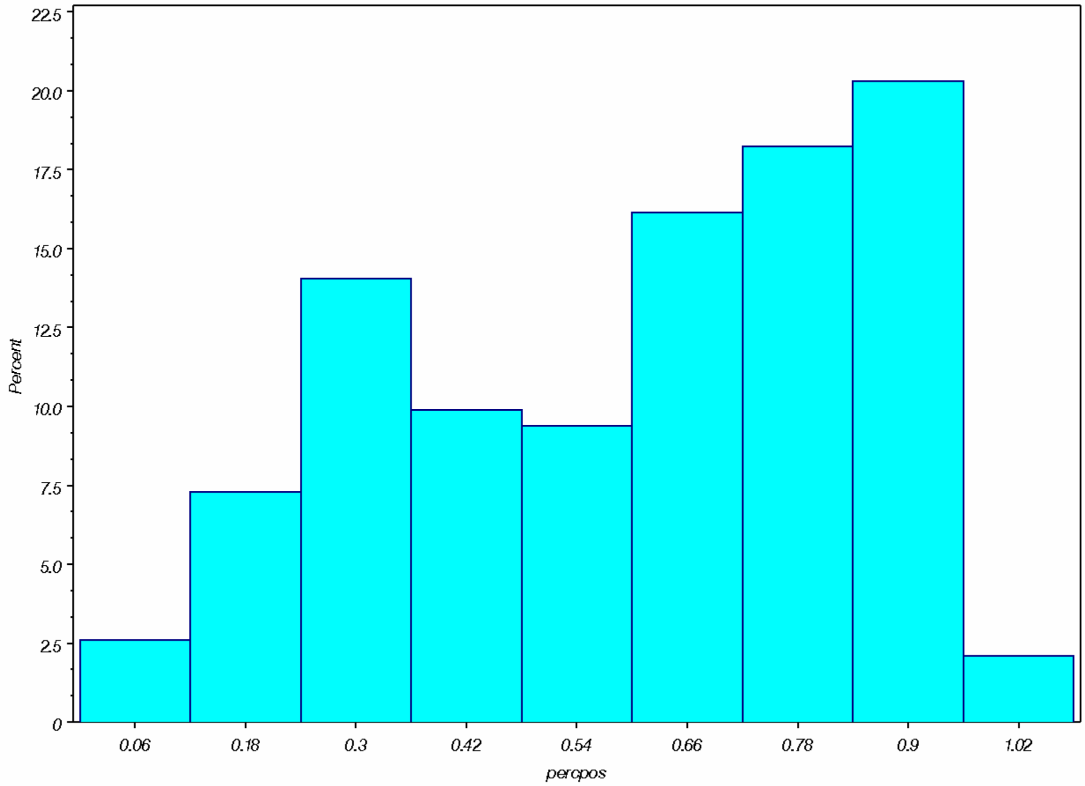

Figure 10. Frequency distribution of proportion positive catches by the factors YEAR, TRIP_LENGTH and AREA (***Index 2***; 20" Size Limit).

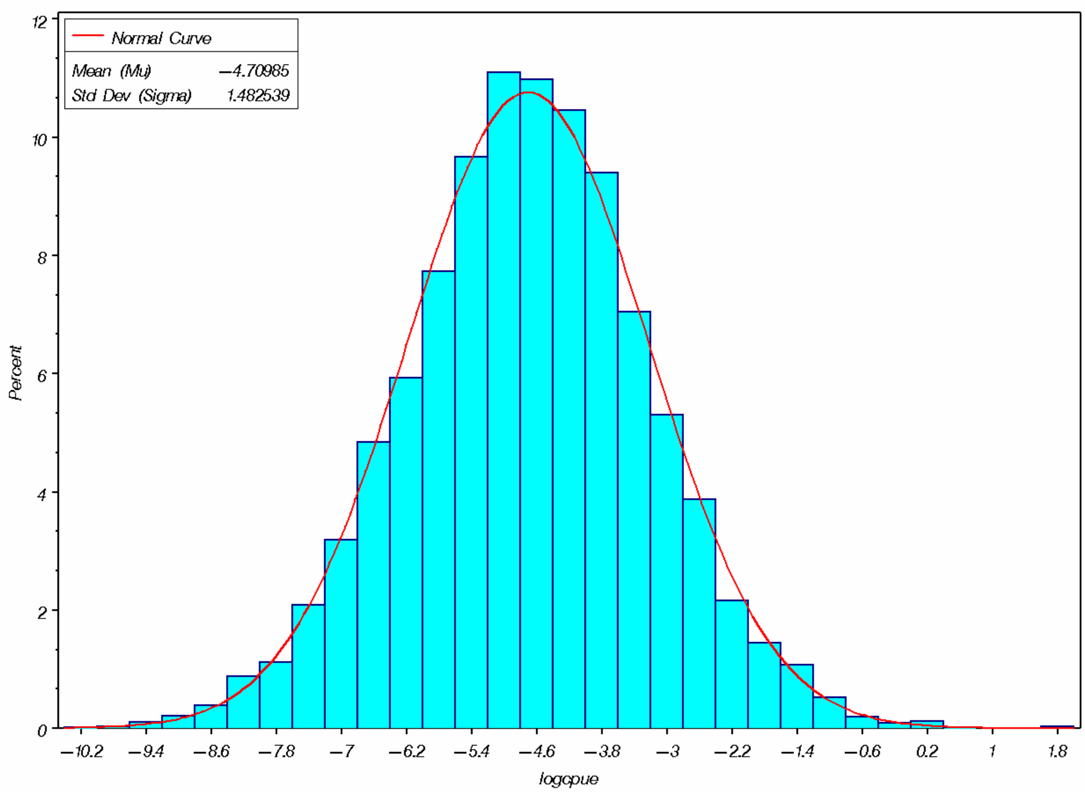

Figure 11. Frequency distribution of log(CPUE) on positive trips (***Index 2***; 20" Size Limit).

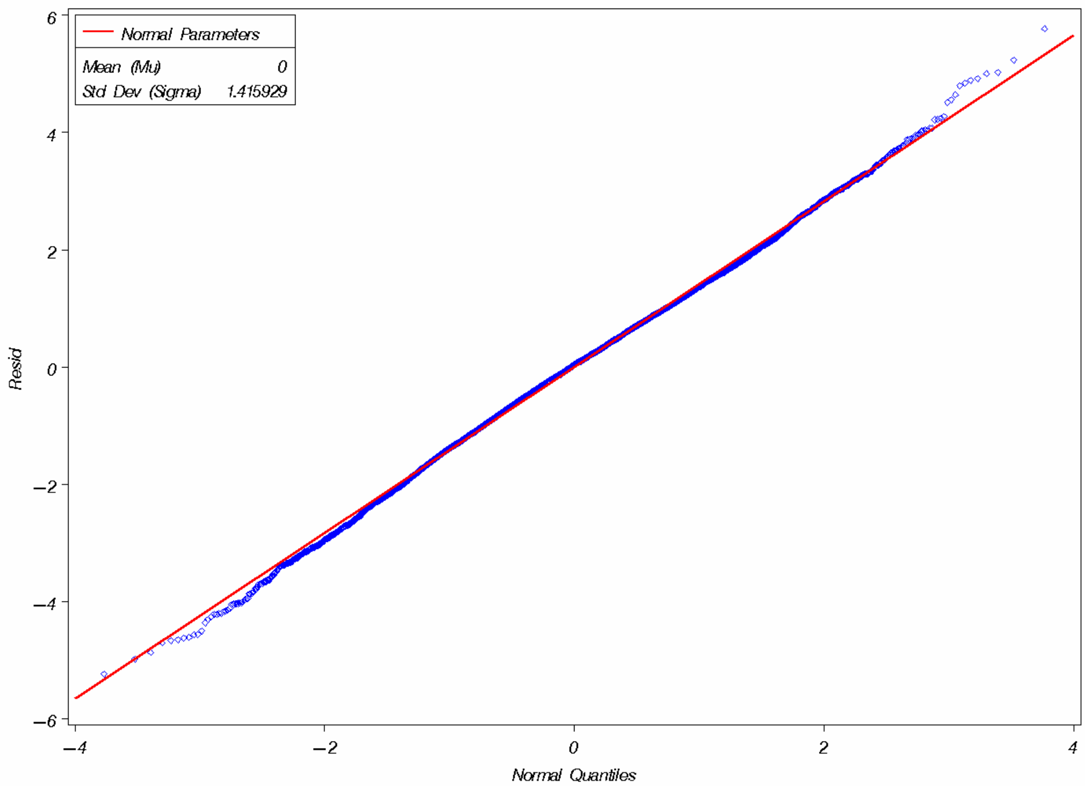

Figure 12. QQ plot of the fit of the lognormal model (***Index 2***; 20” Size Limit).

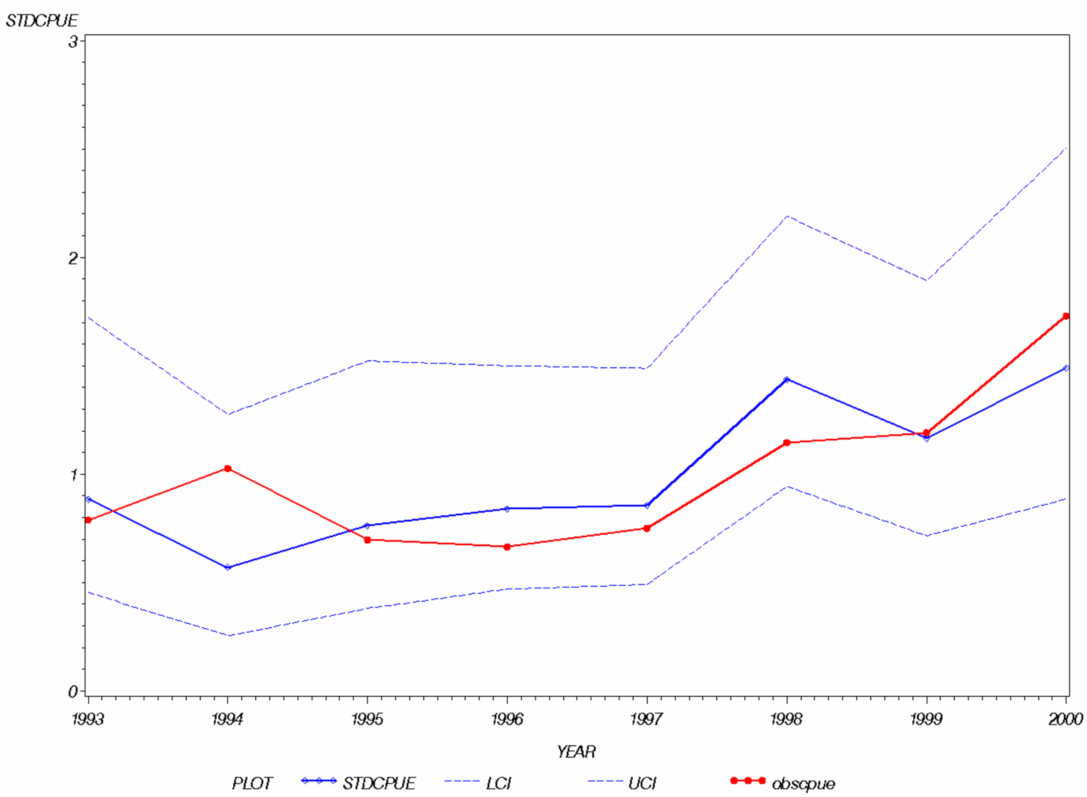

Figure 13. Relative nominal CPUE (red), relative standardized index (blue) and 95% confidence intervals (blue dotted) (***Index 2***; 20” Size Limit).

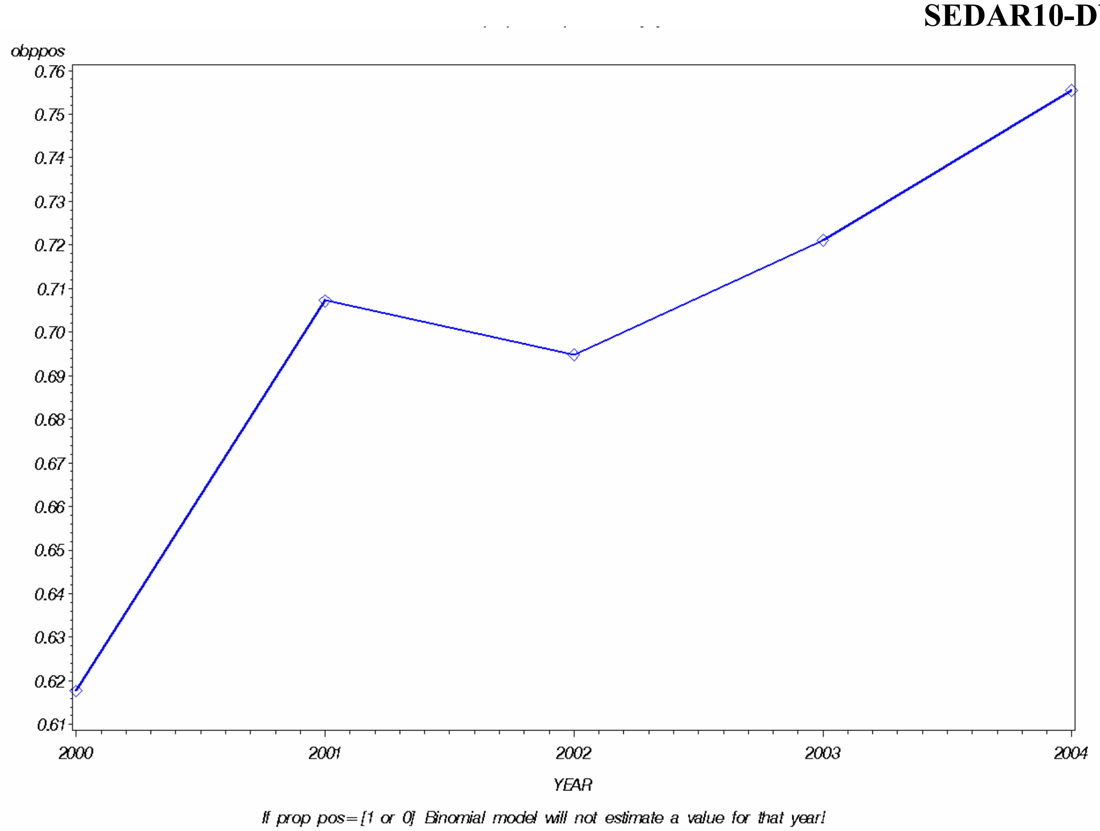

Figure 14. Annual trend in proportion of positive trips (***Index 3***; 24” Size Limit).

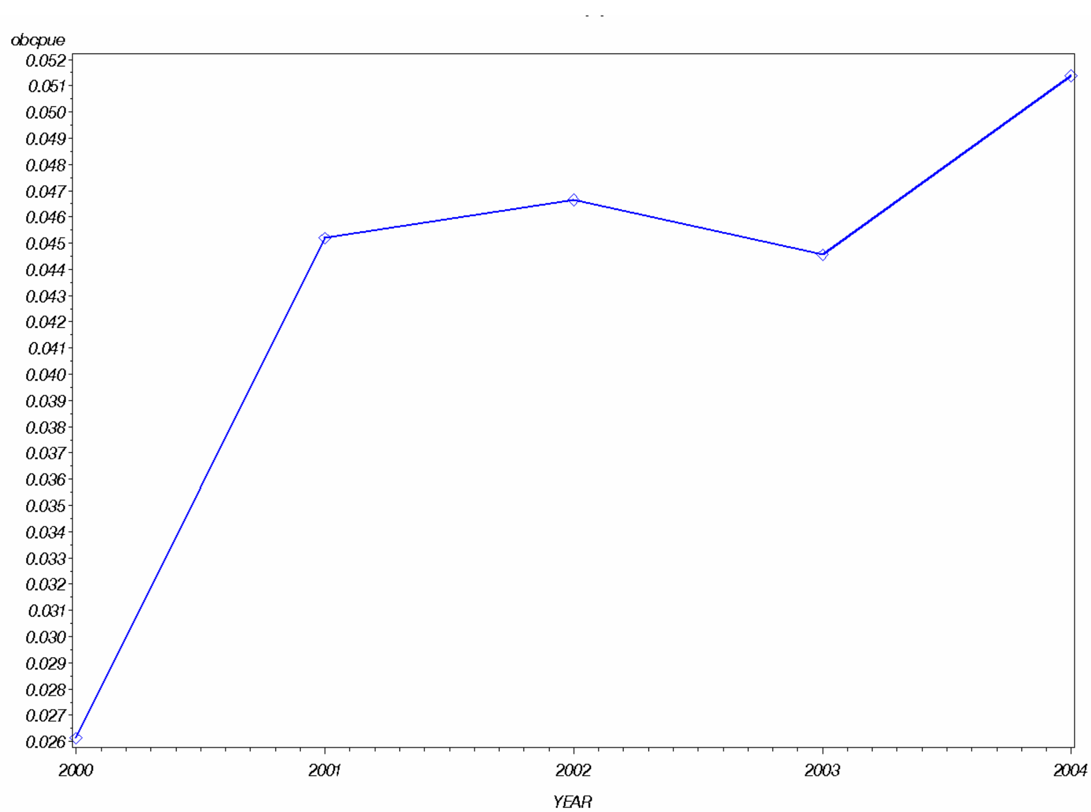

Figure 15. Annual trend in nominal CPUE (***Index 3***; 24” Size Limit).

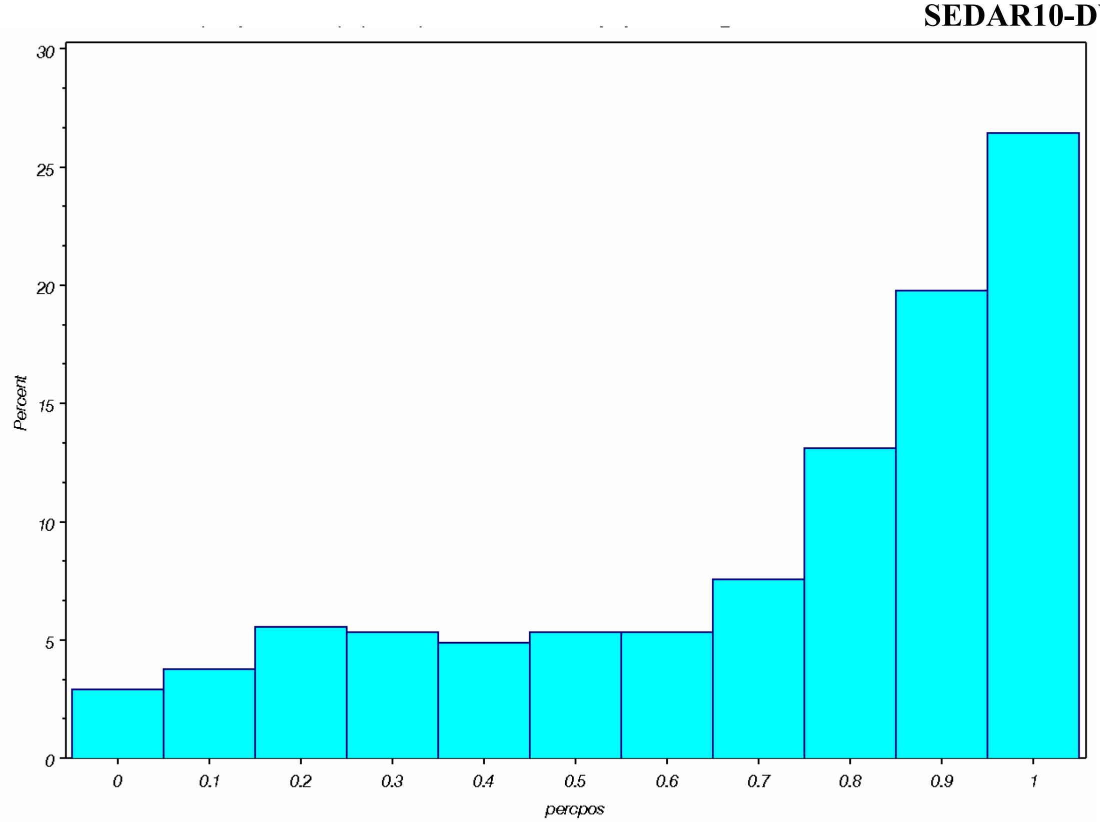

Figure 16. Frequency distribution of proportion positive catches by the factors YEAR, TRIP_LENGTH, AREA and SEASON (***Index 3***; 24" Size Limit).

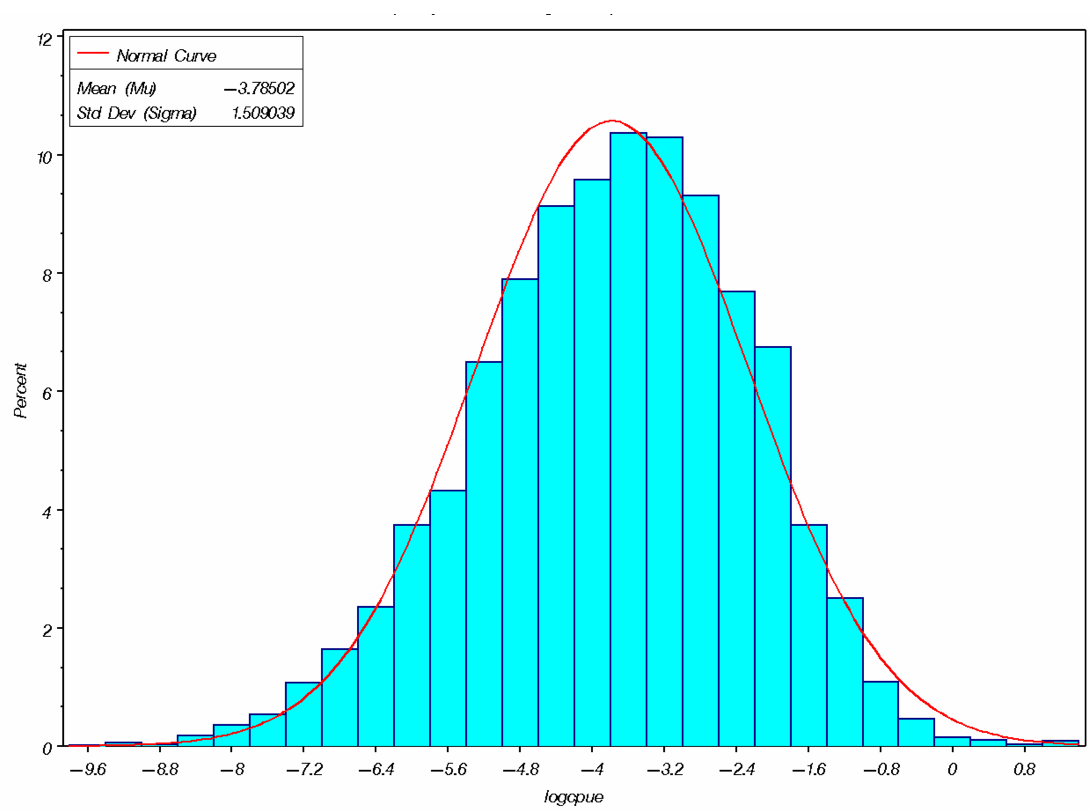

Figure 17. Frequency distribution of log(CPUE) on positive trips (***Index 3***; 24" Size Limit).

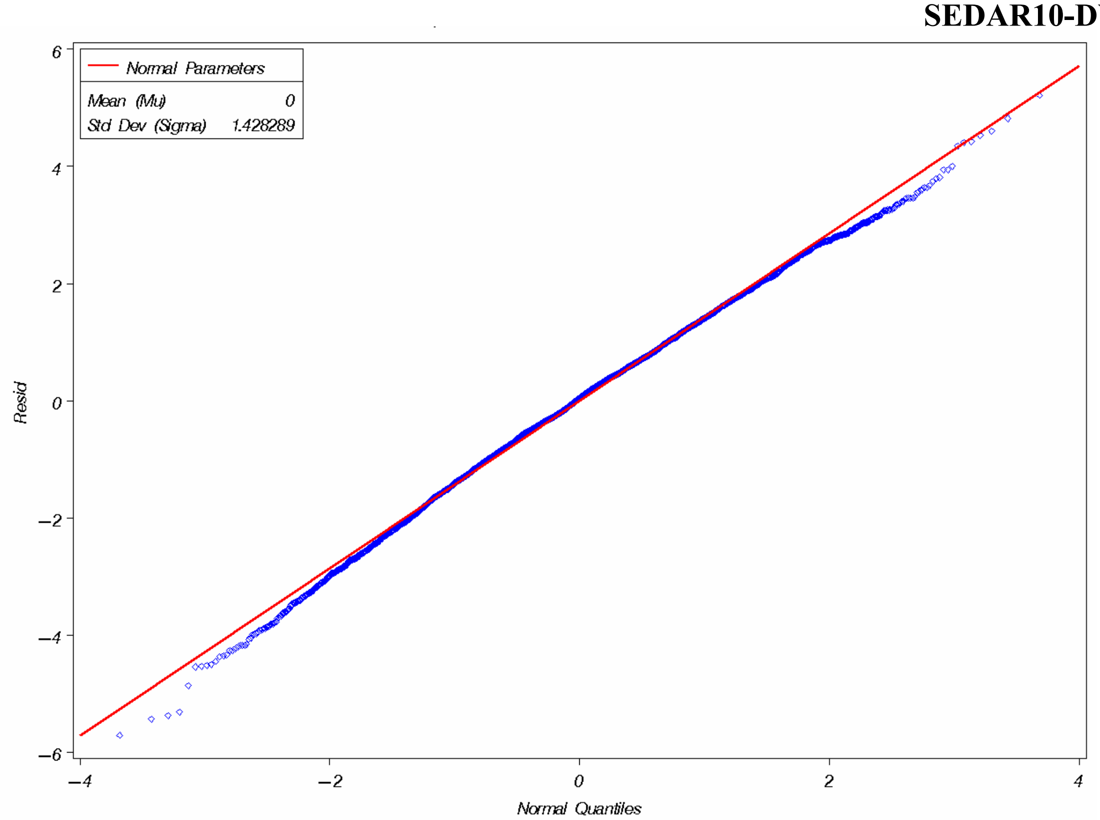

Figure 18. QQ plot of the fit of the lognormal model (***Index 3***; 24" Size Limit).

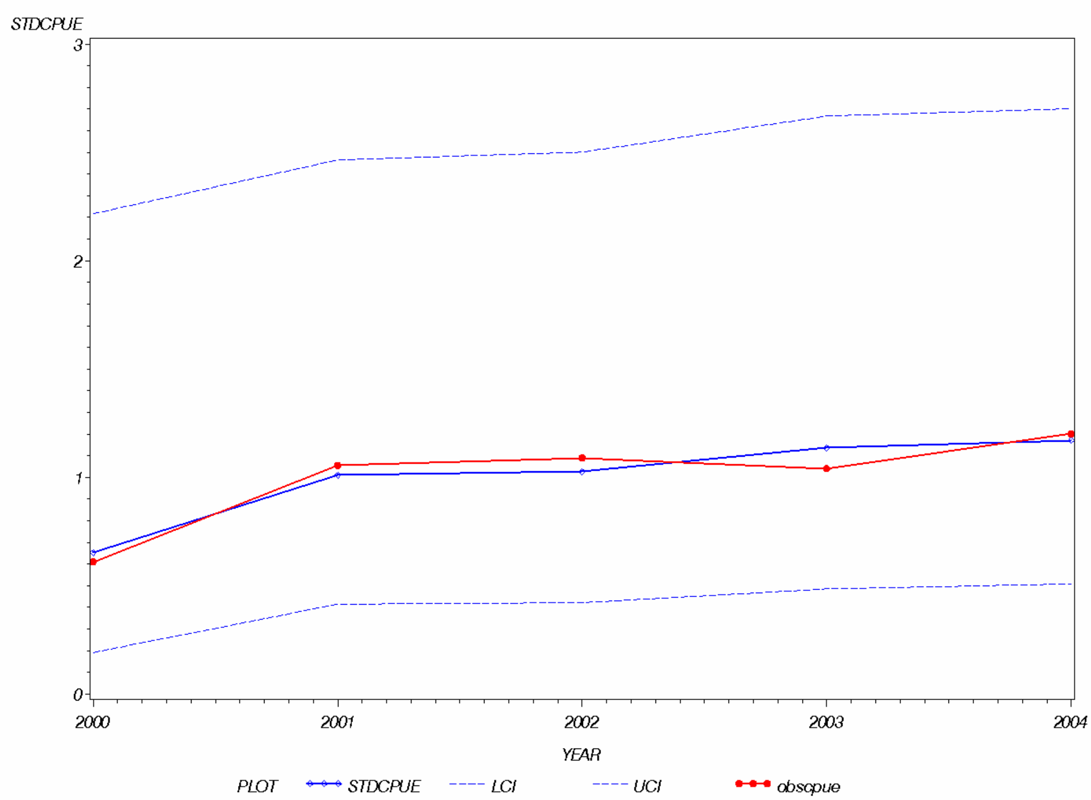

Figure 19. Relative nominal CPUE (red), relative standardized index (blue) and 95% confidence intervals (blue dotted) (***Index 3***; 24" Size Limit).

APPENDIX 1: REVISED INDICES

REVISIONS

The commercial longline indices were revised according the recommendations of the CPUE working group and the SEDAR10 Data Workshop plenary. The recommendations were as follows:

1) Include 1990-1992 in the commercial longline indices. The panel reviewed the available data, and found no conclusive reason to exclude these years.

2) The working group agreed that misreporting of gag grouper as black grouper was a problem in the Gulf of Mexico, in particular for NFMS statistical grids 3 to 11 (Fig 1). The group recognized that gag and black grouper co-occurred in the Florida Keys (NMFS grids 1 and 2) and here, misidentification of species is likely to happen. However, sufficient data are not available to correct for this problem in these particular areas. Because gag landings are low in grids 1 and 2, the group made the following recommendations:

   a) Exclude statistical grids 1 and 2
   b) Assume all black grouper reported in areas 3-11 are gag grouper
   c) Thus, equation 1 is replaced by:

$$Gag'(lbs) = Gag(lbs) + Black(lbs)$$

3) Do not include year*factor interaction terms in final GLMs.

4) Construct additional indices of abundance using the Stephens and McCall approach to subset trips based on species composition. This method is intended to restrict the dataset to trips that fished within the habitat of gag grouper.

RESULTS AND DISCUSSION

Three sets of indices are reported: Original, Revised and Revised-SpComp. The original indices were those presented to the SEDAR10-DW index working group. The "revised" indices used recommendations 1-3 (see above). The "Revised-SpComp" indices incorporated all recommendations, including the Stephens and McCall approach to subset trips based on species composition.

The revised indices are very similar to the indices presented at the data workshop (Figs A-1 and A-2). The overall trend of the indices did not change, an increase is still apparent from 1993 to 2004. However, CPUE during the early period (1990-1992) was above average. Therefore, the revised indices are U-shaped, declining until about 1994, and then increasing thereafter. The indices illustrated in Figures A-1 and A-2 are scaled to the mean of the common time intervals (Fig. A1: 1993-2004; Fig A-2: 1993-2000 and 2000-2004) to allow direct comparison of the trends. The index results are summarized in Tables A-1 and A-2. Tabulated results include the standardized CPUE (not scaled) and the relative standardized CPUE (scaled to the mean of the series).

The primary effect of the revisions was to decrease the annual coefficients of variation (CVs; Tables A-1 and A-2). This is primarily due to recommendation 4 (do not include year interaction terms). Including year*factor interactions as random effects inflates the variance estimates substantially.

The commercial longline index was recommended for use by the SEDAR10-DW index working group and plenary. Due to the high proportion of positive trips (>60% each year), it is unnecessary to subset the trips using the Stephens and McCall approach. In fact, doing so excludes a large portion of the trips that did not catch gag, causing the proportion of positive trips to exceed 83% each year. This may violate the assumptions of the delta-lognormal method, for which 20%-80% positive trips is typically recommended.

RECOMMENDATIONS FOR USE

1) The indices constructed using the Stephens and McCall procedure are not recommended due to the high proportion of positive trips (>83% each year).

2) When changes in selectivity can be accounted for in the assessment model, use the revised indices 1990-2004, without breaking the indices at the change in the minimum size limit (June 19^{th} 2000).

3) When changes in selectivity cannot be accounted for in the assessment model (e.g. VPA), consider the use of the broken indices (1990-2000 and 2000-2004). However, the working group has expressed a concern that some information regarding abundance is lost when indices are broken, particularly if abundance is changing at the discontinuity.

Table A-1. A summary of results for indices not broken at change in size limit, including: standardized CPUE, relative standardized CPUE, proportion positive trips (PPT) and index CVs.

ENTIRE TIME SERIES (NOT BROKEN AT CHANGE IN SIZE LIMIT)

	ORIGINAL					REVISED					REVISED-Species Comp				
YEAR	OBS	PPT	STD CPUE	RELATIVE STD CPUE	CV	OBS	PPT	STD CPUE	RELATIVE STD CPUE	CV	OBS	PPT	STD CPUE	RELATIVE STD CPUE	CV
1990						286	0.58	0.027	0.850	0.450	166	0.87	0.050	1.111	0.268
1991						420	0.57	0.018	0.562	0.463	233	0.85	0.030	0.667	0.315
1992						360	0.51	0.014	0.452	0.606	184	0.83	0.028	0.619	0.372
1993	1027	0.72	0.018	0.557	0.623	865	0.75	0.020	0.624	0.251	687	0.89	0.026	0.576	0.168
1994	1352	0.63	0.012	0.364	0.757	1187	0.62	0.011	0.355	0.326	806	0.84	0.018	0.411	0.200
1995	1225	0.61	0.017	0.537	0.619	1020	0.62	0.016	0.499	0.278	659	0.83	0.022	0.497	0.195
1996	1789	0.62	0.017	0.533	0.559	1472	0.65	0.019	0.586	0.208	957	0.87	0.026	0.590	0.148
1997	1798	0.65	0.018	0.565	0.542	1535	0.65	0.019	0.585	0.210	1062	0.84	0.025	0.562	0.152
1998	1656	0.70	0.030	0.907	0.422	1369	0.70	0.033	1.029	0.157	954	0.92	0.045	1.008	0.105
1999	1641	0.70	0.027	0.817	0.456	1443	0.69	0.025	0.780	0.181	1008	0.89	0.033	0.740	0.127
2000	1693	0.66	0.033	1.010	0.415	1477	0.66	0.032	1.014	0.160	932	0.90	0.046	1.025	0.114
2001	1684	0.71	0.052	1.614	0.325	1554	0.72	0.058	1.832	0.110	1096	0.93	0.074	1.652	0.081
2002	1622	0.69	0.052	1.593	0.329	1586	0.69	0.056	1.752	0.112	1061	0.92	0.074	1.637	0.083
2003	1757	0.72	0.054	1.671	0.312	1692	0.70	0.062	1.951	0.104	1141	0.95	0.085	1.901	0.071
2004	1620	0.76	0.060	1.832	0.298	1569	0.72	0.068	2.128	0.097	1134	0.93	0.090	2.002	0.072

Table A-2. A summary of results for indices broken at change in size limit, including: standardized CPUE, relative standardized CPUE, proportion positive trips (PPT) and index CVs.

INDICES BROKEN AT CHANGE IN SIZE LIMIT

	ORIGINAL					REVISED					REVISED-Species Comp				
YEAR	OBS	PPT	STD CPUE	RELATIVE STD CPUE	CV	OBS	PPT	STD CPUE	RELATIVE STD CPUE	CV	OBS	PPT	STD CPUE	RELATIVE STD CPUE	CV
1990						286	0.58	0.028	1.264	0.332	166	0.87	0.055	1.568	0.230
1991						420	0.57	0.019	0.850	0.331	233	0.85	0.034	0.970	0.242
1992						360	0.51	0.016	0.706	0.417	184	0.83	0.031	0.898	0.289
1993	1027	0.72	0.020	0.884	0.343	865	0.75	0.022	0.976	0.180	687	0.89	0.030	0.844	0.135
1994	1352	0.63	0.013	0.570	0.419	1187	0.62	0.012	0.541	0.232	806	0.84	0.021	0.587	0.159
1995	1225	0.61	0.017	0.761	0.357	1020	0.62	0.017	0.744	0.202	659	0.83	0.024	0.700	0.155
1996	1789	0.62	0.019	0.840	0.296	1472	0.65	0.020	0.878	0.154	957	0.87	0.030	0.851	0.119
1997	1798	0.65	0.019	0.855	0.282	1535	0.65	0.019	0.875	0.154	1062	0.84	0.028	0.795	0.122
1998	1656	0.70	0.032	1.437	0.213	1369	0.70	0.034	1.529	0.120	954	0.92	0.050	1.440	0.090
1999	1641	0.70	0.026	1.164	0.247	1443	0.69	0.026	1.184	0.136	1008	0.89	0.037	1.067	0.106
2000	822	0.71	0.033	1.489	0.264	622	0.72	0.032	1.454	0.170	423	0.93	0.045	1.279	0.134
2000	871	0.62	0.034	0.652	0.674	855	0.61	0.031	0.592	0.329	509	0.88	0.048	0.713	0.169
2001	1684	0.71	0.052	1.011	0.469	1554	0.72	0.054	1.046	0.154	1096	0.93	0.067	0.993	0.093
2002	1622	0.69	0.053	1.027	0.468	1586	0.69	0.052	0.994	0.161	1061	0.92	0.066	0.969	0.097
2003	1757	0.72	0.059	1.138	0.446	1692	0.70	0.058	1.114	0.148	1141	0.95	0.076	1.129	0.081
2004	1620	0.76	0.061	1.172	0.437	1569	0.72	0.065	1.254	0.134	1134	0.93	0.081	1.197	0.083

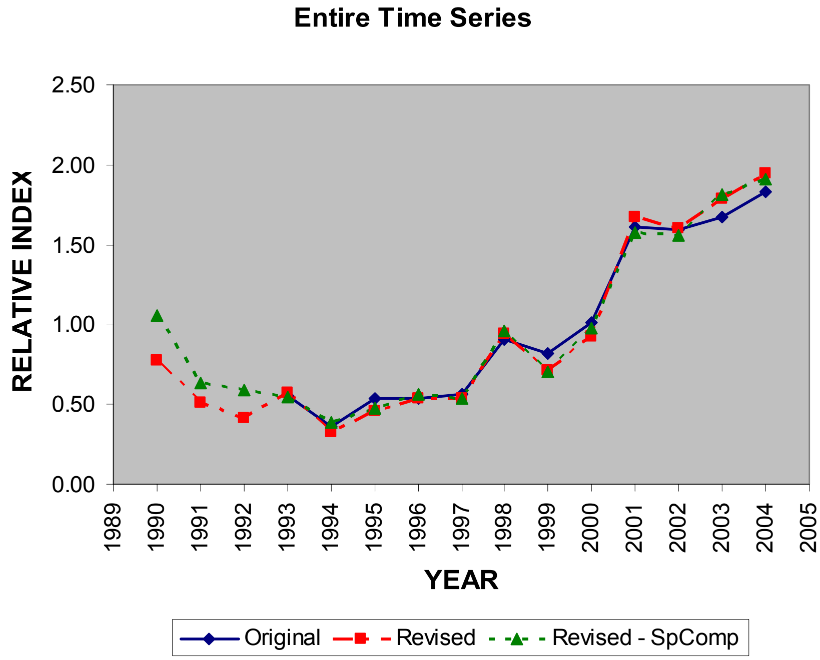

Figure A-1. Indices of abundance for the entire time series (not broken at change in minimum size limit). All indices are scaled to a common time period (1993-2004) to make them directly comparable.

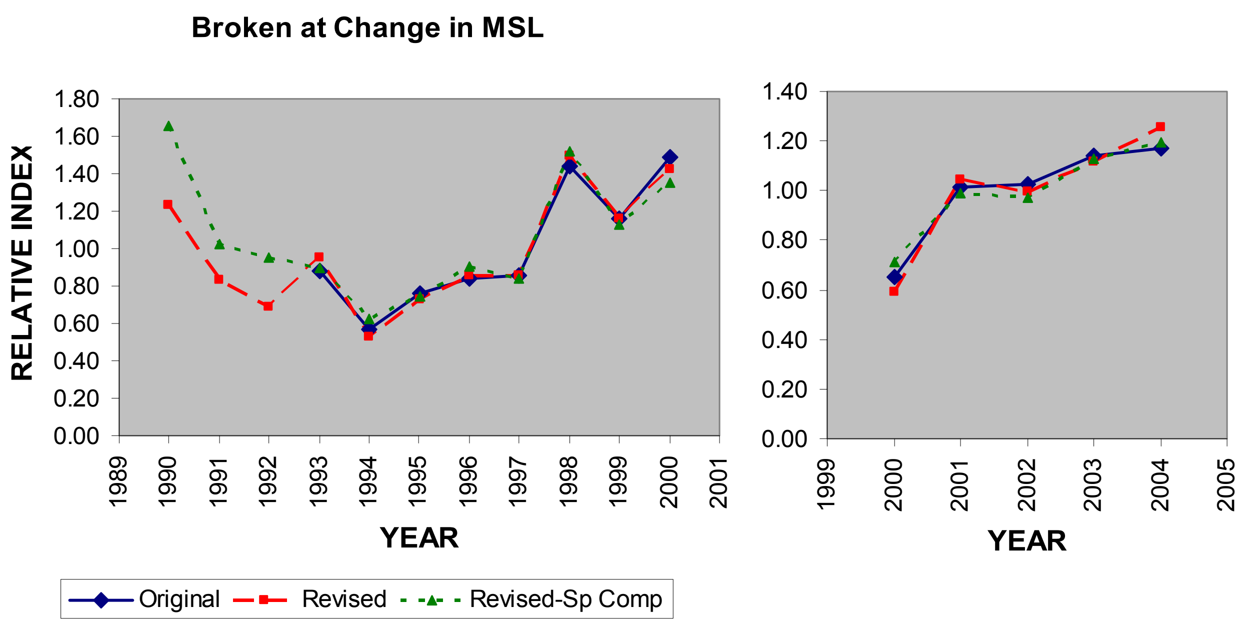

Figure A-2. Indices of abundance for indices broken at change in minimum size limit. All indices are scaled to common time periods (1993-2000 and 2000-2004)) to make them directly comparable.