STANDARDIZED CATCH RATES OF GAG,
MYCTEROPERCA MICROLEPIS, FROM THE
UNITED STATES HEADBOAT FISHERY
IN THE GULF OF MEXICO DURING 1986-2004

Craig A. Brown

NOAA Fisheries, Southeast Fisheries Center, Sustainable Fisheries Division
75 Virginia Beach Drive, Miami, FL, 33149-1099, USA

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 gag (*Mycteroperca microlepis*) were developed in Brown (2001) for potential use in an assessment of gag stock status. The available catch per unit effort (CPUE) series, from 1986 - 2004, is used here to develop new abundance indices for gag.

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 gag catches (1986-2004) is shown in **Figure 1**, with each symbol scaled to reflect the average catch rate at that location. Based upon the distribution of 1986-1999 data, three zones having relatively high catch rates were defined by Brown (2001). For continuity, these same zone definitions were maintained for the current study. The analysis was restricted to data from these three zones, since the expectation of catching gag on a given trip was markedly higher from within those zones throughout the study period and there was concern

regarding an apparently higher incidence of species misidentification south of these zones (between gag and black grouper). 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 gag 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 gag in the catch and to select trips with such a species composition. The list of species examined and the correlations with gag are shown in **Table 1**, by zone. This approach was taken in lieu of defining a sub-fleet of gag-targeting vessels, as was done by Brown (2001), and resulted in a greater number of vessels as well as total observations in the analysis data set. The annual nominal catch rates are somewhat higher applying the new approach, which suggest that the species composition information is more informative in identifying trips likely to catch gag, although the trends appear largely unaffected (**Figure 2**).

It was noted that black grouper (*Mycteroperca microlepis*) appear in the data at greater frequencies than expected (about 8% of the total of gag + black grouper), considering that black grouper are regarded as rare relative to gag in the study area. Although there has been some evidence of species identification confusion between gag and black grouper in logbooks from other fisheries, the degree to which such species misidentification may or may not occur in the Headboat Survey data could not be determined with the available data. For most years, the potential impact of such identification problems is expected to be small, as evidenced by the comparison shown in **Figure 3**. The nominal catch rate trend for gag from the analysis data set is compared to the nominal catch rate trend which would be calculated if all black grouper were treated as gag for both the species composition analysis and the calculations of the catch rates.

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 20 inches total length (TL) was implemented on February 21, 1990, followed by an increase in the minimum size limit to 22 inches TL on June 19, 2000 (**Table 2**). During 1986-1989 (before implementation of the first minimum size regulation), about 40% of the landed catch was less than the 20 inch TL minimum size limit. During the following 4 year period (1991-1994), that fraction dropped to 9% of the catch less than the minimum size. A similar difference could be seen following the change to the new minimum size limit of 22 inches TL in 2000. About 47% of the landed catch was less than the new recreational minimum size limit of 22 inches TL during the prior 4 years (1996-1999); during 2001-2004 the proportion less than the new minimum size dropped to 16% of the catch.

Clearly, the minimum size limits were having an impact on the number of fish being landed from the overall catch. Since only kept fish were recorded, catch rates across the entire time period are not comparable. As a result, the catch rate data were analyzed separately for each of three time periods: 1986-Feb 21 1990, Feb 22 1990-June 19 2000, and June 20 2000-2004. Any potential impact of changing bag limits should be largely addressed by this same split.

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).

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 analyses of Brown (2001) used 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 hours fished as an offset term. For the present analyses, following recommendations of the SEDAR data workshop in preparation for the 2006 stock assessment of gag, the delta-lognormal model approach was used for consistency among current standardization analyses.

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 one at a time at each step, until no factor met the criteria for incorporation into the final model. Factor interaction effects were investigated in similar fashion, with the requirement that each factor in the interaction must be included in the less complex model from which a reduction in deviance per degree of freedom was calculated. In other words, factors were included in the model if not already present, a new deviance per degree of freedom calculated, and then the model was run with the interaction term included to isolate the effect of the interaction term itself.

Following recommendations of the SEDAR data workshop, no year interaction effects were investigated.

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 early period model (1986-1990) is shown in **Table 3** for the proportion positive analysis and in **Table 4** for the positive catch rate analysis. The construction of the middle period model (1990-2000) is shown in **Tables 5** and **6**. The stepwise construction of the late period model (2000-2004) is shown in **Table 7** for the proportion positive analysis and in **Table 8** for the positive catch rate analysis.

A model was also constructed for the entire period 1986 – 2004, for use with assessment models which could allow selectivity to vary when the size limits changed. The stepwise construction of the entire period model (1986-2004) is shown in **Table 9** for the proportion positive analysis and in **Table 10** for the positive catch rate analysis.

Diagnostic plots for the various models are shown in **Figures 4–7**. The index values for the different periods are shown in **Table 11** and in **Figures 8-11**.

Literature Cited

Brown, C.A., S.C. Turner and M. Ortiz. 1999. Standardized catch rates of large (> 195 cm) and large medium (178-195 cm) bluefin tuna, *Thunnus thynnus,* from the rod and reel/handline fishery off the northeast United States during 1983-1997. Int. Comm. Conserv. Atl. Tunas, Col. Vol. Sci. Pap. 49(2): 347-359.

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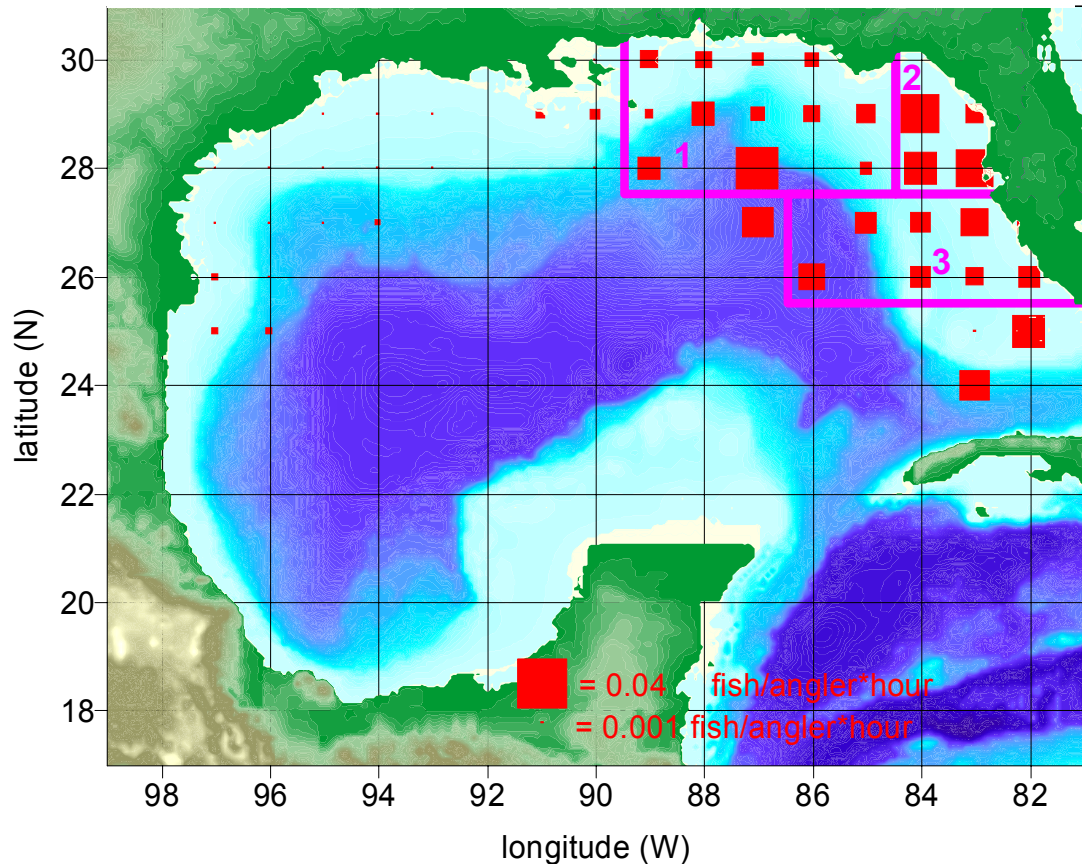
FIGURE 1: The geographic distribution of gag catches (1986-2004). Each symbol is scaled to reflect the average catch rate within that 1 by 1 square. Catch rates from locations for which total effort is below 1500 angler*hours are not shown. Zones 1-3, as defined by Brown (2001) and used for the current study are shown.

TABLE 1a: Species degree of association with gag within Zone 1, calculated using the method of Stephens and MacCall (2004). Higher, positive correlations indicate stronger associations with gag; lower, negative values are less likely to occur on the same trips as gag.

ZONE 1

Species	Common Name	Correlation
EPINEPHELUS MORIO	RED GROUPER	1.0484
PARALICHTHYS ALBIGUTTA	GULF FLOUNDER	0.7643
CENTROPRISTIS PHILADELPHICUS	ROCK SEA BASS	0.6663
LUTJANUS CAMPECHANUS	RED SNAPPER	0.6498
MYCTEROPERCA PHENAX	SCAMP	0.5120
BOTHIDAE	FLOUNDER, UNIDENTIFIED	0.4749
CALAMUS CALAMUS	SAUCEREYE PORGY	0.4475
SERIOLA ZONATA	BANDED RUDDERFISH	0.4017
EPINEPHELUS DRUMMONDHAYI	SPECKLED HIND	0.3554
BALISTES CAPRISCUS	GRAY TRIGGERFISH	0.2675
THUNNUS ATLANTICUS	BLACKFIN TUNA	0.2569
SERIOLA DUMMERILI	GREATER AMBERJACK	0.2550
CARCHARHINUS LIMBATUS	BLACKTIP SHARK	0.2520
CALAMUS NODOSUS	KNOBBED PORGY	0.2047
POMATOMUS SALTATRIX	BLUEFISH	0.1976
PAGRUS PAGRUS	RED PORGY	0.1555
EPINEPHELUS NIVEATUS	SNOWY GROUPER	0.1545
EPINEPHELUS ADSCENSIONIS	ROCK HIND	0.1507
CALAMUS LEUCOSTEUS	WHITEBONE PORGY	0.1327
HAEMULON PLUMIERI	WHITE GRUNT	0.1252
SCOMBEROMORUS MACULATUS	SPANISH MACKEREL	0.0862
SCOMBEROMORUS CAVALLA	KING MACKEREL	0.0806
ORTHOPRISTIS CHRYSOPTERA	PIGFISH	0.0773
EUTHYNNUS ALLETTERATUS	LITTLE TUNNY	0.0609
CENTROPRISTIS STRIATUS	BLACK SEA BASS	0.0579
PRIACANTHUS ARENATUS	BIGEYE	0.0470
LUTJANUS SYNAGRIS	LANE SNAPPER	0.0416
LAGODON RHOMBOIDES	PINFISH	0.0347
PRISTIGENYS ALTA	SHORT BIGEYE	−0.0072
CORYPHAENA HIPPURUS	DOLPHIN	−0.0171
RHOMBOPLITES AURORUBENS	VERMILION SNAPPER	−0.0525
SERIOLA RIVOLIANA	ALMACO JACK	−0.1197
RACHYCENTRON CANADUM	COBIA	−0.1236
SYACIUM PAPILLOSUM	DUSKY FLOUNDER	−0.1342
DIPLECTRUM FORMOSUM	SAND PERCH	−0.3251
PARALICHTHYS DENTATUS	SUMMER FLOUNDER	−0.3320
CARANX CRYSOS	BLUE RUNNER	−0.4804
CENTROPRISTIS OCYURUS	BANK SEA BASS	−0.4940
HAEMULON AUROLINEATUM	TOMTATE	−0.5200
SCIAENOPS OCELLATUS	RED DRUM	−0.8101
CYNOSCION ARENARIUS	SAND SEATROUT	−0.8809
CHAETODIPTERUS FABER	ATLANTIC SPADEFISH	−0.9287

TABLE 1b: Species degree of association with gag within Zone 3, calculated using the method of Stephens and MacCall (2004).   Higher, positive correlations indicate stronger associations with gag; lower, negative values are less likely to occur on the same trips as gag.

ZONE 3

Species	Common Name	Correlation
EPINEPHELUS MORIO	RED GROUPER	1.3332
LANCHNOLAIMUS MAXIMUS	HOGFISH	1.2786
EPINEPHELUS ADSCENSIONIS	ROCK HIND	1.1692
LUTJANUS CAMPECHANUS	RED SNAPPER	0.9432
LUTJANUS GRISEUS	GRAY SNAPPER	0.8594
SERIOLA DUMMERILI	GREATER AMBERJACK	0.8120
CALAMUS CALAMUS	SAUCEREYE PORGY	0.7925
CALAMUS LEUCOSTEUS	WHITEBONE PORGY	0.7347
HOLOCENTRUS ASCENSIONIS	SQUIRRELFISH	0.7120
EPINEPHELUS CRUENTATUS	GRAYSBY	0.7053
RACHYCENTRON CANADUM	COBIA	0.6873
DIPLODUS HOLBROOKI	SPOTTAIL PINFISH	0.6862
PAGRUS PAGRUS	RED PORGY	0.5541
HAEMULON PLUMIERI	WHITE GRUNT	0.5474
EUTHYNNUS ALLETTERATUS	LITTLE TUNNY	0.5338
HAEMULON FLAVOLINEATUM	FRENCH GRUNT	0.4849
SERIOLA ZONATA	BANDED RUDDERFISH	0.3809
BALISTES CAPRISCUS	GRAY TRIGGERFISH	0.3661
SCOMBEROMORUS MACULATUS	SPANISH MACKEREL	0.1859
CENTROPRISTIS STRIATUS	BLACK SEA BASS	0.1371
MYCTEROPERCA PHENAX	SCAMP	0.1045
SERIOLA RIVOLIANA	ALMACO JACK	-0.0260
CALAMUS BAJONADO	JOLTHEAD PORGY	-0.0342
SCOMBEROMORUS CAVALLA	KING MACKEREL	-0.0977
OCYURUS CHRYSURUS	YELLOWTAIL SNAPPER	-0.1334
CALAMUS NODOSUS	KNOBBED PORGY	-0.1867
CALAMUS PENNA	SHEEPSHEAD PORGY	-0.3708
HAEMULON ALBUM	MARGATE	-0.4743
CARANX CRYSOS	BLUE RUNNER	-0.4885
ORTHOPRISTIS CHRYSOPTERA	PIGFISH	-0.4953
CALAMUS PRORIDENS	LITTLEHEAD PORGY	-0.5122
DIPLECTRUM FORMOSUM	SAND PERCH	-0.7538
RHOMBOPLITES AURORUBENS	VERMILION SNAPPER	-0.8723
HAEMULON AUROLINEATUM	TOMTATE	-0.8782
CALAMUS ARCTIFRONS	GRASS PORGY	-1.3121
LUTJANUS SYNAGRIS	LANE SNAPPER	-1.7635
MYCTEROPERCA BONACI	BLACK GROUPER	-4.1210

TABLE 1c: Species degree of association with gag within Zone 3, calculated using the method of Stephens and MacCall (2004).   Higher, positive correlations indicate stronger associations with gag; lower, negative values are less likely to occur on the same trips as gag.

ZONE 3

Species	Common Name	Correlation
EPINEPHELUS MORIO	RED GROUPER	1.1171
LUTJANUS GRISEUS	GRAY SNAPPER	0.7807
CALAMUS BAJONADO	JOLTHEAD PORGY	0.6357
MYCTEROPERCA PHENAX	SCAMP	0.5589
PARALICHTHYS DENTATUS	SUMMER FLOUNDER	0.5044
BALISTES CAPRISCUS	GRAY TRIGGERFISH	0.4820
HOLOCENTRUS ASCENSIONIS	SQUIRRELFISH	0.3602
CALAMUS PRORIDENS	LITTLEHEAD PORGY	0.3582
SERIOLA DUMMERILI	GREATER AMBERJACK	0.3480
RACHYCENTRON CANADUM	COBIA	0.3438
ELAGATIS BIPINNULATUS	RAINBOW RUNNER	0.3298
EUTHYNNUS ALLETTERATUS	LITTLE TUNNY	0.2910
SCOMBEROMORUS MACULATUS	SPANISH MACKEREL	0.2905
CALAMUS PENNA	SHEEPSHEAD PORGY	0.2716
DIPLODUS HOLBROOKI	SPOTTAIL PINFISH	0.2351
SERIOLA ZONATA	BANDED RUDDERFISH	0.1653
CENTROPRISTIS STRIATUS	BLACK SEA BASS	0.1042
PAGRUS PAGRUS	RED PORGY	0.0365
SCOMBEROMORUS CAVALLA	KING MACKEREL	0.0242
HAEMULON PLUMIERI	WHITE GRUNT	-0.0263
OCYURUS CHRYSURUS	YELLOWTAIL SNAPPER	-0.0331
CALAMUS NODOSUS	KNOBBED PORGY	-0.0557
CALAMUS ARCTIFRONS	GRASS PORGY	-0.1426
ORTHOPRISTIS CHRYSOPTERA	PIGFISH	-0.2084
HAEMULON FLAVOLINEATUM	FRENCH GRUNT	-0.2323
CARANX CRYSOS	BLUE RUNNER	-0.4250
DIPLECTRUM FORMOSUM	SAND PERCH	-0.4692
LUTJANUS SYNAGRIS	LANE SNAPPER	-0.5259
LAGODON RHOMBOIDES	PINFISH	-0.5314
RHOMBOPLITES AURORUBENS	VERMILION SNAPPER	-0.7402
HAEMULON AUROLINEATUM	TOMTATE	-0.7614
MYCTEROPERCA BONACI	BLACK GROUPER	-2.8097
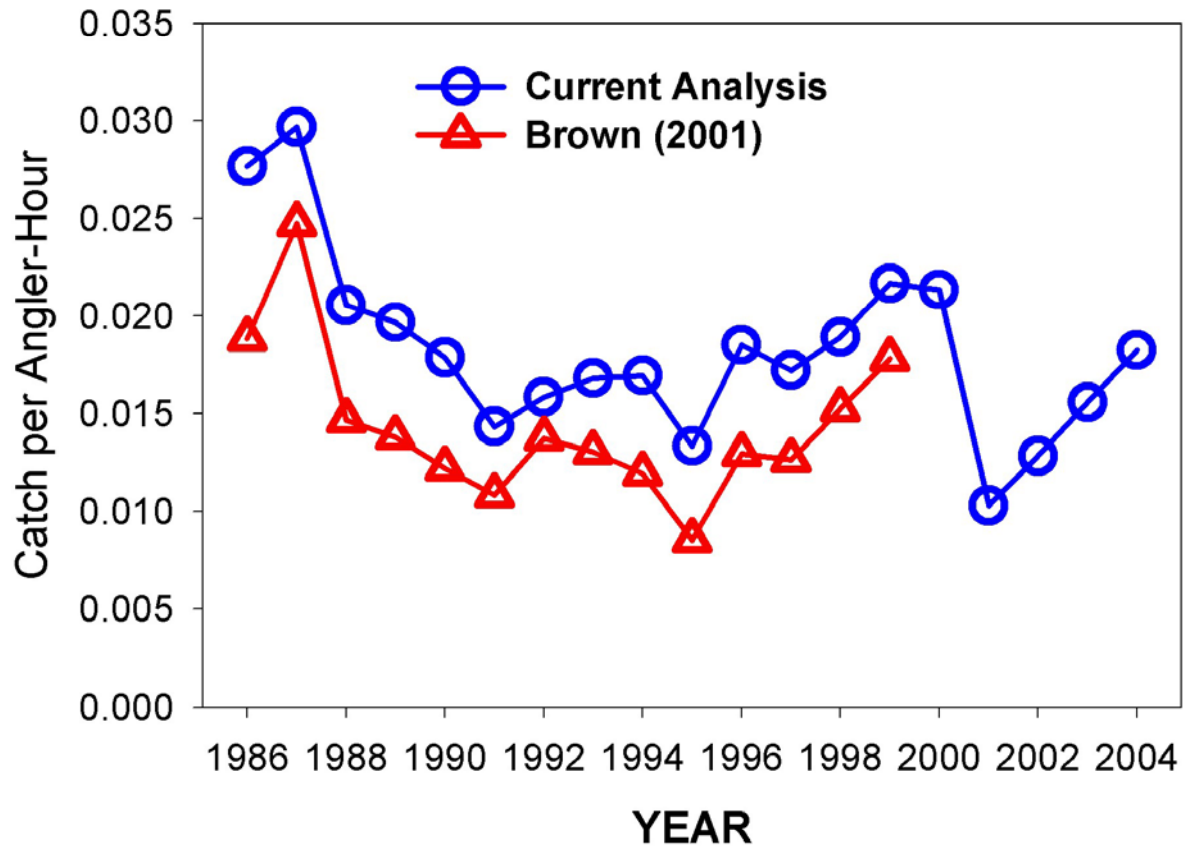
Figure 2: Comparison of nominal gag catch rate trends between the data set used in Brown (2001), wherein data were restricted to vessels identified as consistently targeting gag, and the current analysis, wherein the data were restricted to trips defined by catch species composition to be likely to encounter gag.
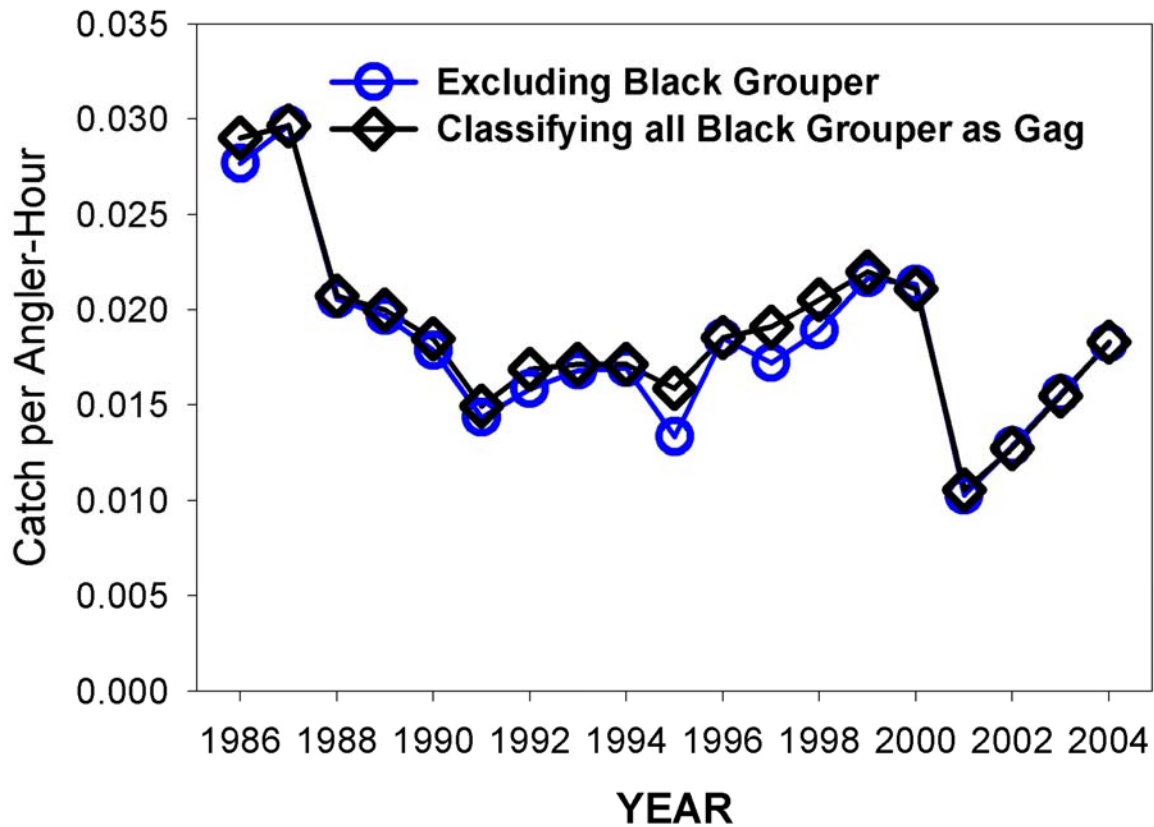
Figure 3: Comparison of nominal gag catch rate trends between data sets wherein catch rates were calculated using the catch in number of gag as reported in the Headboat Survey database (Current Analysis) or by assuming the extreme case that all reported black grouper were actually gag. In each case, the Stephens and McCall (2004) species composition approach was applied under those assumptions.

TABLE 2. 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 3: Results of the stepwise procedure to develop the proportion positive catch rate model for the indices 1986-1989.

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************************************************************************************************
There are no explanatory factors in the base model.
FACTOR                    DEGF  DEVIANCE   DEV/DF   %REDUCTION    LOGLIKE      CHISQ   PROBCHISQ
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BASE                      7080    8938.6    1.2625                 -4469.3

TRIPCAT                   7078    8634.3    1.2199        3.38     -4317.2     304.22    0.00000
MONTH                     7069    8754.4    1.2384        1.91     -4377.2     184.19    0.00000
SEASON                    7077    8816.7    1.2458        1.32     -4408.3     121.90    0.00000
YEAR                      7077    8822.4    1.2466        1.26     -4411.2     116.15    0.00000
AREA                      7078    8836.9    1.2485        1.11     -4418.5     101.63    0.00000
ZONE                      7078    8873.6    1.2537        0.70     -4436.8      64.93    0.00000
DAYNIGHT                  7078    8924.7    1.2609        0.13     -4462.3      13.91    0.00096
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************************************************************************************************
The explanatory factors in the base model are:  TRIPCAT

FACTOR                    DEGF  DEVIANCE   DEV/DF   %REDUCTION    LOGLIKE      CHISQ   PROBCHISQ
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BASE                      7078    8634.3    1.2199                 -4317.2

MONTH                     7067    8439.8    1.1943        2.10     -4219.9     194.55    0.00000
ZONE                      7076    8457.8    1.1953        2.02     -4228.9     176.58    0.00000
AREA                      7076    8462.6    1.1960        1.96     -4231.3     171.75    0.00000
DAYNIGHT                  7076    8498.6    1.2011        1.54     -4249.3     135.70    0.00000
SEASON                    7075    8504.3    1.2020        1.46     -4252.2     130.01    0.00000
YEAR                      7075    8536.2    1.2065        1.09     -4268.1      98.16    0.00000
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************************************************************************************************
The explanatory factors in the base model are:  TRIPCAT MONTH

FACTOR                    DEGF  DEVIANCE   DEV/DF   %REDUCTION    LOGLIKE      CHISQ   PROBCHISQ
------------------------- ------ --------- --------- ------------ ----------- ----------- -----------

BASE                      7067    8439.8    1.1943                 -4219.9

DAYNIGHT                  7065    8312.7    1.1766        1.48     -4156.4     127.09    0.00000
ZONE                      7065    8328.8    1.1789        1.29     -4164.4     110.96    0.00000
AREA                      7065    8334.8    1.1797        1.22     -4167.4     104.98    0.00000
YEAR                      7064    8346.1    1.1815        1.07     -4173.0      93.71    0.00000
SEASON                    7067    8439.8    1.1943        0.00     -4219.9       0.00       .
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TABLE 3(cont.): Results of the stepwise procedure to develop the proportion positive catch rate model for the indices 1986-1989.

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The explanatory factors in the base model are:  TRIPCAT MONTH DAYNIGHT
FACTOR                       DEGF  DEVIANCE   DEV/DF   %REDUCTION   LOGLIKE       CHISQ   PROBCHISQ
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BASE                         7065   8312.7   1.1766                 -4156.4

ZONE                         7063   8187.1   1.1592         1.48    -4093.5      125.62    0.00000
AREA                         7063   8190.8   1.1597         1.44    -4095.4      121.88    0.00000
YEAR                         7062   8255.4   1.1690         0.65    -4127.7       57.27    0.00000
SEASON                       7065   8312.7   1.1766         0.00    -4156.4        0.00       .
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The explanatory factors in the base model are:  TRIPCAT MONTH DAYNIGHT ZONE
FACTOR                       DEGF  DEVIANCE   DEV/DF   %REDUCTION   LOGLIKE       CHISQ   PROBCHISQ
-------------------------    ----- --------  -------  ------------ -----------  ----------  -----------
BASE                         7063   8187.1   1.1592                 -4093.5

YEAR                         7060   8126.1   1.1510         0.70    -4063.1       60.97    0.00000
AREA                         7061   8181.9   1.1587         0.03    -4091.0        5.17    0.07530
SEASON                       7063   8187.1   1.1592         0.00    -4093.5        0.00       .
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The explanatory factors in the base model are:  TRIPCAT MONTH DAYNIGHT ZONE YEAR
FACTOR                       DEGF  DEVIANCE   DEV/DF   %REDUCTION   LOGLIKE       CHISQ   PROBCHISQ
-------------------------    ----- --------  -------  ------------ -----------  ----------  -----------
BASE                         7060   8126.1   1.1510                 -4063.1

AREA                         7058   8120.3   1.1505         0.04    -4060.1        5.84    0.05403
SEASON                       7060   8126.1   1.1510         0.00    -4063.1        0.00       .
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The explanatory factors in the base model are:  TRIPCAT MONTH DAYNIGHT ZONE YEAR
FACTOR                       DEGF  DEVIANCE   DEV/DF   %REDUCTION   LOGLIKE       CHISQ   PROBCHISQ
-------------------------    ----- --------  -------  ------------ -----------  ----------  -----------
BASE                         7060   8126.1   1.1510                 -4063.1

TRIPCAT*ZONE                 7056   7973.5   1.1300         1.82    -3986.8      152.61    0.00000
MONTH*ZONE                   7039   8058.0   1.1448         0.54    -4029.0       68.15    0.00000
TRIPCAT*MONTH                7038   8059.2   1.1451         0.51    -4029.6       60.97    0.00000
MONTH*DAYNIGHT               7041   8092.2   1.1493         0.15    -4046.1      152.61    0.00000
DAYNIGHT*ZONE                7056   8117.0   1.1504         0.06    -4058.5        9.16    0.05728
TRIPCAT*DAYNIGHT             7059   8125.8   1.1511        -0.01    -4062.9        0.34    0.55734
TRIPCAT*DAYNIGHT             7059   8125.8   1.1511        -0.01    -4062.9        0.34    0.55734
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*******************************************************************************
The explanatory factors in the base model are:  TRIPCAT MONTH DAYNIGHT ZONE YEAR TRIPCAT*ZONE
FACTOR                       DEGF  DEVIANCE   DEV/DF   %REDUCTION   LOGLIKE       CHISQ   PROBCHISQ
-------------------------    ----- --------  -------  ------------ -----------  ----------  -----------
BASE                         7056   7973.5   1.1300                 -3986.8

DAYNIGHT*ZONE                7052   7916.9   1.1226         0.65    -3958.4       56.64    0.00000
TRIPCAT*MONTH                7034   7904.8   1.1238         0.55    -3952.4      152.61    0.00000
MONTH*ZONE                   7035   7919.4   1.1257         0.38    -3959.7        0.32    0.57160
MONTH*DAYNIGHT               7037   7934.1   1.1275         0.23    -3967.0        0.32    0.57160
TRIPCAT*DAYNIGHT             7055   7973.2   1.1301        -0.01    -3986.6        0.32    0.57160
TRIPCAT*DAYNIGHT             7055   7973.2   1.1301        -0.01    -3986.6        0.32    0.57160
*******************************************************************************
```

FINAL MODEL: TRIPCAT+MONTH+DAYNIGHT+ZONE+YEAR+TRIPCAT*ZONE

TABLE 4: Results of the stepwise procedure to develop the positive catch rate model for the indices 1986-1989.

```
************************************************************************************
There are no explanatory factors in the base model.
FACTOR                    DEGF  DEVIANCE   DEV/DF   %REDUCTION    LOGLIKE     CHISQ    PROBCHISQ
------------------------- ----- --------- --------- ------------ ----------- ----------- -----------
BASE                      4773   5894.4    1.2349                 -7277.2
ZONE                      4771   5026.1    1.0535      14.70      -6896.8     760.80     0.00000
AREA                      4771   5100.2    1.0690      13.44      -6931.8     690.91     0.00000
MONTH                     4762   5497.7    1.1545       6.51      -7110.9     332.62     0.00000
SEASON                    4770   5600.5    1.1741       4.93      -7155.2     244.14     0.00000
TRIPCAT                   4771   5819.4    1.2197       1.23      -7246.7      61.11     0.00000
DAYNIGHT                  4771   5843.0    1.2247       0.83      -7256.3      41.75     0.00000
YEAR                      4770   5853.7    1.2272       0.63      -7260.7      33.02     0.00000
************************************************************************************


************************************************************************************
The explanatory factors in the base model are:  ZONE
FACTOR                    DEGF  DEVIANCE   DEV/DF   %REDUCTION    LOGLIKE     CHISQ    PROBCHISQ
------------------------- ----- --------- --------- ------------ ----------- ----------- -----------
BASE                      4771   5026.1    1.0535                 -6896.8
MONTH                     4760   4822.5    1.0131       3.83      -6798.1     197.39     0.00000
SEASON                    4768   4885.4    1.0246       2.74      -6829.1     135.53     0.00000
DAYNIGHT                  4769   4996.6    1.0477       0.55      -6882.8      28.10     0.00000
YEAR                      4768   5005.0    1.0497       0.36      -6886.8      20.07     0.00016
AREA                      4769   5023.0    1.0533       0.02      -6895.4       2.89     0.23633
TRIPCAT                   4769   5023.8    1.0534       0.00      -6895.8       2.10     0.34911
************************************************************************************


************************************************************************************
The explanatory factors in the base model are:  ZONE MONTH
FACTOR                    DEGF  DEVIANCE   DEV/DF   %REDUCTION    LOGLIKE     CHISQ    PROBCHISQ
------------------------- ----- --------- --------- ------------ ----------- ----------- -----------
BASE                      4760   4822.5    1.0131                 -6798.1
DAYNIGHT                  4758   4781.0    1.0048       0.82      -6777.5      41.28     0.00000
YEAR                      4757   4793.8    1.0077       0.53      -6783.9      28.45     0.00000
AREA                      4758   4820.1    1.0130       0.01      -6796.9       2.40     0.30096
SEASON                    4760   4822.5    1.0131       0.00      -6798.1       0.00       .
TRIPCAT                   4758   4820.6    1.0132      -0.00      -6797.2       1.83     0.40049
************************************************************************************


************************************************************************************
The explanatory factors in the base model are:  ZONE MONTH YEAR
FACTOR                    DEGF  DEVIANCE   DEV/DF   %REDUCTION    LOGLIKE     CHISQ    PROBCHISQ
------------------------- ----- --------- --------- ------------ ----------- ----------- -----------
BASE                      4757   4793.8    1.0077                 -6783.9
DAYNIGHT                  4755   4759.9    1.0010       0.67      -6766.9      33.95     0.00000
AREA                      4755   4791.7    1.0077       0.00      -6782.8       2.12     0.34591
SEASON                    4757   4793.8    1.0077       0.00      -6783.9       0.00       .
TRIPCAT                   4755   4792.3    1.0078      -0.01      -6783.1       1.56     0.45845
************************************************************************************


************************************************************************************
The explanatory factors in the base model are:  ZONE MONTH YEAR
FACTOR                    DEGF  DEVIANCE   DEV/DF   %REDUCTION    LOGLIKE     CHISQ    PROBCHISQ
------------------------- ----- --------- --------- ------------ ----------- ----------- -----------
BASE                      4757   4793.8    1.0077                 -6783.9
ZONE*TRIPCAT              4751   4746.0    0.9989       0.87      -6759.9      47.91     0.00000
MONTH*DAYNIGHT            4736   4737.7    1.0004       0.73      -6755.8      56.26     0.00005
ZONE*DAYNIGHT            4751   4753.3    1.0005       0.72      -6763.7      40.49     0.00000
ZONE*MONTH               4737   4747.5    1.0022       0.55      -6760.7      46.41     0.00071
MONTH*TRIPCAT            4733   4753.1    1.0042       0.35      -6763.5      40.73     0.01784
************************************************************************************
```

FINAL MODEL: ZONE + MONTH + YEAR

TABLE 5: Results of the stepwise procedure to develop the proportion positive catch rate model for the indices 1990-2000.

```
************************************************************************************************
There are no explanatory factors in the base model.

FACTOR                     DEGF  DEVIANCE   DEV/DF   %REDUCTION    LOGLIKE      CHISQ   PROBCHISQ
------------------------- ------ --------  --------  -----------  ----------- ----------- -----------

BASE                      23524   31534.4   1.3405                 -15767.2

TRIPCAT                   23522   29185.0   1.2408        7.44     -14592.5    2349.34    0.00000
MONTH                     23513   30989.7   1.3180        1.68     -15494.9     544.65    0.00000
YEAR                      23514   31085.6   1.3220        1.38     -15542.8     448.77    0.00000
AREA                      23522   31112.8   1.3227        1.33     -15556.4     421.61    0.00000
TOURNAMENT                23522   31112.8   1.3227        1.33     -15556.4     421.61    0.00000
SEASON                    23521   31180.4   1.3256        1.11     -15590.2     353.97    0.00000
ZONE                      23522   31247.5   1.3284        0.90     -15623.7     286.91    0.00000
DAYNIGHT                  23522   31530.9   1.3405        0.00     -15765.5       3.43    0.17970
************************************************************************************************



************************************************************************************************
The explanatory factors in the base model are:  TRIPCAT

FACTOR                     DEGF  DEVIANCE   DEV/DF   %REDUCTION    LOGLIKE      CHISQ   PROBCHISQ
------------------------- ------ --------  --------  -----------  ----------- ----------- -----------

BASE                      23522   29185.0   1.2408                 -14592.5

DAYNIGHT                  23520   28559.5   1.2143        2.13     -14279.8     625.51    0.00000
MONTH                     23511   28560.8   1.2148        2.09     -14280.4     624.23    0.00000
ZONE                      23520   28685.7   1.2196        1.70     -14342.9     499.30    0.00000
AREA                      23520   28795.0   1.2243        1.33     -14397.5     389.99    0.00000
TOURNAMENT                23520   28795.0   1.2243        1.33     -14397.5     389.99    0.00000
SEASON                    23519   28795.2   1.2243        1.32     -14397.6     389.79    0.00000
YEAR                      23512   28791.3   1.2245        1.31     -14395.7     393.72    0.00000
************************************************************************************************



************************************************************************************************
The explanatory factors in the base model are:  TRIPCAT DAYNIGHT

FACTOR                     DEGF  DEVIANCE   DEV/DF   %REDUCTION    LOGLIKE      CHISQ   PROBCHISQ
------------------------- ------ --------  --------  -----------  ----------- ----------- -----------

BASE                      23520   28559.5   1.2143                 -14279.8

MONTH                     23509   27875.7   1.1857        2.35     -13937.9     683.81    0.00000
ZONE                      23518   28102.3   1.1949        1.59     -14051.2     457.22    0.00000
SEASON                    23517   28124.1   1.1959        1.51     -14062.1     435.40    0.00000
YEAR                      23510   28169.5   1.1982        1.32     -14084.7     390.07    0.00000
AREA                      23518   28185.6   1.1985        1.30     -14092.8     373.92    0.00000
TOURNAMENT                23518   28185.6   1.1985        1.30     -14092.8     373.92    0.00000
************************************************************************************************
```

TABLE 5 (cont.): Results of the stepwise procedure to develop the proportion positive catch rate model for the indices 1990-2000.

```
********************************************************************************
The explanatory factors in the base model are:  TRIPCAT DAYNIGHT MONTH

FACTOR                    DEGF  DEVIANCE   DEV/DF   %REDUCTION    LOGLIKE     CHISQ  PROBCHISQ
------------------------- ------ --------- --------- ------------ ----------- ----------- -----------
BASE                      23509  27875.7   1.1857                 -13937.9

YEAR                      23499  27415.3   1.1667         1.61    -13707.6    460.44   0.00000
ZONE                      23507  27637.0   1.1757         0.85    -13818.5    238.73   0.00000
AREA                      23507  27688.9   1.1779         0.66    -13844.4    186.83   0.00000
TOURNAMENT                23507  27688.9   1.1779         0.66    -13844.4    186.83   0.00000
SEASON                    23509  27875.7   1.1857         0.00    -13937.9      0.00     .
********************************************************************************


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

FACTOR                    DEGF  DEVIANCE   DEV/DF   %REDUCTION    LOGLIKE     CHISQ  PROBCHISQ
------------------------- ------ --------- --------- ------------ ----------- ----------- -----------
BASE                      23499  27415.3   1.1667                 -13707.6

ZONE                      23497  26930.6   1.1461         1.76    -13465.3    484.63   0.00000
AREA                      23497  27036.5   1.1506         1.37    -13518.2    378.79   0.00000
TOURNAMENT                23497  27036.5   1.1506         1.37    -13518.2    378.79   0.00000
SEASON                    23499  27415.3   1.1667         0.00    -13707.6      0.00     .
********************************************************************************


********************************************************************************
The explanatory factors in the base model are:  TRIPCAT DAYNIGHT MONTH YEAR ZONE

FACTOR                    DEGF  DEVIANCE   DEV/DF   %REDUCTION    LOGLIKE     CHISQ  PROBCHISQ
------------------------- ------ --------- --------- ------------ ----------- ----------- -----------
BASE                      23497  26930.6   1.1461                 -13465.3

AREA                      23495  26921.5   1.1458         0.03    -13460.7      9.16   0.01024
TOURNAMENT                23495  26921.5   1.1458         0.03    -13460.7      9.16   0.01024
SEASON                    23497  26930.6   1.1461         0.00    -13465.3      0.00     .
********************************************************************************
```

FINAL MODEL: TRIPCAT + DAYNIGHT + MONTH + YEAR + ZONE

TABLE 6: Results of the stepwise procedure to develop the positive catch rate model for the indices 1990-2000.

```
*******************************************************************************************
There are no explanatory factors in the base model.

FACTOR                     DEGF  DEVIANCE   DEV/DF   %REDUCTION   LOGLIKE      CHISQ   PROBCHISQ
-------------------------- ------ --------- --------- ------------ ----------- ----------- -----------
BASE                       14270   15803.0   1.1074                 -20977.3

ZONE                       14268   14298.1   1.0021         9.51    -20263.2     1428.13     0.00000
MONTH                      14259   14624.6   1.0256         7.39    -20424.3     1105.92     0.00000
AREA                       14268   14752.1   1.0339         6.64    -20486.2      982.05     0.00000
SEASON                     14267   14886.6   1.0434         5.78    -20551.0      852.51     0.00000
TRIPCAT                    14268   15640.9   1.0962         1.01    -20903.7      147.11     0.00000
YEAR                       14260   15714.9   1.1020         0.49    -20937.4       79.75     0.00000
DAYNIGHT                   14268   15781.7   1.1061         0.12    -20967.7       19.21     0.00007
*******************************************************************************************


*******************************************************************************************
The explanatory factors in the base model are:  ZONE

FACTOR                     DEGF  DEVIANCE   DEV/DF   %REDUCTION   LOGLIKE      CHISQ   PROBCHISQ
-------------------------- ------ --------- --------- ------------ ----------- ----------- -----------
BASE                       14268   14298.1   1.0021                 -20263.2

MONTH                      14257   13654.1   0.9577         4.43    -19934.4      657.65     0.00000
YEAR                       14258   13818.5   0.9692         3.29    -20019.8      486.89     0.00000
SEASON                     14265   13833.5   0.9698         3.23    -20027.5      471.39     0.00000
TRIPCAT                    14266   14067.0   0.9861         1.60    -20146.9      232.55     0.00000
AREA                       14266   14122.1   0.9899         1.22    -20174.8      176.76     0.00000
DAYNIGHT                   14266   14275.3   1.0007         0.15    -20251.8       22.78     0.00001
*******************************************************************************************


*******************************************************************************************
The explanatory factors in the base model are:  ZONE MONTH

FACTOR                     DEGF  DEVIANCE   DEV/DF   %REDUCTION   LOGLIKE      CHISQ   PROBCHISQ
-------------------------- ------ --------- --------- ------------ ----------- ----------- -----------
BASE                       14257   13654.1   0.9577                 -19934.4

YEAR                       14247   13159.8   0.9237         3.55    -19671.3      526.21     0.00000
TRIPCAT                    14255   13421.3   0.9415         1.69    -19811.6      245.49     0.00000
AREA                       14255   13513.2   0.9480         1.02    -19860.4      148.03     0.00000
DAYNIGHT                   14255   13636.9   0.9566         0.11    -19925.4       18.01     0.00012
SEASON                     14257   13654.1   0.9577         0.00    -19934.4        0.00     .
*******************************************************************************************


*******************************************************************************************
The explanatory factors in the base model are:  ZONE MONTH YEAR

FACTOR                     DEGF  DEVIANCE   DEV/DF   %REDUCTION   LOGLIKE      CHISQ   PROBCHISQ
-------------------------- ------ --------- --------- ------------ ----------- ----------- -----------
BASE                       14247   13159.8   0.9237                 -19671.3

TRIPCAT                    14245   12948.8   0.9090         1.59    -19555.9      230.75     0.00000
AREA                       14245   12995.3   0.9123         1.24    -19581.5      179.54     0.00000
DAYNIGHT                   14245   13129.2   0.9217         0.22    -19654.6       33.28     0.00000
SEASON                     14247   13159.8   0.9237         0.00    -19671.3        0.00     .
*******************************************************************************************
```

TABLE 6 (cont.): Results of the stepwise procedure to develop the positive catch rate model for the indices 1990-2000.

```
*****************************************************************************************
The explanatory factors in the base model are:  ZONE MONTH YEAR TRIPCAT

FACTOR                      DEGF  DEVIANCE   DEV/DF   %REDUCTION   LOGLIKE    CHISQ   PROBCHISQ
--------------------------  ----  --------  --------  ----------  --------  --------  ---------
BASE                       14245   12948.8   0.9090                -19555.9

DAYNIGHT                   14243   12879.2   0.9042       0.52     -19517.4    76.89   0.00000
AREA                       14243   12911.0   0.9065       0.28     -19535.0    41.72   0.00000
SEASON                     14245   12948.8   0.9090       0.00     -19555.9     0.00      .
*****************************************************************************************


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

FACTOR                      DEGF  DEVIANCE   DEV/DF   %REDUCTION   LOGLIKE    CHISQ   PROBCHISQ
--------------------------  ----  --------  --------  ----------  --------  --------  ---------
BASE                       14245   12948.8   0.9090                -19555.9

ZONE*DAYNIGHT              14239   12722.2   0.8935       1.71     -19429.9   251.94   0.00000
MONTH*DAYNIGHT            14221   12823.9   0.9018       0.80     -19486.8   138.24   0.00000
ZONE*TRIPCAT              14241   12858.0   0.9029       0.67     -19505.7   100.36   0.00000
TRIPCAT*DAYNIGHT         14242   12861.5   0.9031       0.65     -19507.7    96.47   0.00000
ZONE*MONTH               14223   12856.6   0.9039       0.56     -19504.9   101.92   0.00000
MONTH*TRIPCAT            14223   12882.7   0.9058       0.36     -19519.4    73.05   0.00000
*****************************************************************************************



*****************************************************************************************
The explanatory factors in the base model are:  ZONE MONTH YEAR TRIPCAT DAYNIGHT

FACTOR                      DEGF  DEVIANCE   DEV/DF   %REDUCTION   LOGLIKE    CHISQ   PROBCHISQ
--------------------------  ----  --------  --------  ----------  --------  --------  ---------
BASE                       14243   12879.2   0.9042                -19517.4

ZONE*DAYNIGHT              14239   12722.2   0.8935       1.19     -19429.9   175.04   0.00000
MONTH*DAYNIGHT            14221   12823.9   0.9018       0.27     -19486.8    61.35   0.00001
TRIPCAT*DAYNIGHT         14242   12861.5   0.9031       0.13     -19507.7    19.58   0.00001
*****************************************************************************************



*****************************************************************************************
The explanatory factors in the base model are:  ZONE MONTH YEAR TRIPCAT DAYNIGHT ZONE*DAYNIGHT

FACTOR                      DEGF  DEVIANCE   DEV/DF   %REDUCTION   LOGLIKE    CHISQ   PROBCHISQ
--------------------------  ----  --------  --------  ----------  --------  --------  ---------
BASE                       14239   12722.2   0.8935                -19429.9

MONTH*DAYNIGHT            14217   12677.1   0.8917       0.20     -19404.6    50.65   0.00048
TRIPCAT*DAYNIGHT         14238   12719.6   0.8934       0.01     -19428.5     2.89   0.08894


*****************************************************************************************
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```

FINAL MODEL: ZONE+MONTH+YEAR+TRIPCAT+DAYNIGHT+ZONE*DAYNIGHT

TABLE 7: Results of the stepwise procedure to develop the proportion positive catch rate model for the indices 2000-2004.

```
*****************************************************************************************************
There are no explanatory factors in the base model.
FACTOR                     DEGF  DEVIANCE   DEV/DF   %REDUCTION    LOGLIKE      CHISQ   PROBCHISQ
-------------------------  ----  --------   -------  ----------   ---------  ---------  ----------
BASE                       8409  11488.6    1.3662                -5744.3
TRIPCAT                    8407  10595.8    1.2604      7.75       -5297.9     892.84    0.00000
ZONE                       8407  10624.3    1.2637      7.50       -5312.1     864.38    0.00000
AREA                       8407  11069.1    1.3167      3.63       -5534.6     419.52    0.00000
TOURNAMENT                 8407  11069.1    1.3167      3.63       -5534.6     419.52    0.00000
MONTH                      8398  11206.9    1.3345      2.32       -5603.5     281.74    0.00000
SEASON                     8406  11257.8    1.3393      1.97       -5628.9     230.84    0.00000
YEAR                       8405  11471.5    1.3648      0.10       -5735.7      17.15    0.00181
DAYNIGHT                   8407  11487.2    1.3664     -0.01       -5743.6       1.45    0.48362
*****************************************************************************************************


*****************************************************************************************************
The explanatory factors in the base model are:  TRIPCAT
FACTOR                     DEGF  DEVIANCE   DEV/DF   %REDUCTION    LOGLIKE      CHISQ   PROBCHISQ
-------------------------  ----  --------   -------  ----------   ---------  ---------  ----------
BASE                       8407  10595.8    1.2604                -5297.9
ZONE                       8405   9885.3    1.1761      6.68       -4942.7     710.47    0.00000
AREA                       8405  10240.4    1.2184      3.33       -5120.2     355.44    0.00000
TOURNAMENT                 8405  10240.4    1.2184      3.33       -5120.2     355.44    0.00000
DAYNIGHT                   8405  10262.5    1.2210      3.12       -5131.2     333.33    0.00000
MONTH                      8396  10346.1    1.2323      2.23       -5173.1     249.68    0.00000
SEASON                     8404  10402.5    1.2378      1.79       -5201.2     193.31    0.00000
YEAR                       8403  10580.1    1.2591      0.10       -5290.1      15.68    0.00348
*****************************************************************************************************


*****************************************************************************************************
The explanatory factors in the base model are:  TRIPCAT ZONE
FACTOR                     DEGF  DEVIANCE   DEV/DF   %REDUCTION    LOGLIKE      CHISQ   PROBCHISQ
-------------------------  ----  --------   -------  ----------   ---------  ---------  ----------
BASE                       8405   9885.3    1.1761                -4942.7
DAYNIGHT                   8403   9601.7    1.1426      2.85       -4800.8     283.66    0.00000
MONTH                      8394   9759.5    1.1627      1.14       -4879.7     125.86    0.00000
SEASON                     8402   9796.0    1.1659      0.87       -4898.0      89.29    0.00000
YEAR                       8401   9875.4    1.1755      0.05       -4937.7       9.96    0.04114
AREA                       8403   9879.8    1.1757      0.03       -4939.9       5.56    0.06213
TOURNAMENT                 8403   9879.8    1.1757      0.03       -4939.9       5.56    0.06213
*****************************************************************************************************


*****************************************************************************************************
The explanatory factors in the base model are:  TRIPCAT ZONE DAYNIGHT

FACTOR                     DEGF  DEVIANCE   DEV/DF   %REDUCTION    LOGLIKE      CHISQ   PROBCHISQ
-------------------------  ----  --------   -------  ----------   ---------  ---------  ----------
BASE                       8403   9601.7    1.1426                -4800.8

MONTH                      8392   9449.0    1.1259      1.46       -4724.5     152.72    0.00000
SEASON                     8400   9492.5    1.1301      1.10       -4746.2     109.21    0.00000
YEAR                       8399   9592.7    1.1421      0.05       -4796.3       9.03    0.06046
AREA                       8401   9597.4    1.1424      0.02       -4798.7       4.23    0.12042
TOURNAMENT                 8401   9597.4    1.1424      0.02       -4798.7       4.23    0.12042
*****************************************************************************************************
```

TABLE 7 (cont.): Results of the stepwise procedure to develop the proportion positive catch
rate model for the indices 2000-2004.

```
*****************************************************************************************
The explanatory factors in the base model are:  TRIPCAT ZONE DAYNIGHT MONTH

FACTOR                         DEGF  DEVIANCE   DEV/DF   %REDUCTION   LOGLIKE    CHISQ   PROBCHISQ
---------------------------- ------ --------- --------- ------------ ----------- ----------- -----------
BASE                           8392   9449.0    1.1259                 -4724.5

YEAR                           8388   9439.0    1.1253        0.06      -4719.5    10.00     0.04047
AREA                           8390   9445.7    1.1258        0.01      -4722.8     3.27     0.19482
TOURNAMENT                     8390   9445.7    1.1258        0.01      -4722.8     3.27     0.19482
SEASON                         8392   9449.0    1.1259        0.00      -4724.5     0.00       .
*****************************************************************************************


*****************************************************************************************
The explanatory factors in the base model are:  TRIPCAT ZONE DAYNIGHT MONTH YEAR

FACTOR                         DEGF  DEVIANCE   DEV/DF   %REDUCTION   LOGLIKE    CHISQ   PROBCHISQ
---------------------------- ------ --------- --------- ------------ ----------- ----------- -----------
BASE                           8388   9439.0    1.1253                 -4719.5

AREA                           8386   9435.9    1.1252        0.01      -4717.9     3.10     0.21222
TOURNAMENT                     8386   9435.9    1.1252        0.01      -4717.9     3.10     0.21222
SEASON                         8388   9439.0    1.1253        0.00      -4719.5     0.00       .
*****************************************************************************************


*****************************************************************************************
The explanatory factors in the base model are:  TRIPCAT ZONE DAYNIGHT MONTH YEAR

FACTOR                         DEGF  DEVIANCE   DEV/DF   %REDUCTION   LOGLIKE    CHISQ   PROBCHISQ
---------------------------- ------ --------- --------- ------------ ----------- ----------- -----------
BASE                           8388   9439.0    1.1253                 -4719.5

TRIPCAT*ZONE                   8384   9277.5    1.1066        1.66      -4638.7   161.49     0.00000
ZONE*DAYNIGHT                  8385   9373.9    1.1179        0.65      -4686.9    65.06     0.00000
DAYNIGHT*MONTH                 8370   9403.9    1.1235        0.16      -4702.0    39.43     0.01259
ZONE*MONTH                     8366   9399.5    1.1235        0.16      -4699.8    39.43     0.01259
TRIPCAT*MONTH                  8366   9400.0    1.1236        0.15      -4700.0    38.94     0.01432
TRIPCAT*DAYNIGHT               8387   9438.8    1.1254       -0.01      -4719.4     0.14     0.71133
*****************************************************************************************


*****************************************************************************************
The explanatory factors in the base model are:  TRIPCAT ZONE DAYNIGHT MONTH YEAR TRIPCAT*ZONE

FACTOR                         DEGF  DEVIANCE   DEV/DF   %REDUCTION   LOGLIKE    CHISQ   PROBCHISQ
---------------------------- ------ --------- --------- ------------ ----------- ----------- -----------
BASE                           8384   9277.5    1.1066                 -4638.7

ZONE*MONTH                     8362   9232.9    1.1041        0.22      -4616.4    44.60     0.00298
DAYNIGHT*MONTH                 8366   9247.8    1.1054        0.11      -4623.9    44.60     0.00298
ZONE*DAYNIGHT                  8381   9267.8    1.1058        0.07      -4633.9     9.62     0.02209
TRIPCAT*MONTH                  8362   9253.6    1.1066       -0.01      -4626.8    23.88     0.35346
TRIPCAT*DAYNIGHT               8383   9277.4    1.1067       -0.01      -4638.7     0.03     0.86021
*****************************************************************************************
```

FINAL MODEL: TRIPCAT+ ZONE +DAYNIGHT+MONTH+YEAR +TRIPCAT*ZONE

TABLE 8: Results of the stepwise procedure to develop the positive catch rate model for the indices 2000-2004.

```
**********************************************************************************************
There are no explanatory factors in the base model.

FACTOR                      DEGF  DEVIANCE   DEV/DF   %REDUCTION    LOGLIKE      CHISQ  PROBCHISQ
-------------------------- ------ --------- --------- ------------ ----------- ----------- -----------
BASE                        4801    5359.7    1.1164                  -7077.5

ZONE                        4799    4141.1    0.8629       22.70      -6458.2    1238.62    0.00000
AREA                        4799    4736.6    0.9870       11.59      -6780.8     593.43    0.00000
MONTH                       4790    4890.1    1.0209        8.55      -6857.4     440.28    0.00000
SEASON                      4798    4973.4    1.0366        7.15      -6898.0     359.13    0.00000
YEAR                        4797    5223.2    1.0888        2.46      -7015.6     123.85    0.00000
TRIPCAT                     4799    5332.1    1.1111        0.47      -7065.2      24.73    0.00000
DAYNIGHT                    4799    5336.1    1.1119        0.40      -7067.0      21.11    0.00003
**********************************************************************************************


**********************************************************************************************
The explanatory factors in the base model are:  ZONE

FACTOR                      DEGF  DEVIANCE   DEV/DF   %REDUCTION    LOGLIKE      CHISQ  PROBCHISQ
-------------------------- ------ --------- --------- ------------ ----------- ----------- -----------
BASE                        4799    4141.1    0.8629                  -6458.2

MONTH                       4788    3892.5    0.8130        5.79      -6309.6     297.34    0.00000
SEASON                      4796    3960.6    0.8258        4.30      -6351.2     214.07    0.00000
AREA                        4797    4043.7    0.8430        2.31      -6401.1     114.35    0.00000
TRIPCAT                     4797    4070.3    0.8485        1.67      -6416.8      82.78    0.00000
YEAR                        4795    4088.5    0.8527        1.19      -6427.5      61.43    0.00000
DAYNIGHT                    4797    4130.4    0.8610        0.22      -6452.0      12.39    0.00204
**********************************************************************************************


**********************************************************************************************
The explanatory factors in the base model are:  ZONE MONTH

FACTOR                      DEGF  DEVIANCE   DEV/DF   %REDUCTION    LOGLIKE      CHISQ  PROBCHISQ
-------------------------- ------ --------- --------- ------------ ----------- ----------- -----------
BASE                        4788    3892.5    0.8130                  -6309.6

AREA                        4786    3816.0    0.7973        1.92      -6261.9      95.24    0.00000
TRIPCAT                     4786    3833.7    0.8010        1.47      -6273.0      73.04    0.00000
YEAR                        4784    3837.5    0.8022        1.33      -6275.4      68.30    0.00000
DAYNIGHT                    4786    3881.5    0.8110        0.24      -6302.8      13.48    0.00118
SEASON                      4788    3892.5    0.8130        0.00      -6309.6       0.00    .
**********************************************************************************************


**********************************************************************************************
The explanatory factors in the base model are:  ZONE MONTH AREA

FACTOR                      DEGF  DEVIANCE   DEV/DF   %REDUCTION    LOGLIKE      CHISQ  PROBCHISQ
-------------------------- ------ --------- --------- ------------ ----------- ----------- -----------
BASE                        4786    3816.0    0.7973                  -6261.9

YEAR                        4782    3772.6    0.7889        1.05      -6234.5      54.93    0.00000
DAYNIGHT                    4784    3799.7    0.7943        0.39      -6251.6      20.59    0.00003
TRIPCAT                     4784    3812.0    0.7968        0.06      -6259.4       5.00    0.08191
SEASON                      4786    3816.0    0.7973        0.00      -6261.9       0.00    .
**********************************************************************************************
```

TABLE 8 (cont.): Results of the stepwise procedure to develop the proportion positive catch rate model for the indices 2000-2004.

```
*****************************************************************************************
The explanatory factors in the base model are:  ZONE MONTH AREA YEAR

FACTOR                      DEGF  DEVIANCE   DEV/DF   %REDUCTION   LOGLIKE     CHISQ   PROBCHISQ
-------------------------- ------ --------- --------- ------------ ----------- ----------- -----------
BASE                        4782   3772.6    0.7889                -6234.5

DAYNIGHT                    4780   3761.1    0.7868       0.26      -6227.1     14.74    0.00063
TRIPCAT                     4780   3769.6    0.7886       0.04      -6232.6      3.81    0.14867
SEASON                      4782   3772.6    0.7889       0.00      -6234.5      0.00       .
*****************************************************************************************


*****************************************************************************************
The explanatory factors in the base model are:  ZONE MONTH AREA YEAR

FACTOR                      DEGF  DEVIANCE   DEV/DF   %REDUCTION   LOGLIKE     CHISQ   PROBCHISQ
-------------------------- ------ --------- --------- ------------ ----------- ----------- -----------
BASE                        4782   3772.6    0.7889                -6234.5

ZONE*MONTH                  4760   3703.8    0.7781       1.37      -6190.3     88.36    0.00000
MONTH*AREA                  4760   3716.8    0.7808       1.03      -6198.7     71.63    0.00000
MONTH*TRIPCAT               4758   3729.0    0.7837       0.66      -6206.5     55.84    0.00024
ZONE*DAYNIGHT               4777   3746.2    0.7842       0.60      -6217.6     33.72    0.00000
AREA*DAYNIGHT               4779   3748.3    0.7843       0.58      -6218.9     31.06    0.00000
ZONE*TRIPCAT               4776   3754.2    0.7861       0.36      -6222.7     23.49    0.00065
MONTH*DAYNIGHT              4764   3748.5    0.7868       0.26      -6219.1     30.83    0.03011
ZONE*AREA                  4781   3768.8    0.7883       0.08      -6232.1      4.81    0.02825
AREA*TRIPCAT               4778   3767.0    0.7884       0.06      -6230.9      7.10    0.13049
*****************************************************************************************


*****************************************************************************************
The explanatory factors in the base model are:  ZONE MONTH AREA YEAR ZONE*MONTH

FACTOR                      DEGF  DEVIANCE   DEV/DF   %REDUCTION   LOGLIKE     CHISQ   PROBCHISQ
-------------------------- ------ --------- --------- ------------ ----------- ----------- -----------
BASE                        4760   3703.8    0.7781                -6190.3

MONTH*TRIPCAT               4736   3663.3    0.7735       0.59      -6163.9     52.80    0.00062
MONTH*AREA                  4749   3674.0    0.7736       0.58      -6170.9     38.84    0.00006
ZONE*DAYNIGHT               4755   3679.7    0.7739       0.55      -6174.6     31.43    0.00001
AREA*DAYNIGHT               4757   3682.3    0.7741       0.52      -6176.3     27.96    0.00000
ZONE*TRIPCAT               4754   3685.3    0.7752       0.38      -6178.2     24.14    0.00049
MONTH*DAYNIGHT              4742   3681.9    0.7764       0.22      -6176.0     28.55    0.05418
AREA*TRIPCAT               4756   3698.7    0.7777       0.06      -6186.9      6.70    0.15279
ZONE*AREA                  4759   3701.1    0.7777       0.05      -6188.5      3.52    0.06054
*****************************************************************************************
```

FINAL MODEL: ZONE + MONTH + AREA + YEAR + ZONE*MONTH

TABLE 9: Results of the stepwise procedure to develop the proportion positive catch rate model for the indices 1986-2004.

```
************************************************************************************************
There are no explanatory factors in the base model.

FACTOR                      DEGF  DEVIANCE   DEV/DF   %REDUCTION    LOGLIKE      CHISQ   PROBCHISQ
------------------------- ------ ---------- --------- ------------ ----------- ----------- -----------
BASE                        39468  52721.1   1.3358                -26360.6

TRIPCAT                     39466  49560.3   1.2558        5.99    -24780.2    3160.77    0.00000
MONTH                       39457  51741.3   1.3113        1.83    -25870.7     979.77    0.00000
AREA                        39466  51797.4   1.3125        1.75    -25898.7     923.74    0.00000
ZONE                        39466  51844.3   1.3136        1.66    -25922.1     876.82    0.00000
YEAR                        39450  51992.1   1.3179        1.34    -25996.0     729.04    0.00000
SEASON                      39465  52024.2   1.3182        1.31    -26012.1     696.93    0.00000
DAYNIGHT                    39466  52699.9   1.3353        0.04    -26350.0      21.21    0.00002
************************************************************************************************


************************************************************************************************
The explanatory factors in the base model are:  TRIPCAT

FACTOR                      DEGF  DEVIANCE   DEV/DF   %REDUCTION    LOGLIKE      CHISQ   PROBCHISQ
------------------------- ------ ---------- --------- ------------ ----------- ----------- -----------
BASE                        39466  49560.3   1.2558                -24780.2

ZONE                        39464  48248.7   1.2226        2.64    -24124.4    1311.61    0.00000
DAYNIGHT                    39464  48335.4   1.2248        2.47    -24167.7    1224.93    0.00000
AREA                        39464  48427.6   1.2271        2.28    -24213.8    1132.71    0.00000
MONTH                       39455  48456.4   1.2281        2.20    -24228.2    1103.95    0.00000
YEAR                        39448  48654.5   1.2334        1.78    -24327.3     905.81    0.00000
SEASON                      39463  48793.6   1.2364        1.54    -24396.8     766.76    0.00000
************************************************************************************************


************************************************************************************************
The explanatory factors in the base model are:  TRIPCAT ZONE

FACTOR                      DEGF  DEVIANCE   DEV/DF   %REDUCTION    LOGLIKE      CHISQ   PROBCHISQ
------------------------- ------ ---------- --------- ------------ ----------- ----------- -----------
BASE                        39464  48248.7   1.2226                -24124.4

DAYNIGHT                    39462  47192.4   1.1959        2.18    -23596.2    1056.28    0.00000
YEAR                        39446  47236.9   1.1975        2.05    -23618.5    1011.81    0.00000
MONTH                       39453  47641.8   1.2076        1.23    -23820.9     606.92    0.00000
SEASON                      39461  47879.5   1.2133        0.76    -23939.8     369.22    0.00000
AREA                        39462  48236.5   1.2224        0.02    -24118.2      12.27    0.00216
************************************************************************************************


************************************************************************************************
The explanatory factors in the base model are:  TRIPCAT ZONE DAYNIGHT

FACTOR                      DEGF  DEVIANCE   DEV/DF   %REDUCTION    LOGLIKE      CHISQ   PROBCHISQ
------------------------- ------ ---------- --------- ------------ ----------- ----------- -----------
BASE                        39462  47192.4   1.1959                -23596.2

YEAR                        39444  46357.7   1.1753        1.72    -23178.9     834.71    0.00000
MONTH                       39451  46502.6   1.1787        1.43    -23251.3     689.86    0.00000
SEASON                      39459  46764.1   1.1851        0.90    -23382.0     428.38    0.00000
AREA                        39460  47183.2   1.1957        0.01    -23591.6       9.22    0.00996
************************************************************************************************
```

TABLE 9 (cont.): Results of the stepwise procedure to develop the proportion positive catch rate model for the indices 1986-2004.

```
********************************************************************************************
The explanatory factors in the base model are:  TRIPCAT ZONE DAYNIGHT YEAR

FACTOR                     DEGF  DEVIANCE   DEV/DF   %REDUCTION    LOGLIKE      CHISQ   PROBCHISQ
-------------------------- ------ --------- --------- ------------ ----------- ----------- -----------
BASE                       39444  46357.7   1.1753                 -23178.9

MONTH                      39433  45647.4   1.1576          1.50   -22823.7     710.29    0.00000
SEASON                     39441  45908.0   1.1640          0.96   -22954.0     449.76    0.00000
AREA                       39442  46350.3   1.1751          0.01   -23175.1       7.48    0.02373
********************************************************************************************



********************************************************************************************
The explanatory factors in the base model are:  TRIPCAT ZONE DAYNIGHT YEAR MONTH

FACTOR                     DEGF  DEVIANCE   DEV/DF   %REDUCTION    LOGLIKE      CHISQ   PROBCHISQ
-------------------------- ------ --------- --------- ------------ ----------- ----------- -----------
BASE                       39433  45647.4   1.1576                 -22823.7

AREA                       39431  45637.5   1.1574          0.02   -22818.7       9.99    0.00677
SEASON                     39433  45647.4   1.1576          0.00   -22823.7       0.00    .
********************************************************************************************


********************************************************************************************
The explanatory factors in the base model are:  TRIPCAT ZONE DAYNIGHT YEAR MONTH

FACTOR                     DEGF  DEVIANCE   DEV/DF   %REDUCTION    LOGLIKE      CHISQ   PROBCHISQ
-------------------------- ------ --------- --------- ------------ ----------- ----------- -----------
BASE                       39433  45647.4   1.1576                 -22823.7

TRIPCAT*ZONE               39429  45192.0   1.1462          0.99   -22596.0     455.49    0.00000
ZONE*MONTH                 39411  45462.2   1.1535          0.35   -22731.1     185.24    0.00000
ZONE*DAYNIGHT              39429  45534.8   1.1549          0.24   -22767.4     112.64    0.00000
DAYNIGHT*MONTH             39411  45584.9   1.1567          0.08   -22792.4      62.55    0.00001
TRIPCAT*MONTH              39411  45600.7   1.1571          0.05   -22800.3      46.75    0.00158
TRIPCAT*DAYNIGHT           39432  45647.4   1.1576         -0.00   -22823.7       0.00    0.94761
********************************************************************************************
```

FINAL MODEL: TRIPCAT + ZONE + DAYNIGHT + YEAR + MONTH

TABLE 10: Results of the stepwise procedure to develop the positive catch rate model for the indices 1986-2004.

```
************************************************************************************************
There are no explanatory factors in the base model.

FACTOR                    DEGF  DEVIANCE   DEV/DF   %REDUCTION    LOGLIKE      CHISQ   PROBCHISQ
------------------------- ----- --------- --------- ------------ ----------- ---------- -----------
BASE                      24151  27648.3   1.1448                 -35902.8

ZONE                      24149  24280.8   1.0055       12.17     -34334.4    3136.84    0.00000
AREA                      24149  25136.0   1.0409        9.08     -34752.5    2300.74    0.00000
MONTH                     24140  25564.7   1.0590        7.49     -34956.7    1892.31    0.00000
SEASON                    24148  26008.4   1.0770        5.92     -35164.5    1476.73    0.00000
YEAR                      24133  27147.9   1.1249        1.74     -35682.3     441.09    0.00000
TRIPCAT                   24149  27460.2   1.1371        0.67     -35820.4     164.84    0.00000
DAYNIGHT                  24149  27634.8   1.1443        0.04     -35896.9      11.83    0.00270
************************************************************************************************


************************************************************************************************
The explanatory factors in the base model are:  ZONE

FACTOR                    DEGF  DEVIANCE   DEV/DF   %REDUCTION    LOGLIKE      CHISQ   PROBCHISQ
------------------------- ----- --------- --------- ------------ ----------- ---------- -----------
BASE                      24149  24280.8   1.0055                 -34334.4

MONTH                     24138  23227.0   0.9623        4.30     -33798.6    1071.60    0.00000
SEASON                    24146  23511.3   0.9737        3.16     -33945.5     777.81    0.00000
YEAR                      24131  23600.5   0.9780        2.73     -33991.2     686.36    0.00000
AREA                      24147  24036.7   0.9954        1.00     -34212.4     243.96    0.00000
TRIPCAT                   24147  24037.4   0.9955        0.99     -34212.8     243.31    0.00000
DAYNIGHT                  24147  24277.7   1.0054        0.00     -34332.9       3.06    0.21652
************************************************************************************************


************************************************************************************************
The explanatory factors in the base model are:  ZONE MONTH

FACTOR                    DEGF  DEVIANCE   DEV/DF   %REDUCTION    LOGLIKE      CHISQ   PROBCHISQ
------------------------- ----- --------- --------- ------------ ----------- ---------- -----------
BASE                      24138  23227.0   0.9623                 -33798.6

YEAR                      24120  22496.9   0.9327        3.07     -33413.0     771.33    0.00000
TRIPCAT                   24136  23002.2   0.9530        0.96     -33681.2     234.87    0.00000
AREA                      24136  23034.0   0.9543        0.82     -33697.9     201.52    0.00000
DAYNIGHT                  24136  23217.0   0.9619        0.03     -33793.4      10.38    0.00556
SEASON                    24138  23227.0   0.9623        0.00     -33798.6       0.00    .
************************************************************************************************


************************************************************************************************
The explanatory factors in the base model are:  ZONE MONTH YEAR

FACTOR                    DEGF  DEVIANCE   DEV/DF   %REDUCTION    LOGLIKE      CHISQ   PROBCHISQ
------------------------- ----- --------- --------- ------------ ----------- ---------- -----------
BASE                      24120  22496.9   0.9327                 -33413.0

TRIPCAT                   24118  22293.9   0.9244        0.89     -33303.5     218.95    0.00000
AREA                      24118  22305.0   0.9248        0.85     -33309.5     206.99    0.00000
DAYNIGHT                  24118  22480.6   0.9321        0.06     -33404.2      17.53    0.00016
SEASON                    24120  22496.9   0.9327        0.00     -33413.0       0.00    .
************************************************************************************************
```

TABLE 10 (cont.): Results of the stepwise procedure to develop the proportion positive catch rate model for the indices 1986-2004.

```
***********************************************************************************************
The explanatory factors in the base model are:  ZONE MONTH YEAR

FACTOR                     DEGF  DEVIANCE   DEV/DF   %REDUCTION   LOGLIKE      CHISQ  PROBCHISQ
-------------------------- ------ --------- --------- ------------ ----------- ----------- -----------
BASE                       24120  22496.9   0.9327                -33413.0

ZONE*TRIPCAT               24114  22095.3   0.9163         1.76    -33195.4     435.07  0.00000
MONTH*TRIPCAT              24096  22221.4   0.9222         1.13    -33264.2     297.59  0.00000
ZONE*DAYNIGHT              24114  22363.7   0.9274         0.57    -33341.2     143.49  0.00000
MONTH*ZONE                 24098  22393.3   0.9293         0.37    -33357.2     111.53  0.00000
MONTH*DAYNIGHT             24096  22409.6   0.9300         0.29    -33366.0      93.96  0.00000
ZONE*SEASON                24114  22430.6   0.9302         0.27    -33377.3      71.34  0.00000
MONTH*SEASON               24120  22496.9   0.9327         0.00    -33413.0       0.00    .
***********************************************************************************************


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

FACTOR                     DEGF  DEVIANCE   DEV/DF   %REDUCTION   LOGLIKE      CHISQ  PROBCHISQ
-------------------------- ------ --------- --------- ------------ ----------- ----------- -----------
BASE                       24118  22293.9   0.9244                -33303.5

ZONE*TRIPCAT               24114  22095.3   0.9163         0.87    -33195.4     216.13  0.00000
MONTH*TRIPCAT              24096  22221.4   0.9222         0.23    -33264.2      78.65  0.00000
***********************************************************************************************
```

FINAL MODEL: ZONE +MONTH+YEAR
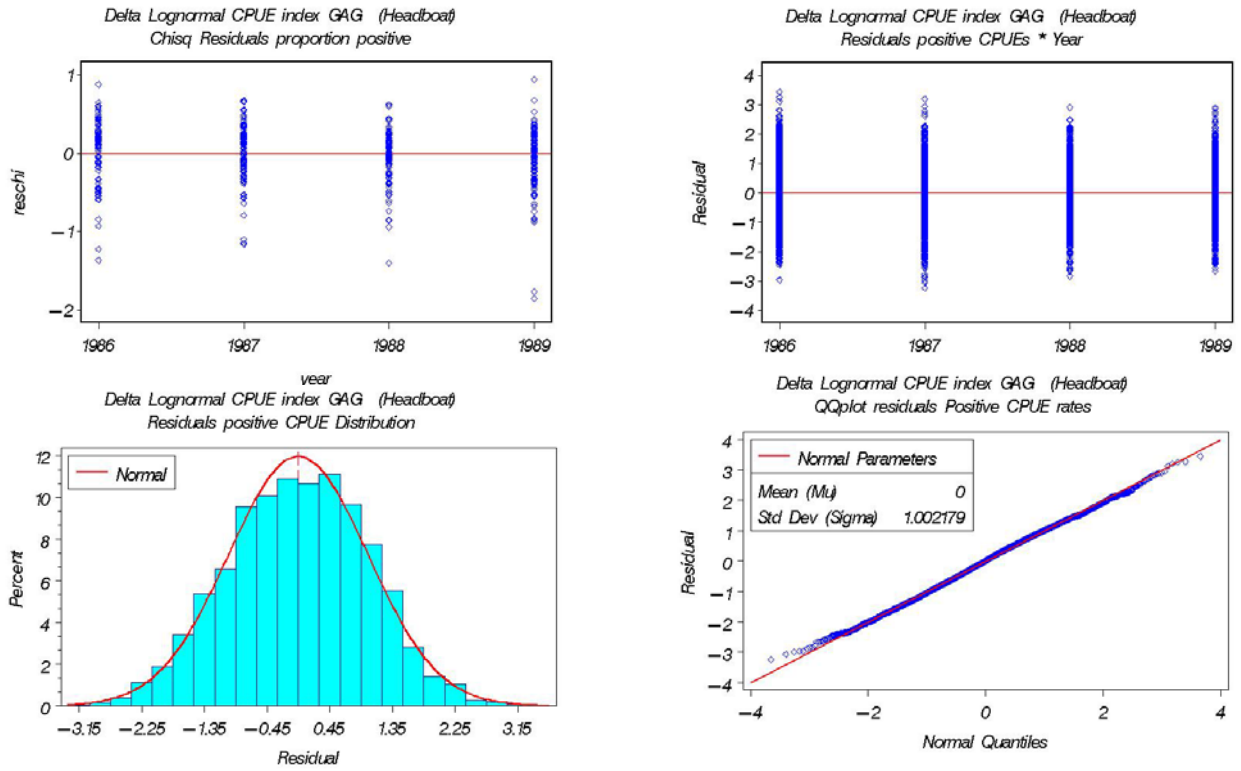
Figure 4. Diagnostic plots for the delta lognormal model fit to the early period 1986-1999
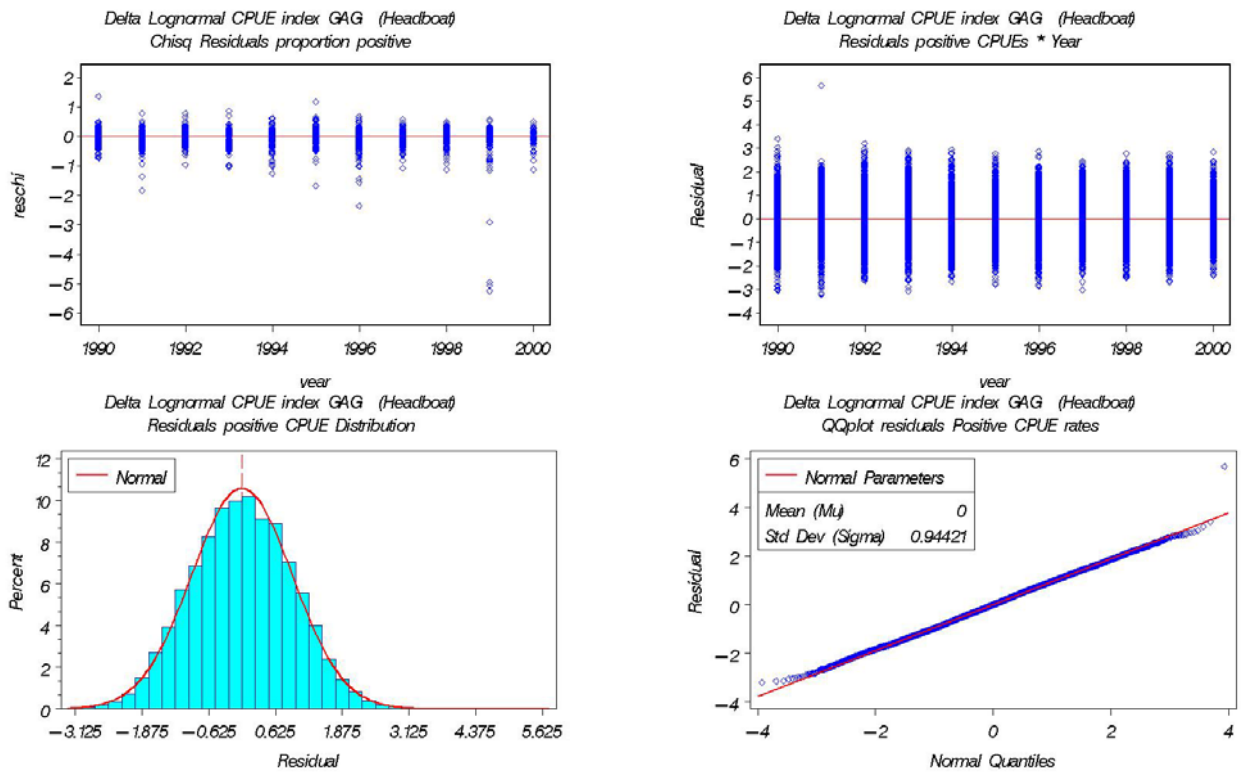
Figure 5. Diagnostic plots for the delta lognormal model fit to the middle period 1990-2000.
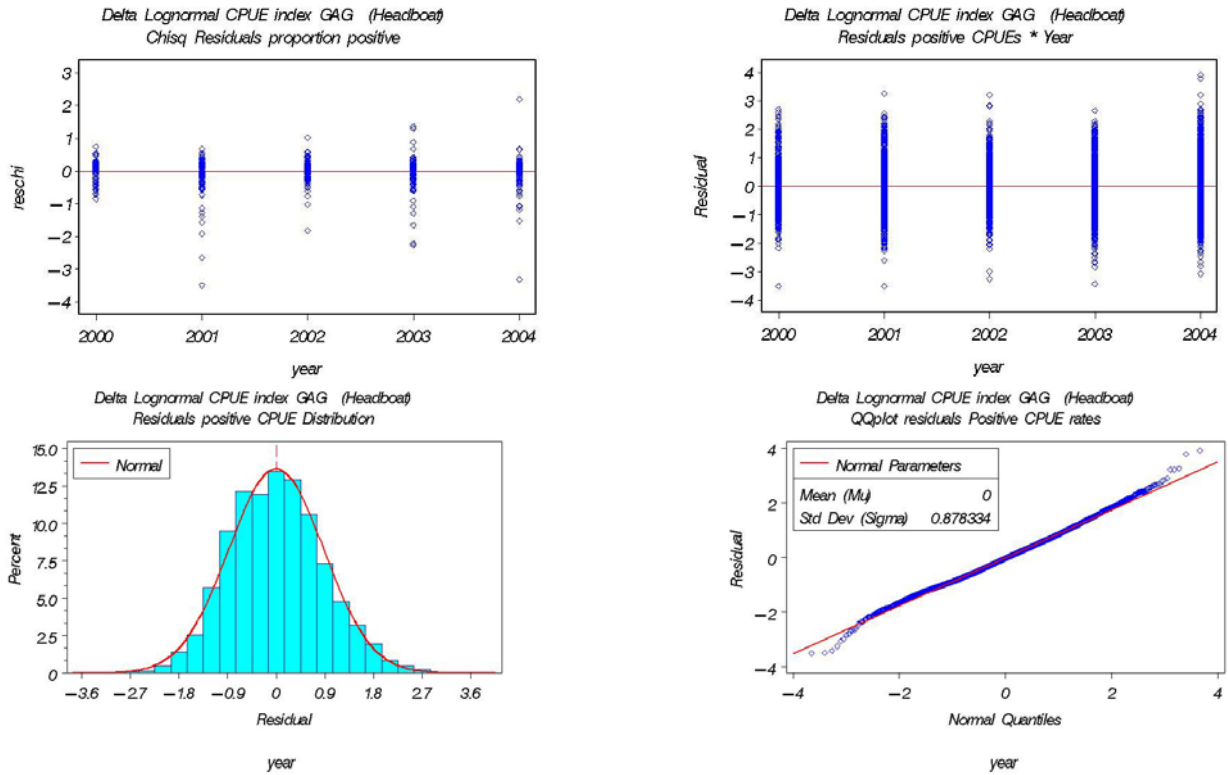
Figure 6. Diagnostic plots for the delta lognormal model fit to the late period 2000-2004
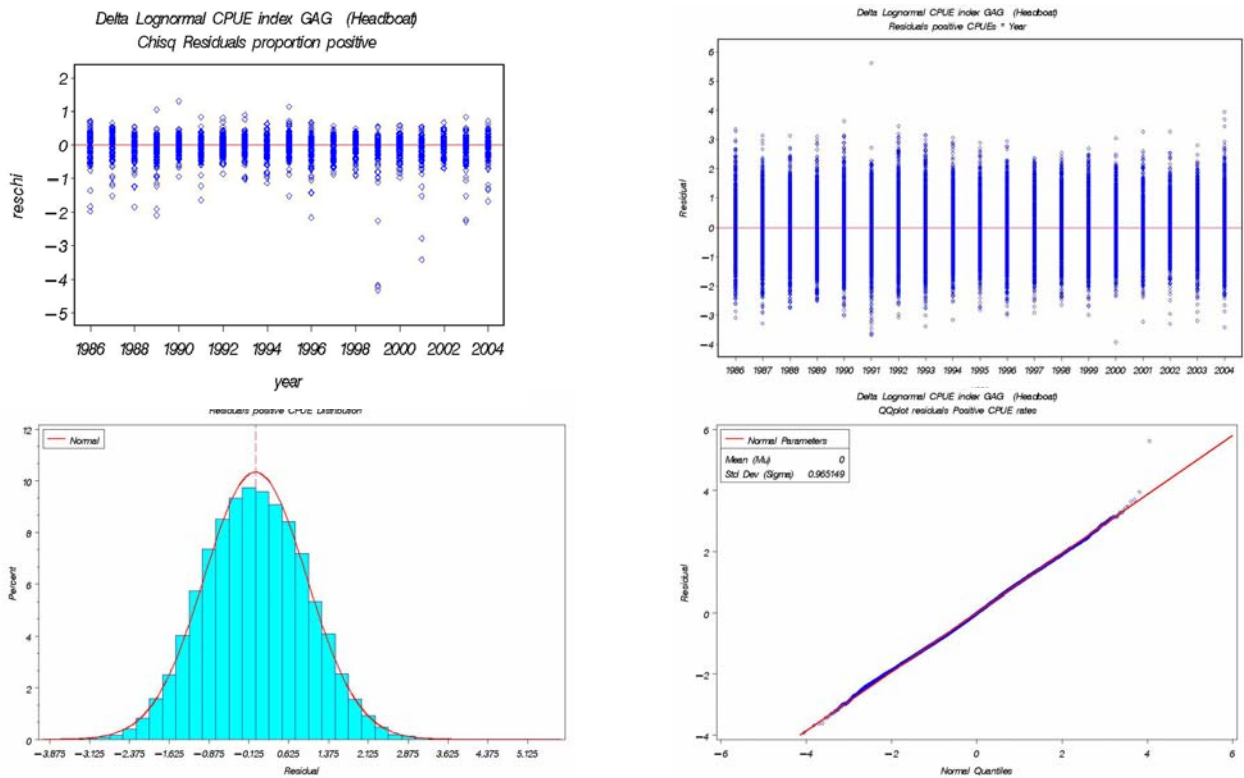

Figure 7. Diagnostic plots for the delta lognormal model fit to the entire period 1986-2004.

	Early Period (1986-1990)				Middle Period (1990-2000)				Late Period (2000-2004)				Entire Period (1986-2004)			
YEAR	INDEX	LCI	UCI	CV	INDEX	LCI	UCI	CV	INDEX	LCI	UCI	CV	INDEX	LCI	UCI	CV
1986	0.978	0.551	1.735	0.293									1.140	0.837	1.554	0.156
1987	1.205	0.782	1.858	0.219									1.317	1.038	1.670	0.119
1988	0.950	0.545	1.658	0.284									1.057	0.788	1.417	0.147
1989	0.866	0.468	1.603	0.315									0.993	0.726	1.357	0.157
1990					0.691	0.363	1.314	0.330					0.720	0.507	1.022	0.177
1991					0.606	0.301	1.218	0.360					0.597	0.389	0.918	0.218
1992					0.705	0.355	1.403	0.354					0.718	0.470	1.097	0.214
1993					0.836	0.467	1.493	0.297					0.826	0.578	1.179	0.179
1994					0.868	0.480	1.569	0.303					0.836	0.577	1.212	0.187
1995					0.866	0.475	1.579	0.307					0.853	0.574	1.269	0.200
1996					1.331	0.928	1.908	0.182					1.350	1.079	1.690	0.113
1997					1.339	0.944	1.899	0.176					1.327	1.067	1.651	0.110
1998					1.262	0.854	1.864	0.197					1.260	0.990	1.603	0.121
1999					1.258	0.871	1.817	0.185					1.237	0.983	1.557	0.115
2000					1.239	0.788	1.950	0.230	0.915	0.435	1.929	0.386	1.048	0.776	1.416	0.151
2001									0.880	0.465	1.666	0.327	0.778	0.516	1.174	0.208
2002									0.940	0.498	1.774	0.326	0.825	0.546	1.247	0.209
2003									1.102	0.644	1.884	0.273	1.039	0.762	1.415	0.155
2004									1.163	0.685	1.976	0.270	1.078	0.810	1.436	0.144

TABLE 11: Relative Abundance Indices for gag (*Mycteroperca microlepis*) in the Gulf of Mexico
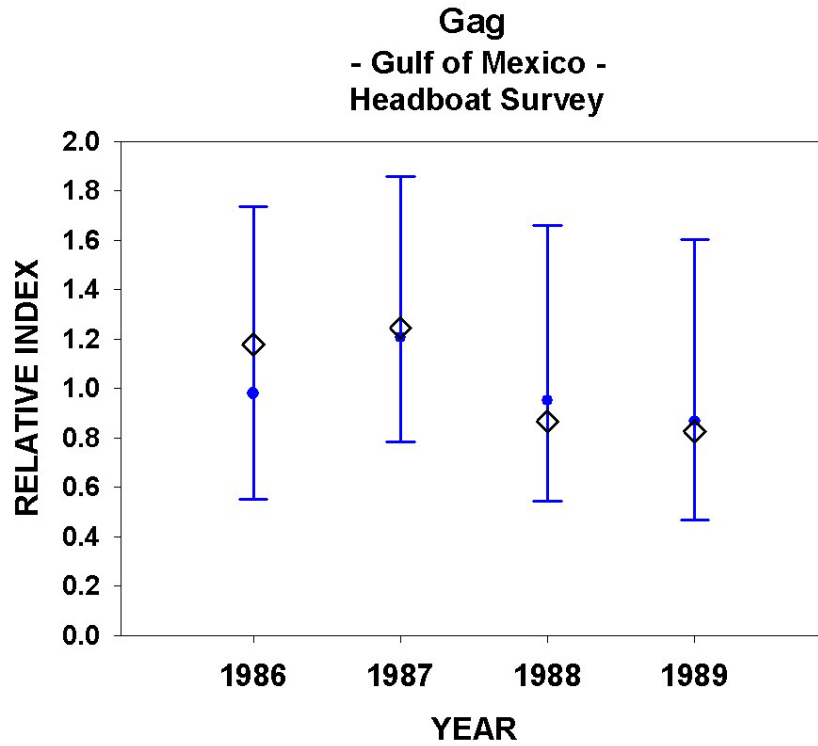
FIGURE 8: Relative abundance indices for gag in the Gulf of Mexico **(1986-1990)** with approximate 95% confidence intervals. Diamonds indicate relative nominal catch rates.
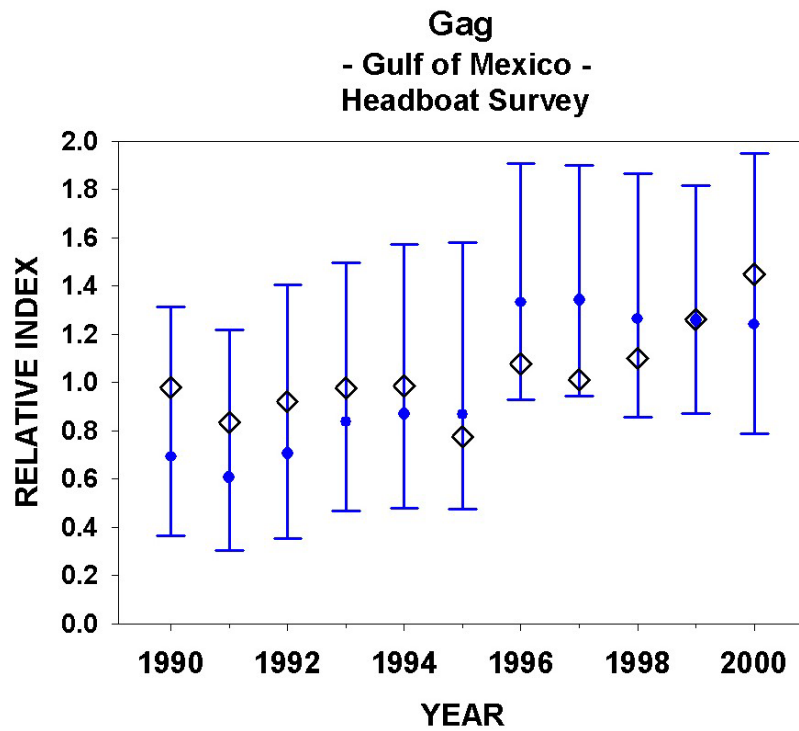

FIGURE 9: Relative abundance indices for gag in the Gulf of Mexico **(1990-2000)** with approximate 95% confidence intervals. Diamonds indicate relative nominal catch rates.
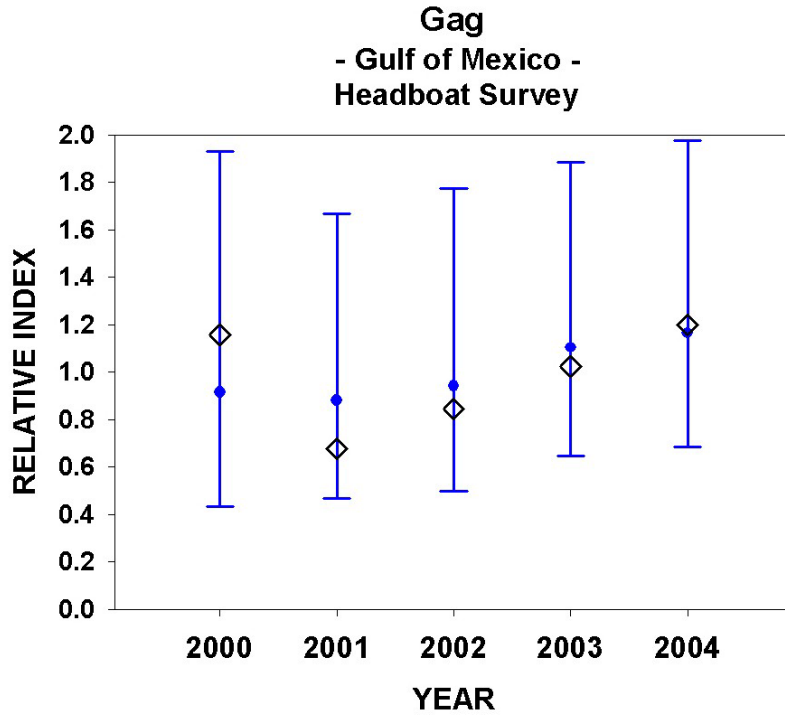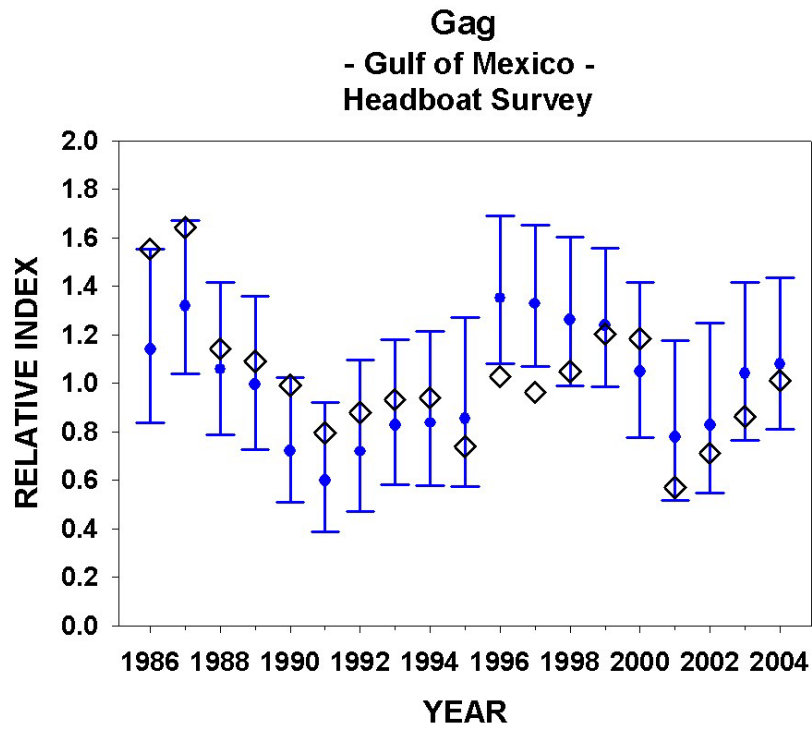
FIGURE 10: Relative abundance indices for gag in the Gulf of Mexico **(1990-2000)** with approximate 95% confidence intervals. Diamonds indicate relative nominal catch rates.

FIGURE 11: Relative abundance indices for gag in the Gulf of Mexico **(1986-2004)** with approximate 95% confidence intervals. Diamonds indicate relative nominal catch rates.