SEDAR 15A-DW-09

Revised standardized catch rates of mutton snapper from the United States Gulf of Mexico and South Atlantic handline and longline fisheries, 1990-2006

Kevin McCarthy

National Marine Fisheries Service, Southeast Fisheries Science Center Sustainable Fisheries Division, 75 Virginia Beach Drive, Miami, FL, 33149-1099
Kevin.J.McCarthy@noaa.gov

Sustainable Fisheries Division Contribution SFD-2007-024

Introduction

Initial mutton snapper indices of abundance were constructed for the SEDAR 15A data workshop and are described in SEDAR 15A-DW-09 (McCarthy, 2007). The indices working group recommended the construction of revised indices that included the years 1990-1993 along with the examination of affects that changes in minimum size regulations may have had on mutton snapper cpue.

Handline and longline catch and fishing effort data from commercial vessels operating under federal fishing permits in the Gulf of Mexico and south Atlantic were available through the National Marine Fisheries Service coastal logbook program. No size information is available in the coastal logbook data, however, size frequency data of mutton snapper in commercial landings were available through the Trip Interview Program (TIP). Port agents attempt to randomly sample vessels and the landings from those vessels and record lengths of individual fish in the course of sampling the commercial landings. The TIP data were used to assess the potential affect that minimum size regulations may have had on mutton snapper cpue.

Methods

The available TIP data were examined for changes among years in the size of mutton snapper landed by handline/rod and reel fishers and by longline fishers. Scatter plots of total lengths of individual fish and the mean total length of measured fish were compared among years. Changes in the size composition of the landings following changes in minimum size regulations would suggest that regulations could have affected the cpue of mutton snapper.

Construction of the mutton snapper indices of abundance followed the methods described in SEDAR 15A-DW-09 (McCarthy, 2007). For the revised indices, the time series was expanded to include the years 1990-1993. The 17 year time series, 1990-2006, includes all the available data from the coastal logbook database. As in the initial construction of commercial mutton snapper indices, data from May and June for all years beginning in 1993 were excluded from the analyses because the commercial

fishery was closed during those periods.

For each fishing trip, the logbook database includes a unique trip identifier, the landing date, fishing gear deployed, areas fished (equivalent to NMFS shrimp statistical grids, Figure 1), number of days at sea, number of crew, gear specific fishing effort (e.g. number of lines fished, number of hooks per line and estimated total fishing time), species caught and whole weight of the landings. Multiple areas fished may be recorded for a single fishing trip. In such cases, assigning catch and effort to specific locations was not possible; therefore, only trips in which one area fished was reported were included in these analyses. Prior to 2001, handline and electric reel (bandit rigs) gears were reported as a single gear type. Data from trips using those gear types were combined in these analyses.

Handline catch rate was calculated in weight of fish per hook-hour. For each trip, catch per unit effort was calculated as:

CPUE = landings of mutton snapper/(number of lines fished*hooks per line*total hours fished)

Longline catch rate was calculated in weight of fish per hook fished. For each trip, catch per unit effort was calculated as:

CPUE = total pounds of mutton snapper/(number of longline sets*number of hooks per set)

The data for number of hours fished while using longline gear is unreliable in the coastal logbook program due to misreporting. Calculating CPUE by hook-hour could not be done for the longline data.

Data were restricted geographically to Areas 1 – 7 in the Gulf and Areas 2479-3477 (Figure 1) in the south Atlantic for handlines. Longline data were restricted to Areas 1-6 in the Gulf of Mexico. Landings reported from longline vessels in the south Atlantic were insufficient to be included in the analysis.

Mutton snapper trips were identified using a modified Stephens and MacCall (2004) approach, where trips are subset based upon the reported species composition of the landings. This method is intended to identify trips that fished in locations containing mutton snapper habitat and, therefore, had the potential of catching mutton snapper. For the initial indices of abundance (McCarthy, 2007), all trips with mutton snapper landings were included as mutton snapper trips in addition to trips identified by the Stephens and MacCall method. In the construction of the revised indices, only those trips identified by the Stephens and MacCall method were included in the analysis. Including trips not identified by the Stephens and MacCall method is an *ad hoc* approach to constructing a data set, increases the proportion of positive trips substantially without adequate justification, and is ultimately unnecessary, at least in this case, because the initial and revised indices differed little.

Once trips were identified, restrictions were made by eliminating trips with reported data for days at sea, number of lines fished (or longline sets), number of hooks per line, or hours fished that fell beyond the 99.5 percentile of the data as a whole. For example, handline vessel trips with more than 10 hooks per line reported were eliminated from the dataset. The data were also filtered by eliminating longline trips that reported fishing fewer than 100 hooks per set (the lowest 1% of the range of hooks/set) and longline trips that reported more than 24 sets per day. Finally, data from

handline trips that reported fishing more than 24 hours per day were removed from the data set.

Index Development

Handline

For the handline index, five factors were considered as possible influences on the proportion of trips that landed mutton snapper and the cpue of trips that landed mutton snapper. The factors are summarized below:

Factor	Levels	Value
YEAR	17	1990-2006
AREA	10	Figure 1 areas: 1, 2, 3-7, 2479-2480, 2481, 2482, 2579-2580, 2679-2580, 2779-3081, 3100-3477
DAYS	4	1=1 day at sea, 2=2-3 days at sea, 4= 4-6 days at sea, 7=7-12 days at sea
MONTH	10	Month of the year, May and June excluded
CREW	3	1, 2, 3 or more crew members

The delta lognormal model approach (Lo et al. 1992) was used to develop standardized indices of abundance for the handline data. This method combines separate generalized linear model (GLM) analyses of the proportion of successful trips (trips that landed mutton snapper) and the catch rates on successful trips to construct a single standardized CPUE index. 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 each GLM procedure of proportion positive trips, a type-3 model was fit, a binomial error distribution was assumed, and the logit link was selected. The response variable was proportion successful trips. During the analysis of catch rates on successful trips, a type-3 model assuming lognormal error distribution was examined. The linking function selected was "normal", and the response variable was ln(CPUE). The response variable was calculated as: ln(CPUE) = ln(pounds of mutton snapper/hook hour). All 2-way interactions among significant main effects were examined.

A stepwise approach was used to quantify the relative importance of the factors. Each potential factor was added to the null model sequentially and the resulting reduction in deviance per degree of freedom 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 ($p<0.05$), and the reduction in deviance per degree of freedom was $\geq$1%. This model then became the base model, and the process was repeated, adding factors and interactions 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 model was fit using a SAS macro, GLIMMIX (Russ Wolfinger, SAS Institute). All factors were modeled as fixed effects except two-way interaction terms containing YEAR which 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.

Longline

In developing the longline index, the same factors considered for the handline index were also examined.

Factor	Levels	Value
YEAR	17	1990-2006
AREA	3	Figure 1 areas: 1-2, 3, 4-6
DAYS	4	1-8, 9-12, 13-21 days at sea
MONTH	10	Month of the year, May and June excluded
CREW	3	1-2, 3, 4 or more crew members

The delta lognormal model approach (Lo et al. 1992) was again used to develop standardized indices of abundance for the longline data using the methods described above for the handline index.

Results and Discussion

Size frequency data

Scatter plots of individual total lengths of mutton snapper landed by commercial vessels and measured by TIP port agents are shown in Figure 2. Sample sizes were low, ranging from 3 to 245 fish per year and are provided in Table 1. The average number of fish sampled per year was 138 in the Atlantic and 26 in the Gulf of Mexico. The handline/rod and reel data (Figure 2 A and B) indicates no clear relationship between minimum size regulations and the total length of landed mutton snapper. Most of the measured fish were above even the largest minimum size of 406.4 mm (16 inches) established in 1994. The mean size landed was always well above the 406.4 mm minimum size (the lowest was for Atlantic handline vessels in 1989 when the mean size of measured fish was 429.2 mm) and there were no apparent changes in mean length of landed mutton snapper coincident with changes in minimum size regulations. No effect on cpue due to changes in minimum size regulations was assumed for the construction of handline standardized indices of abundance.

All mutton snappers measured from longline vessels were larger than the largest minimum size of 406.4 mm established in 1994 (Figure 2 C and D). Sample sizes were often small, ranging from 2 to 802 individuals (Table 1). The average number of samples per year in the Gulf of Mexico was 132 and 262 average samples per year in the Atlantic. Provided there was no sampling bias, those data suggest that longline vessels since 1990 have landed mutton snapper larger than the largest minimum size implemented and that minimum size regulations have had little or no effect on longline mutton snapper cpue. A single sample from a longline vessel in the Gulf of Mexico was recorded as 70 mm, but this is likely a data entry error. Construction of longline standardized indices of abundance assumed no effect from changes in minimum size regulations.

Handline index of abundance

The final models for the binomial on proportion positive trips and the lognormal on CPUE of successful trips were:

PPT = AREA + DAYS at SEA + YEAR + AREA*YEAR

LN(CPUE) = DAYS at SEA + AREA + CREW + YEAR + AREA*YEAR + AREA*CREW

Binomial models that included either of the interaction terms AREA*DAYS at SEA or DAYS at SEA*YEAR failed to converge, therefore, those interaction terms were excluded from the analysis. The linear regression statistics of the final models are summarized in Table 2. Relative nominal CPUE, number of trips, proportion positive trips, and relative abundance indices are provided in Table 3 for the mutton snapper handline data. Sample sizes were 76 to 2,264 trips per year with the fewest trips in the period 1990-1992. During those years only a 20% random sample of commercial fishers in Florida were selected to report catch and effort data to the coastal logbook program. Positive trips ranged from 29 to 45%, much lower than the initial handline index that included all positive trips in addition to those trips identified by the Stephens and MacCall method as mutton snapper trips.

The delta-lognormal handline abundance indices, with 95% confidence intervals, are shown in Figure 3. Standardized catch rates developed from mutton snapper handline data were generally increasing over the time series. CPUE was highly variable from 1990-1994 and had higher CVs than in later years, perhaps due to small sample size. During the period 1996-1999, cpue was relatively unchanged. Catch rates decreased during 2000, but increased through 2003 and changed little since then. QQ plots of residuals for successful catch rates, frequency distributions of ln(CPUE) for positive catches, plots of residuals for lognormal models on successful catch rates by each main effect, and plots of chi-square residuals for the delta lognormal model on proportion successful trips by each main effect are shown in Figure 4. These data appear to have met the assumptions for the analysis.

Longline index of abundance

The final models for the binomial on proportion positive trips and the lognormal on CPUE of successful trips were:

PPT = AREA + YEAR + DAYS at SEA

LN(CPUE) = AREA + YEAR + DAYS at SEA + AREA*YEAR

The linear regression statistics of the final model are summarized in Table 4. Relative nominal CPUE, number of trips, proportion positive trips, and relative abundance indices, 95% confidence intervals, and coefficients of variation are provided in Table 5 for the mutton snapper longline data. Sample sizes ranged from approximately 19 trips per year to 266 trips per year. Low sample sizes in the initial years of the time series were due to the 20% random sampling in Florida prior to 1993. Positive trips made up 39 to 64% of all mutton snapper trips per year. As with the handline data, the proportion positive trips was lower in this analysis than in the initial mutton snapper longline index of abundance (McCarthy, 2007) because only those trips identified by the Stephens-MacCall method as mutton snapper trips were used in the analysis.

The delta-lognormal longline abundance indices developed, with 95% confidence intervals, are shown in Figure 5. Mutton snapper standardized catch rates developed

from longline data increased gradually over the first half of the time series. After 1999, however, yearly mean CPUEs increased more substantially except for lower mean CPUE in 2001 and 2005. Confidence intervals became broader as the time series progressed for these data. Coefficients of variation, however, were largest in the first several years of the series. QQ plots of residuals for successful catch rates, frequency distributions of ln(CPUE) for positive catches, plots of residuals for lognormal models on successful catch rates by each main effect, and plots of chi-square residuals for the delta lognormal model on proportion successful trips by each main effect are shown in Figure 6. These data appear to have met the assumptions for the analysis.

The longline index had a greater increase in CPUE over time than did the handline index. Sample sizes were lower and coefficients of variation were greater for the longline index than the handline index. In addition, the effort measure used in the handline index (hook-hours) is a better effort measure than was the available effort measure used in the longline index (total hooks fished per trip). The longline index is also limited in spatial coverage compared to the range of the mutton snapper fishery and the spatial coverage of the handline data. In spite of those differences, the CPUE trends are in general agreement between the two indices with higher mean CPUEs late in the time series of both indices. The initial indices of abundance constructed from commercial handline and longline data differ little from the indices presented here, aside from the longer time series in the revised indices (Figures 7 and 8).

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.

McCarthy, K. 2007. Standardized catch rates of mutton snapper from the United States Gulf of Mexico and South Atlantic handline and longline fisheries, 1990-2006. SEDAR DW-15A-09. SFD-2007-

13.

Stephens, A. and A. MacCall. 2004. A multispecies approach to subsetting logbook data for purposes of estimating CPUE. Fish. Res. 70:299-310.

Table 1. Sample sizes of measured mutton snapper from Atlantic and Gulf of Mexico commercial handline and longline vessel landings.

Year	Atlantic		Gulf of Mexico	
	handline	longline	handline	longline
1990	74	71	3	22
1991	202	66	13	37
1992	216	190	9	31
1993	152	30	14	110
1994	89	102	22	117
1995	245	26	18	89
1996	58	2	57	84
1997	161	55	60	183
1998	145	262	34	587
1999	182	424	20	802
2000	171	367	37	366
2001	90	75	59	480
2002	117	42	36	336
2003	99	105	9	423
2004	163	170	11	199
2005	94	121	21	157
2006	87	130	19	433
Total	2,345	2,238	442	4,456

Table 2. Linear regression statistics for the final GLM models on proportion positive trips (a) and catch rates on positive trips (b) for mutton snapper in the Gulf of Mexico for vessels reporting handline landings 1990-2006.

a.

source	df	% reduction dev/df	chi square	p>chi square
Area	9	4.28	1418.33	<0.0001
Days at sea	11	2.64	847.83	<0.0001
Year	16	0.18	43.28	0.0003
Area*Year	132	1.10	491.13	<0.0001

b.

source	df	% reduction dev/df	chi square	p>chi square
Days at sea	3	22.72	837.34	<0.0001
Area	9	10.09	274.79	<0.0001
Crew	2	2.89	77.44	<0.0001
Year	16	0.88	75.63	<0.0001
Area*Year	130	2.82	358.79	<0.0001
Area*Crew	18	1.25	127.44	<0.0001

Table 3. Handline relative nominal CPUE, number of trips, proportion positive trips, and relative abundance index for mutton snapper (1990-2005) in the Gulf of Mexico.

YEAR	Relative Nominal CPUE	Trips	Proportion Successful Trips	Relative Index	Lower 95% CI (Index)	Upper 95% CI (Index)	CV (Index)
1990	0.529062	76	0.447368	0.821502	0.4168	1.61916	0.349265
1991	0.803914	99	0.363636	1.289936	0.663679	2.507139	0.341661
1992	0.970832	578	0.403114	0.962631	0.682128	1.358481	0.173511
1993	1.219914	1,830	0.392896	1.146831	0.843629	1.559004	0.154431
1994	1.092995	2,022	0.361029	0.775275	0.566887	1.060267	0.157493
1995	0.977261	2,181	0.332875	0.858692	0.634176	1.162691	0.152416
1996	1.216038	2,264	0.33083	0.994414	0.734991	1.345404	0.152015
1997	1.158785	2,200	0.347727	0.914474	0.676691	1.235812	0.151425
1998	0.996354	1,755	0.321368	0.986621	0.725125	1.342419	0.154888
1999	0.798362	1,607	0.29496	0.868927	0.630908	1.196743	0.16108
2000	0.601347	1,644	0.316302	0.725607	0.530787	0.991934	0.157284
2001	0.927845	1,662	0.304452	0.961591	0.702406	1.316414	0.158012
2002	1.339774	1,859	0.351802	1.110981	0.820042	1.505141	0.152701
2003	1.31301	1,714	0.332555	1.198829	0.878252	1.636422	0.15653
2004	0.9824	1,759	0.324048	1.084486	0.795971	1.477577	0.155578
2005	1.031263	1,379	0.340827	1.11366	0.814868	1.522012	0.157148
2006	1.040845	1,156	0.32872	1.185543	0.854678	1.644494	0.164717

Table 4. Linear regression statistics for the final GLM models on proportion positive trips (a) and catch rates on positive trips (b) for mutton snapper in the Gulf of Mexico for vessels reporting longline landings 1990-2006.

a.

source	df	% reduction dev/df	chi square	p>chi square
Area	2	16.18	695.56	<0.0001
Year	16	1.72	97.41	<0.0001
Days at sea	2	1.91	65.16	<0.0001

b.

source	df	% reduction dev/df	chi square	p>chi square
Area	2	21.87	267.72	<0.0001
Year	16	9.10	157.51	<0.0001
Days at sea	2	3.47	58.23	<0.0001
Area*Year	31	3.62	89.30	<0.0001

Table 5. Longline relative nominal CPUE, number of trips, proportion positive trips, and relative abundance index for mutton snapper (1990-2005) in the Gulf of Mexico.

YEAR	Relative Nominal CPUE	Trips	Proportion Successful Trips	Relative Index	Lower 95% CI (Index)	Upper 95% CI (Index)	CV (Index)
1990	0.226114	19	0.473684	0.105271	0.026216	0.422717	0.788132
1991	0.251342	44	0.477273	0.40158	0.147444	1.093747	0.53412
1992	0.343107	45	0.4	0.470005	0.165736	1.332868	0.558649
1993	0.289495	135	0.392593	0.377013	0.163173	0.871094	0.437778
1994	0.803849	132	0.492424	0.65007	0.293857	1.438088	0.413162
1995	0.438806	144	0.506944	0.590953	0.27161	1.285757	0.403836
1996	0.378318	242	0.454545	0.398491	0.188417	0.842788	0.388039
1997	1.334329	253	0.565217	0.758331	0.368223	1.561733	0.373325
1998	1.358057	266	0.578947	0.737159	0.363056	1.496748	0.365521
1999	1.270027	182	0.478022	0.850902	0.396195	1.827472	0.396587
2000	1.719245	161	0.546584	1.317985	0.623833	2.784537	0.387455
2001	1.102011	176	0.596591	1.006202	0.48764	2.07621	0.374389
2002	1.01522	152	0.5	1.32654	0.619615	2.839999	0.394825
2003	1.766106	237	0.493671	1.483123	0.716454	3.070198	0.376171
2004	1.830992	239	0.58159	2.586274	1.280449	5.223804	0.362646
2005	1.177602	227	0.599119	1.475298	0.733762	2.966226	0.360138
2006	1.69538	263	0.642586	2.464802	1.23878	4.904218	0.354424

Figure 1. Gulf of Mexico and South Atlantic Coastal Logbook defined fishing areas.

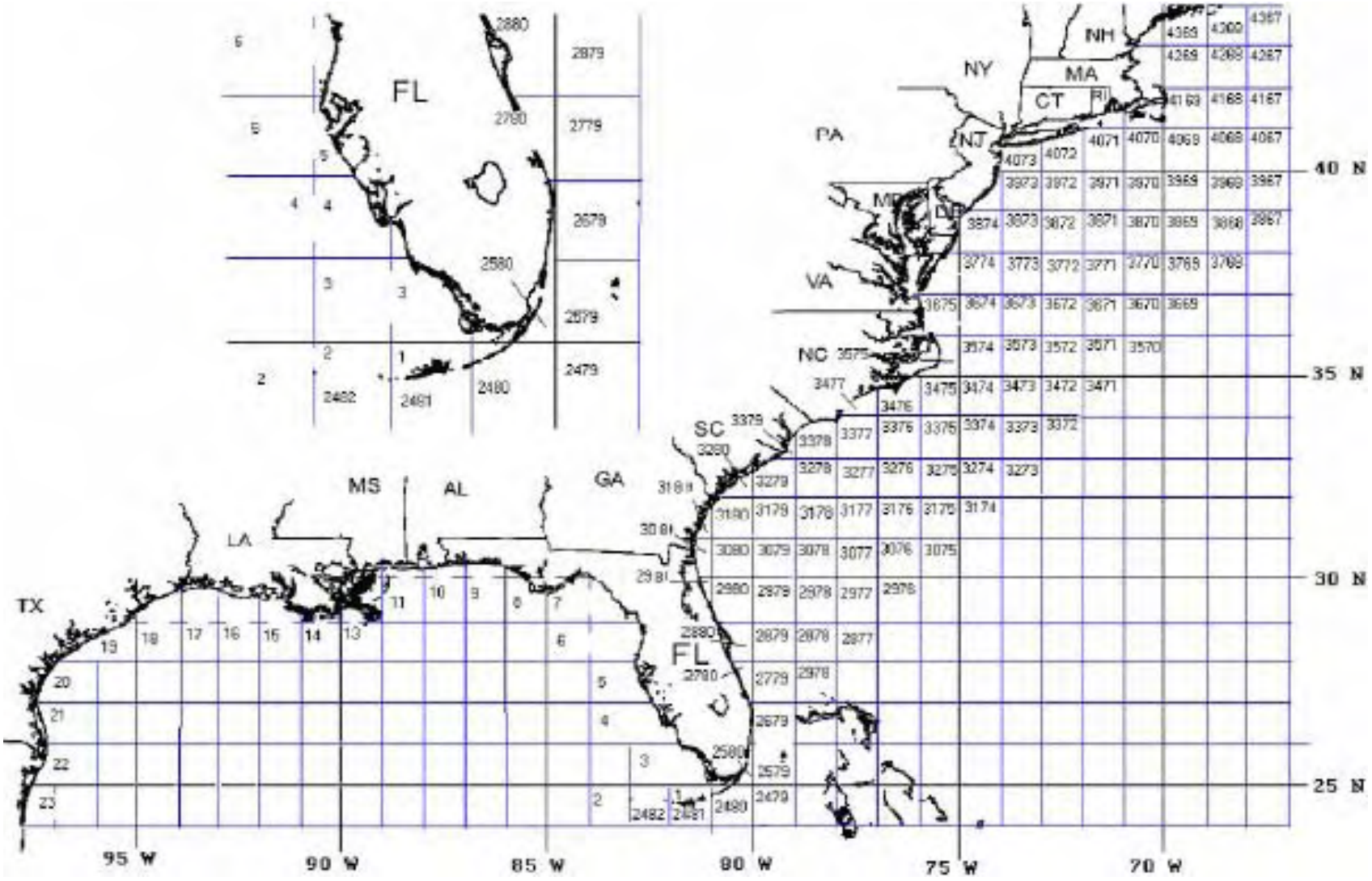
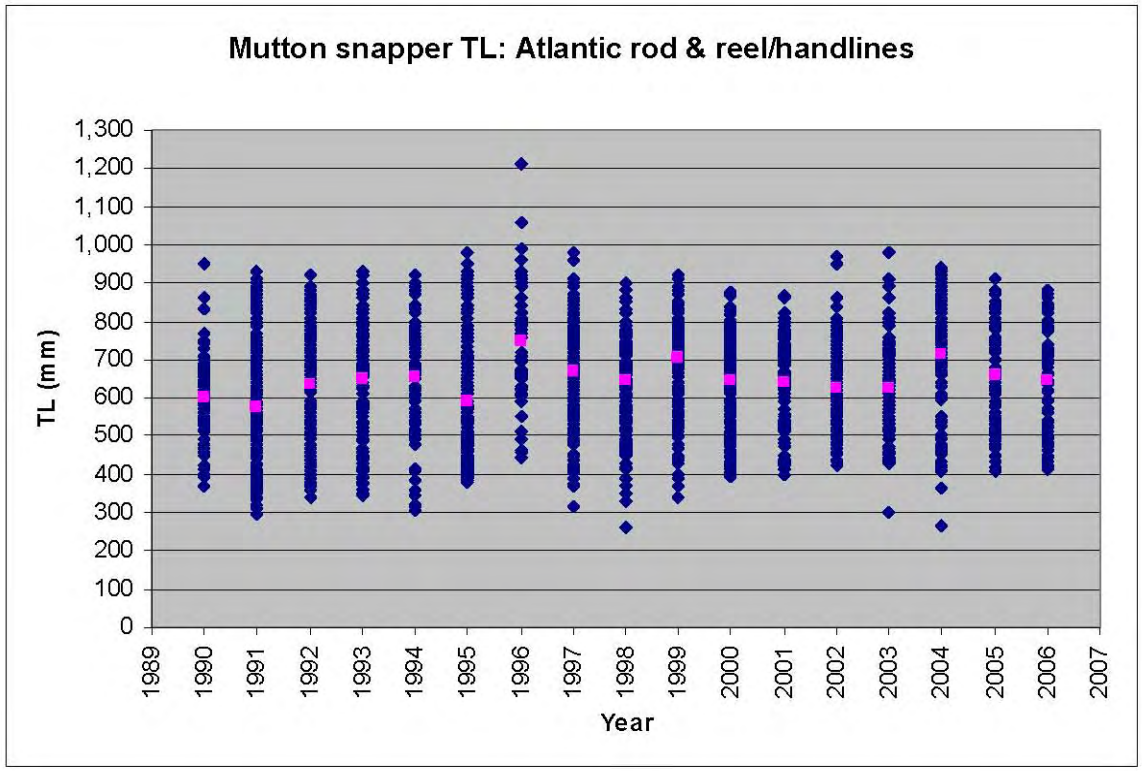


Figure 2. Total lengths of mutton snapper measured from commercial landings by the TIP; A. Atlantic handline vessel landings, B. Gulf of Mexico handline vessel landings, C. Atlantic longline vessel landings, D. Gulf of Mexico longline vessel landings.

A.



B.

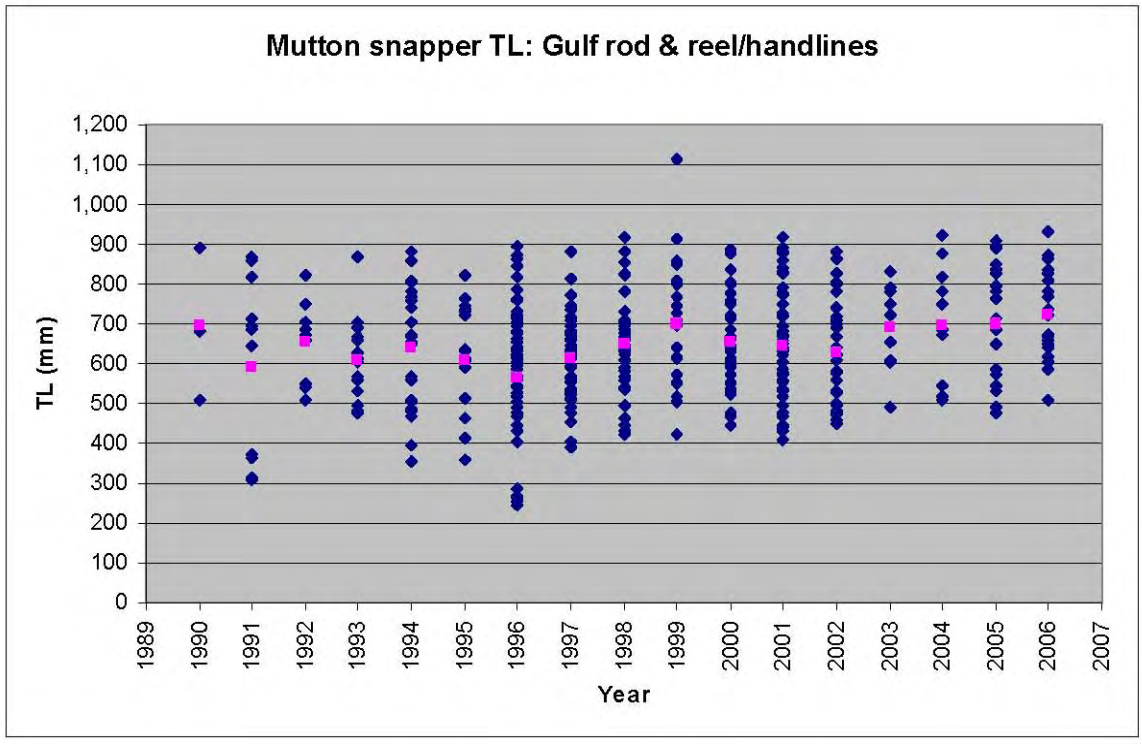
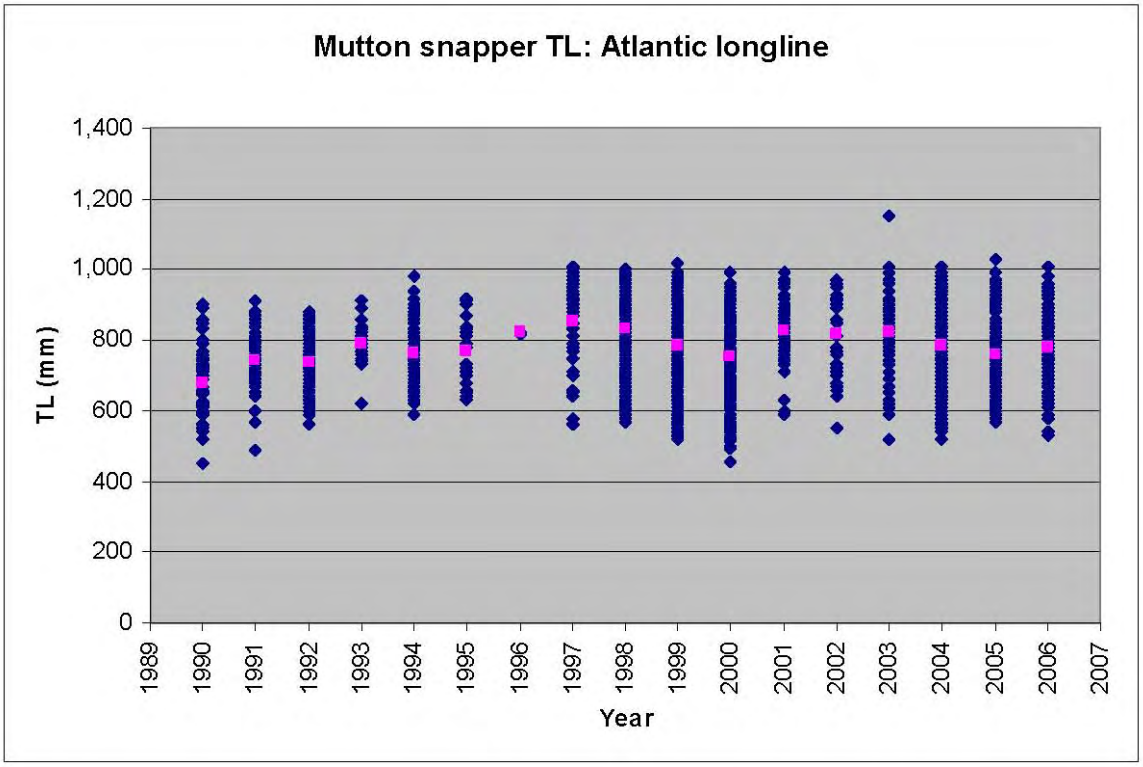


Figure 2. Continued.

C.



D.

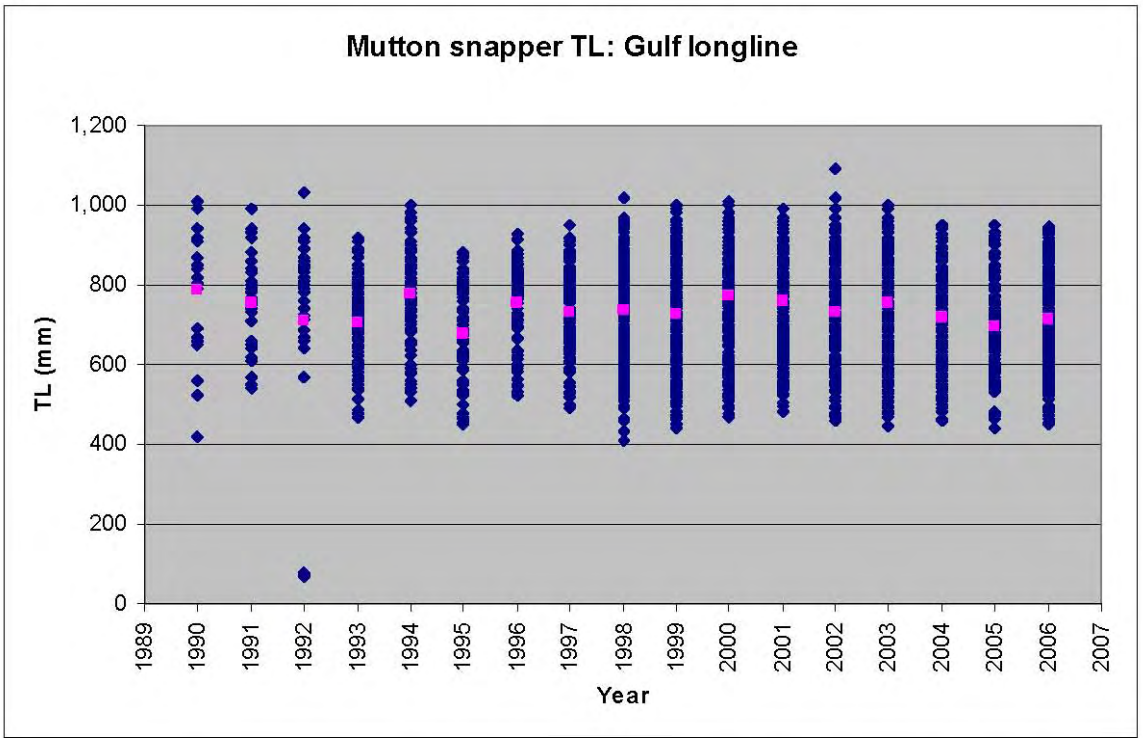


Figure 3. Mutton snapper (1990-2006) nominal CPUE (squares), standardized CPUE (diamonds) and upper and lower 95% confidence limits of the standardized CPUE estimates (dotted) for vessels fishing handlines in the Gulf of Mexico and South Atlantic.

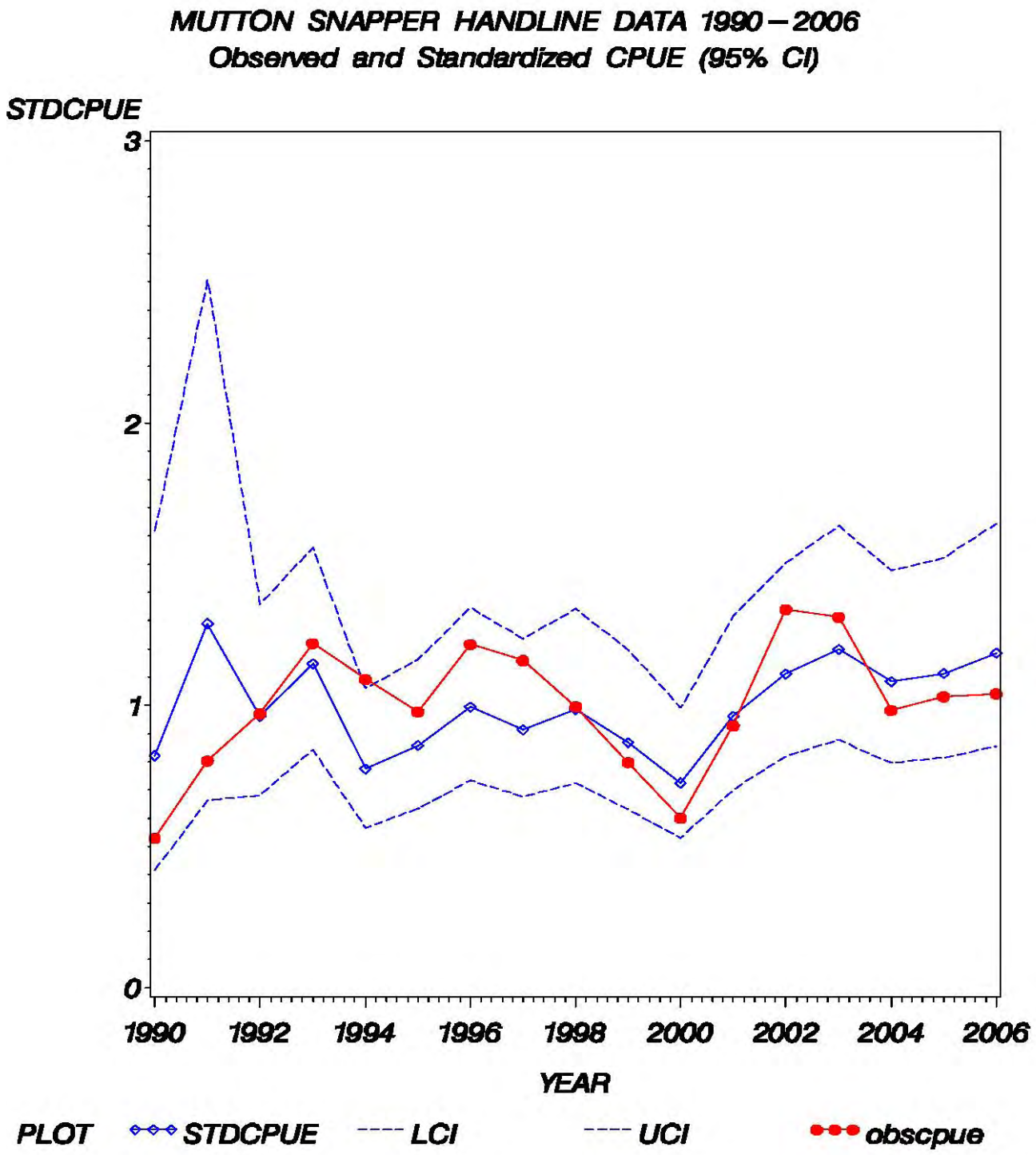
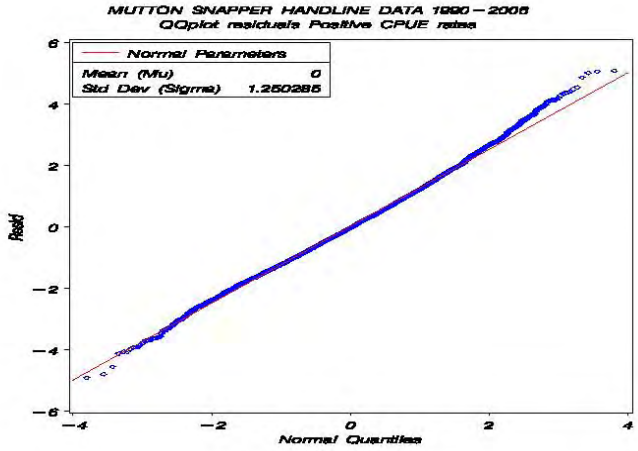
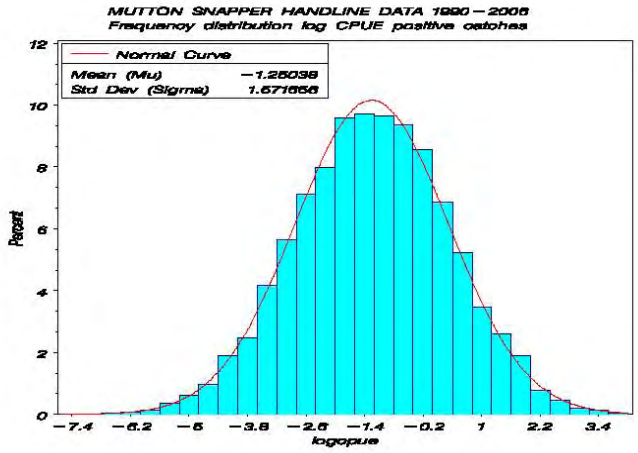


Figure 4. QQ plots of residuals (a), error distribution ln(CPUE) (b), residuals (c-f) of the final delta-lognormal model of successful catch rates, and residuals (g-i) of the final delta-lognormal of proportion positive catches for handline vessels landing mutton snapper, 1990-2006.

a.



b.



c.

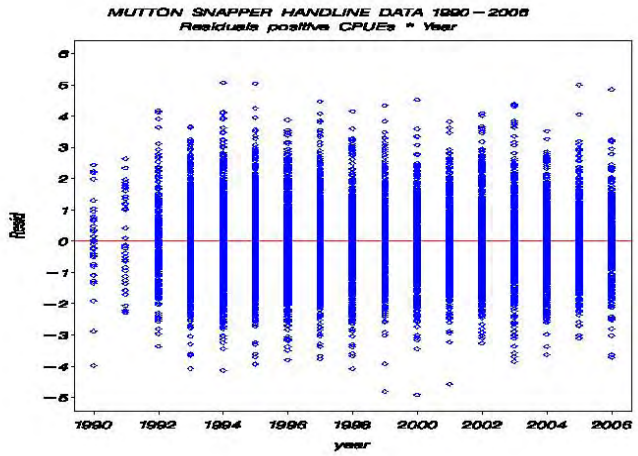
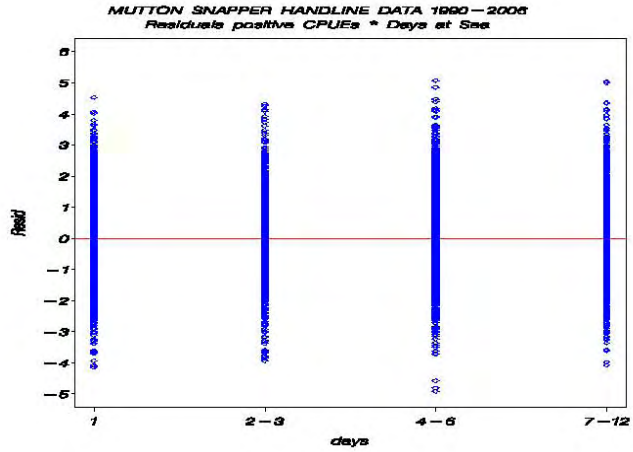
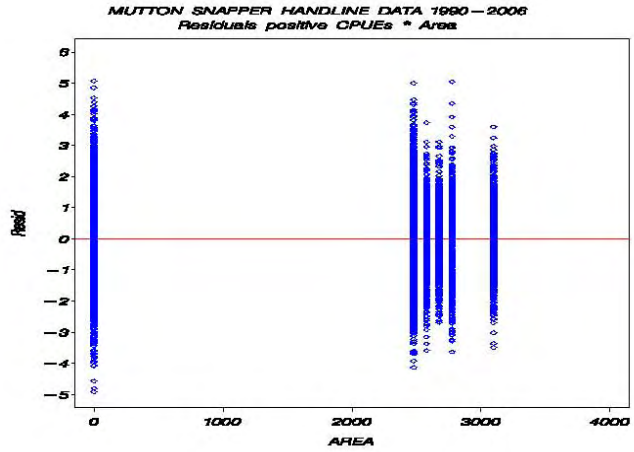


Figure 4. continued.

d.



e.



f.

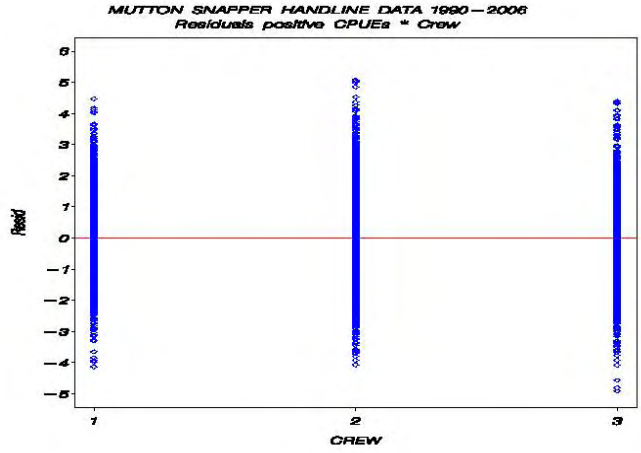
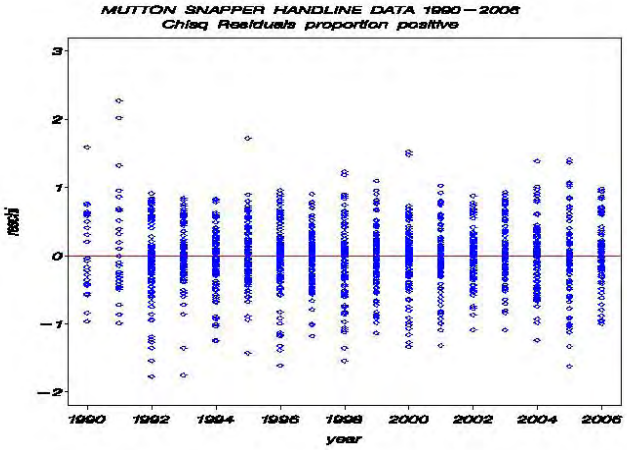
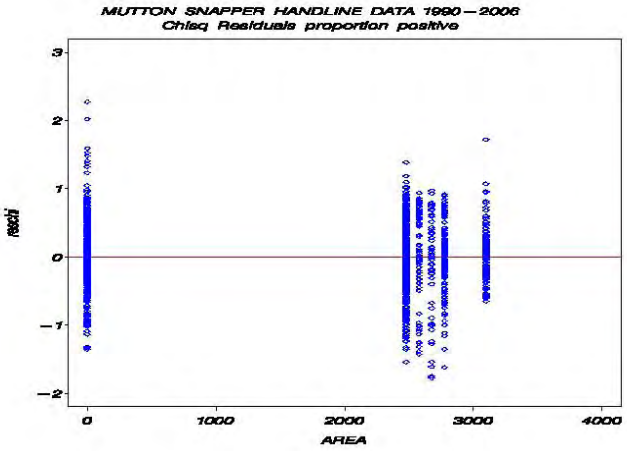


Figure 4. continued.

g.



h.



i.

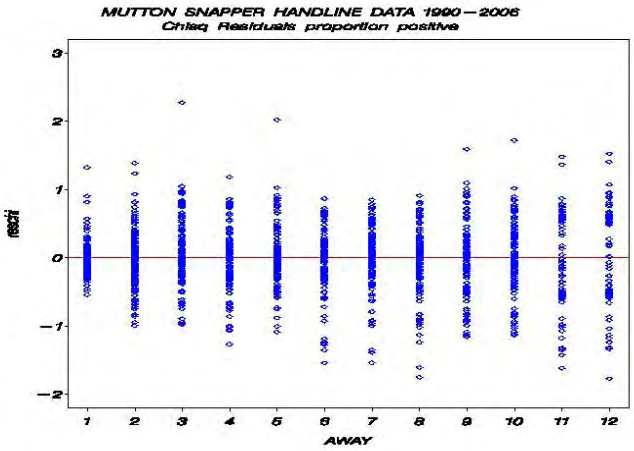


Figure 5. Mutton snapper (1990-2006) nominal CPUE (squares), standardized CPUE (diamonds) and upper and lower 95% confidence limits of the standardized CPUE estimates (dotted) for vessels fishing longlines in the Gulf of Mexico.

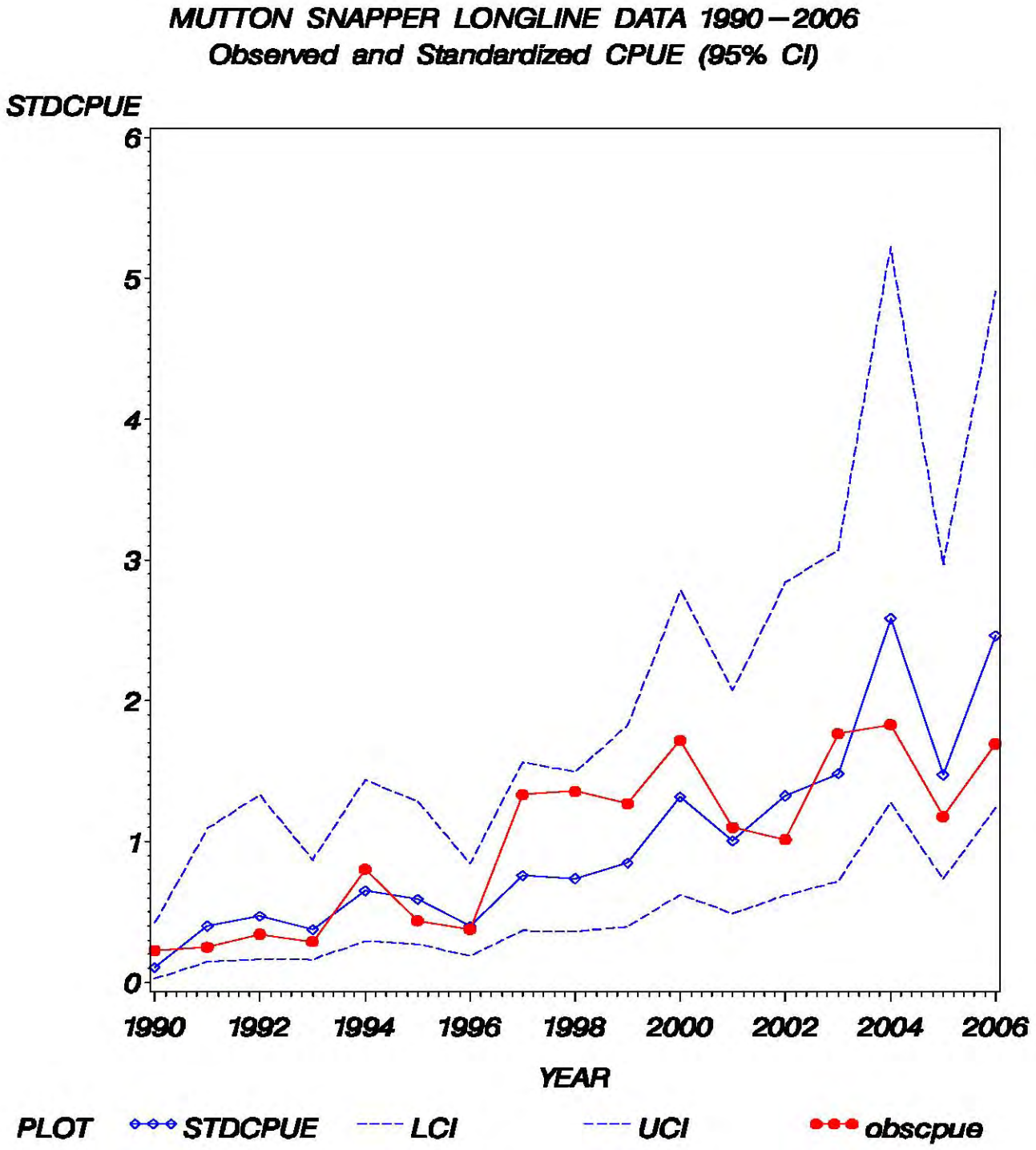
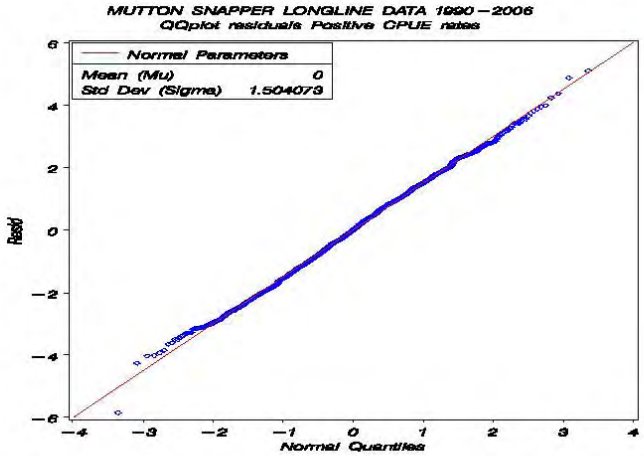
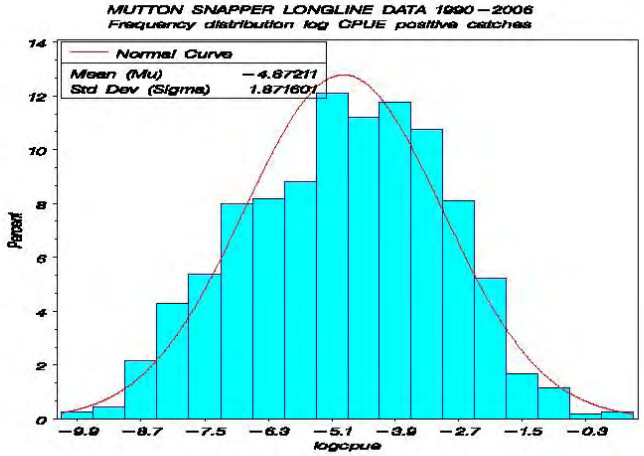


Figure 6. QQ plots of residuals (a), error distribution ln(CPUE) (b), residuals (c-e) of the final delta-lognormal model of successful catch rates, and residuals (f-h) of the final delta-lognormal of proportion positive catches for longline vessels landing mutton snapper, 1990-2006.

a.



b.



c.

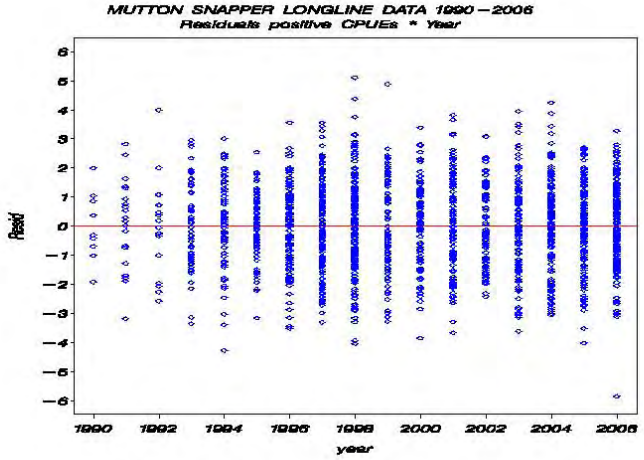
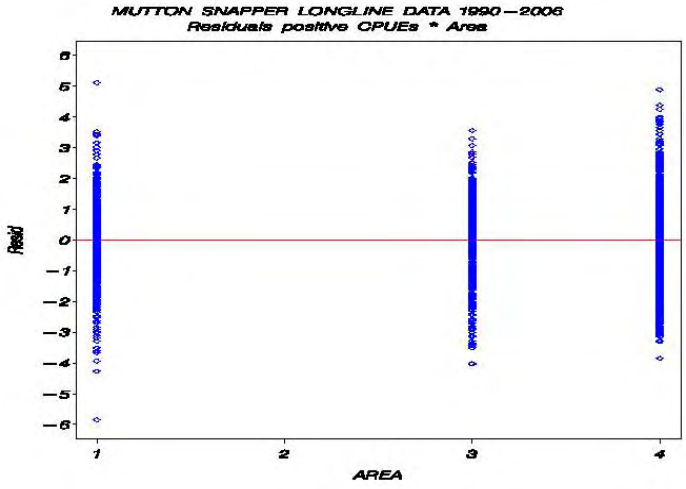
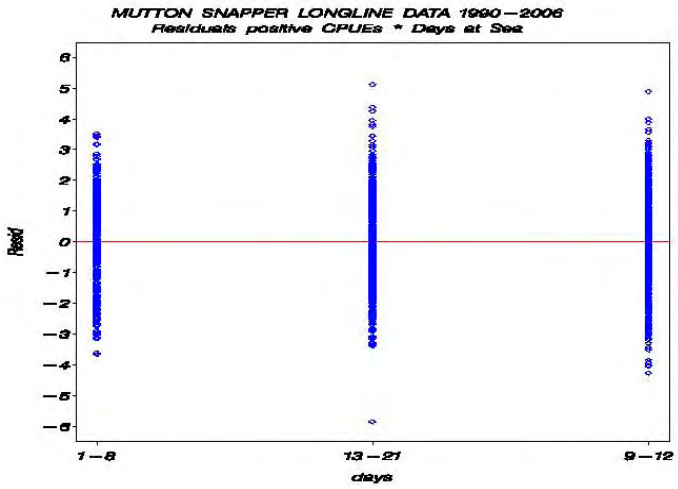


Figure 6. continued.

d.



e.



f.

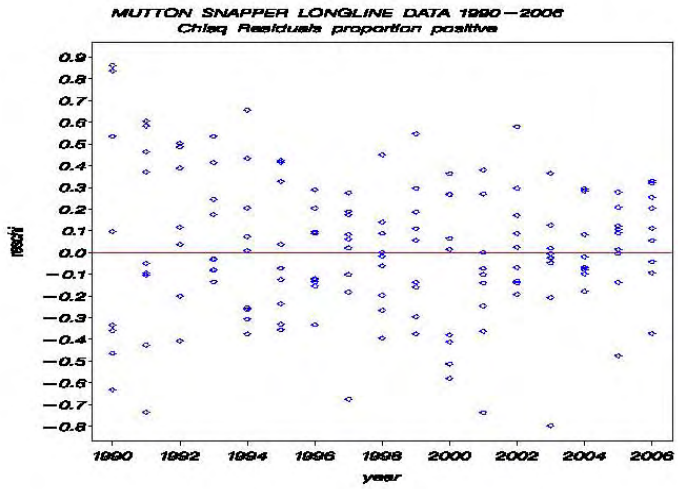
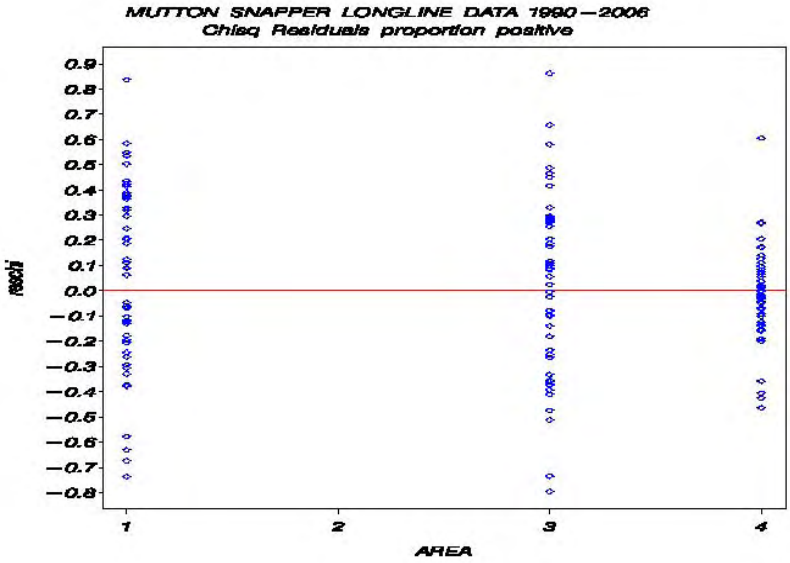


Figure 6. continued.

g.



h.

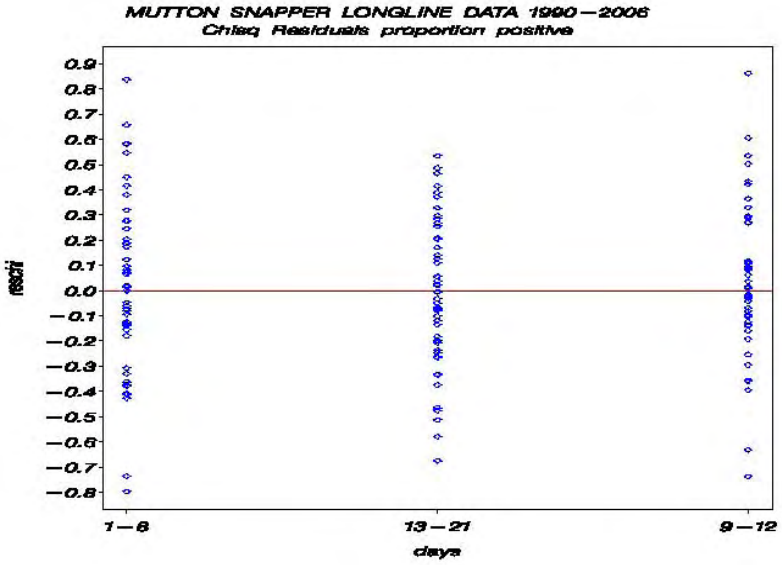


Figure 7. Initial and revised mutton snapper indices of abundance constructed from commercial handline data.

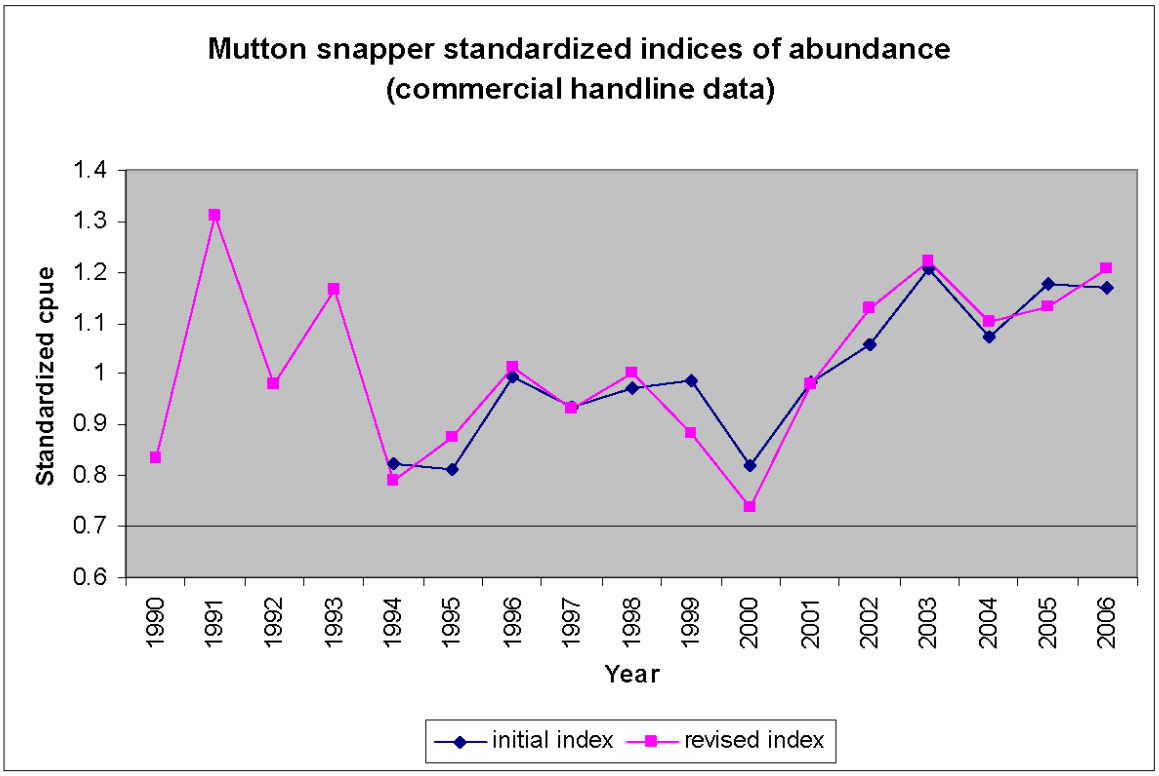


Figure 8. Initial and revised mutton snapper indices of abundance constructed from commercial longline data.