Catch Rates for Gag Caught in the Handline Fishery in the eastern Gulf of Mexico during 1991 to 2000 (Preliminary Results)

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Indices of abundance of Gulf of Mexico gag, *Mycteroperca microlepis*, were developed for use in a population-status assessment from catch and effort data reported in logbooks submitted to the National Marine Fisheries Service Logbook Program by permit holders in the handline fishery.

Data and Methods

Data were obtained from the Gulf of Mexico Reef Fish Logbook database, which contains data from early 1990 to present. The database and data extraction methods are described in Turner 1999. Because data were analyzed by area (NMFS Shrimp Statistical Grids) and gear type, all data from trips that reported fishing in more than one grid, or using more than one gear type, were eliminated from the analyses. We did not include data from Grid 1 because it includes Atlantic waters. Further, Grids 22-25 were not considered because they are in Mexican waters and data were generally not available from those grids. Discrimination between gag and black grouper was very good for the years being considered here, so we did not included black grouper catch in these analyses. Data were restricted in a number of additional ways.

First, data were restricted to the years 1991-2000. The data series was incomplete for 1990, apparently because it took a few months to get the program going, and incomplete for 2001 because the year is still in progress.

Second, data were restricted geographically. Figure 1 shows the total catch, on a relative scale, over the period 1991-2000 by grid. Appreciable amounts of gag were caught in grids 3-11 only, although substantial numbers of trips were run outside this area. Approximately 85% of the total catch came from grids 5-8, and 97% was caught in grids 3-11, hence for the generation of the catch-rate indices we used data from grids 3-11 only. This choice was supported by examination of geographic variation of measures such as the proportion of trips with gag catch, the per-trip catch rate, and the catch relative to the catch of all species.

A variety of potential measures of effort were considered for use in the generation of CPUE estimates. The database contained information on the length of fishing trips (*TripLen*; days), the total amount of time spent fishing (i.e. the total amount of time that lines were in the water; *TimeFished*; hours), the number of handlines used during the trip (*Lines*), and the average number of hooks per line (*Hooks/Line*). The most obvious handline effort measure to use in the calculation of handline CPUE, and one that has been used in similar assessments, is the composite measure *hook-hours*, which is obtained from the product of the variables *Lines*, *Hooks/Line* and *TimeFished*. Unfortunately, a problem was discovered in the database, suggesting that for a significant number of trips, the total number of hooks (product of *Lines* and *Hooks/Line*), rather than *Hooks/Line* was recorded. Methods for correcting these problems are being investigated, but the measure *hook-hours* could not be used in these analyses. Even taking this source of error into account it is apparent that there was a large variation in the number of hooks-per-line across the other effort measures. Therefore, we chose to use *TripLen* (*Days*) as the measure of effort. We chose not to use alternate measures such as *Lines, TimeFished (hours), Line-Hours* or *Line-Days*, because they provided a logically incomplete description of effort, and were not as stable as *TripLen*. Nonetheless, we found that nominal CPUE indices constructed from these effort measures to be very similar to that using *TripLen* (*days*) (Figure 2).

In constructing an abundance index using the CPUE measure *Catch-by-TripLen (lbs/day)* we considered the effects of year, month, grid, and the effort measures *Lines* and *TimeFished*. The final data restriction involved eliminating records when these variables had missing values, values of zero, very large values (*TripLen* > 14 days, *Lines* > 8, *TimeFished* > 160 hours), or logically inconsistent values (records where a derived measure time-fished-per-day, hours/day, was greater than 24).

Because 1) a large proportion of trips had no gag catch, 2) most trips with gag catch caught relatively little gag, and 3) a very few trips caught very large amounts of gag, the distribution of catch values (and, therefore, CPUE values) had 1) a very large zero class, 2) a mode in non-zero classes near zero, and 3) a very long right-hand tail. Thus, we chose to use a 'delta-distribution' approach to model these data. In this situation a binomial distribution is used to model the probability that a trip has gag catch (the proportion of trips with gag; often called the 'proportion positive'), and a separate distribution is used to model the non-zero catch-rate values (based on the approaches developed by previous workers, for example: Lo *et al*. 1992, Brown & Porch 1996, Ortiz *et al*. 1999, Turner 1999, Ortiz *et al*. 2000). Based on previous experience with similar data and examination of the distribution of catch values, we chose to use the Gamma distribution to model the non-zero values. The SAS Generalized Linear Models package (GenMod) was used to find the best models for the proportion of trips with gag (*ProPos*) and non-zero catch-rate (*PosCat*) as a function of a linear combination of the variables *Year, Grid, Month, TimeFished* and *Lines*, and their interactions. Combined annual indices and error measures (coefficients of variation, and 95% CI) were then obtained using output from the SAS module GlimMix.

Best models were found by an ad-hoc step-up procedure. The process began with a comparison of models containing each main effect to a null model. The factor producing the greatest change in model deviance per degree of freedom was added to the model and the process repeated until no factor caused a deviance/degree-of-freedom reduction greater than 1%. Because of the very large number of records in the dataset the contribution of every factor was statistically significant. Therefore, we used deviance as the measure of a factor's contribution to the model, and standardized by degree of freedom to improve the comparison among different factors. Two-way interactions were examined one at a time against the model containing the constituent main effects. Some models could not be fit do to numerical problems. In these situations, we tried to improve the balance of the design by pooling levels of a factor. Because the purpose of the modeling process was to produce standardized annual catch-rate estimates, year was included in a model regardless of the deviance reduction it produced.

Results

Proportion Positive. The following main effects were included in the model (percent reduction in deviance/df compared to the null model shown in parentheses): *Grid* (5.9%), *Year* (3.4%), and *Lines* (1.0%). To overcome numerical fitting problems, we used a pooled categorization of *Lines* (1, 2, 3, 4, 5-8). No two-way interactions were found to be important. The relationships between *ProPos* and the variables *Grid*, *Year* and *Lines* are shown in figures 3-5.

The proportion of trips with gag showed a similar geographic variation to that for total catch, although there are some interesting differences (Figure 3). Gag were caught on over half of all trips in grids 5-7, on roughly a third of the trips in grids 3,4 and 8, and on approximately a fourth of the trips in the northern grids of 9-11. The proportion of trips with gag catch across all grids showed a monotonic increase from less that 20% in 1991 to 50% in 2000, with significant jumps 1992, 1993 and 1997 (Figure 4). Gag were most likely (approximately 49%) to be caught on trips where two handlines were used, moderately likely (39-43%) when 1, 3 or 4 lines were used and much less likely (27%) when five or more lines were employed (Figure 5).

Positive Catch-Rate. The following main effects were included in the model (percent reduction in deviance/df compared to the null model shown in parentheses): *Grid* (12.6%), *Month* (5.9%), and *Year* (2.7%); *TimeFished* met the criteria for inclusion when compared to the null model (1.4%), but not when the more important factors had been added to the model. No two-way interactions were found to be important. The relationships between *PosCat* and the variables *Grid*, *Month* and *Year* are shown in figures 6-8.

The amount of gag caught per day on trips with gag was highest (approximately 140 lbs/day) in grids 7 and 8, moderately high (86-110 lbs/day) in grids 5, 6 and 9, and low (25-50 lbs/day) in the remaining grids (Figure 6). Gag catch rate on trips with gag showed a very strong seasonal signal, varying from a high (123-139 lbs/day) early in the spawning season in (November - January), holding at 91-94 lbs/day during the peak and late spawning season, and dropping to a low (54-63 lbs/day) during the non-spawning season (July - September) (Figure 7). Gag catch rate on those trips showed a clear trend over years, increasing from 60 to 111 lbs/day from 1991 to 2000 (Figure 8). Unusual peaks in the catch rate followed by dips in the trend occurred in 1995 and 1998; the highest catch rate recorded during the decade (119 lbs/day) occurred in 1998.

Abundance Index. The standardized catch per unit effort (catch per day) estimates and their CVs and/or 95% confidence limits, derived from combining the models described above, are shown in Table 1 and Figure 9; CV's are very small primarily because of the very large number of observations used in the regression. Handline CPUE showed a remarkable increase of approximately 400% from 1991 to 1998, after which it leveled off. This increase was produced by the steady increase in the proportion of trips catching gag (Figure 4), the overall increase in the catch rate of gag on those trips (Figure 8), which combine to produce a rapidly increasing catch, and a declining length of trips (effort) during the decade (Figure 10).

Table 1. Standardized catch per unit effort (catch per day; on a relative scale) annual estimates obtained using a Generalized Linear Model.

Year	Mean CPUE	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Coefficient of Variation
1991	0.337	0.272	0.402	.098
1992	0.474	0.395	0.554	.085
1993	0.739	0.673	0.806	.046
1994	0.715	0.660	0.770	.040
1995	0.892	0.824	0.959	.039
1996	0.954	0.885	1.024	.037
1997	1.051	0.982	1.121	.034
1998	1.676	1.589	1.763	.026
1999	1.464	1.391	1.537	.025
2000	1.697	1.615	1.779	.025

Acknowledgements

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References

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Figures

Figure 1. Total catch of gag in the handline fishery over the years 1991 – 2000 for the database excluding multi-grid and multi-gear trips; numbers above each bar are the number of trips used from the given grid.

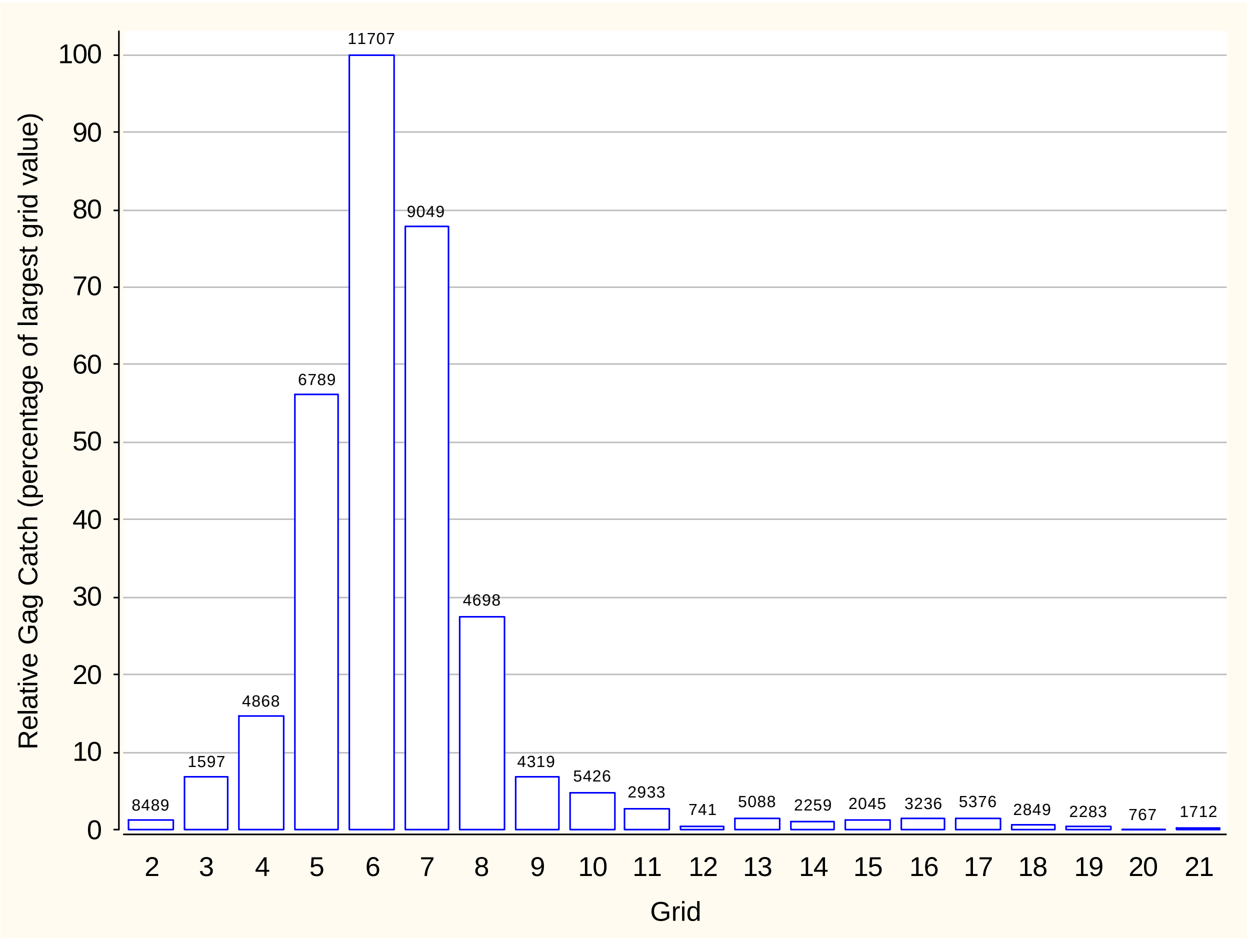

Figure 2. Nominal CPUE indices for 1991 to 2000, shown on a relative scale to facilitate comparison of measures with different units.

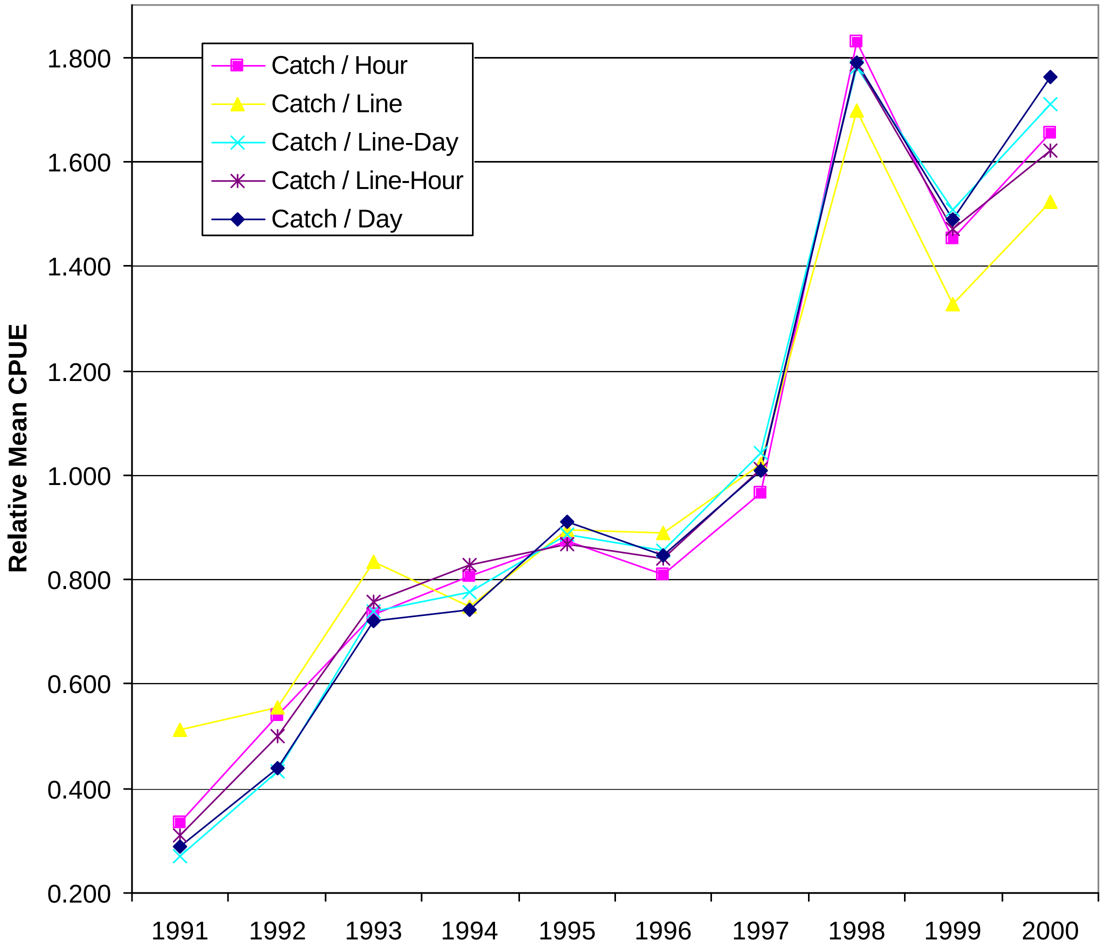

Figure 3. Proportion of trips with gag catch (*ProPos*) for grids 3-11.

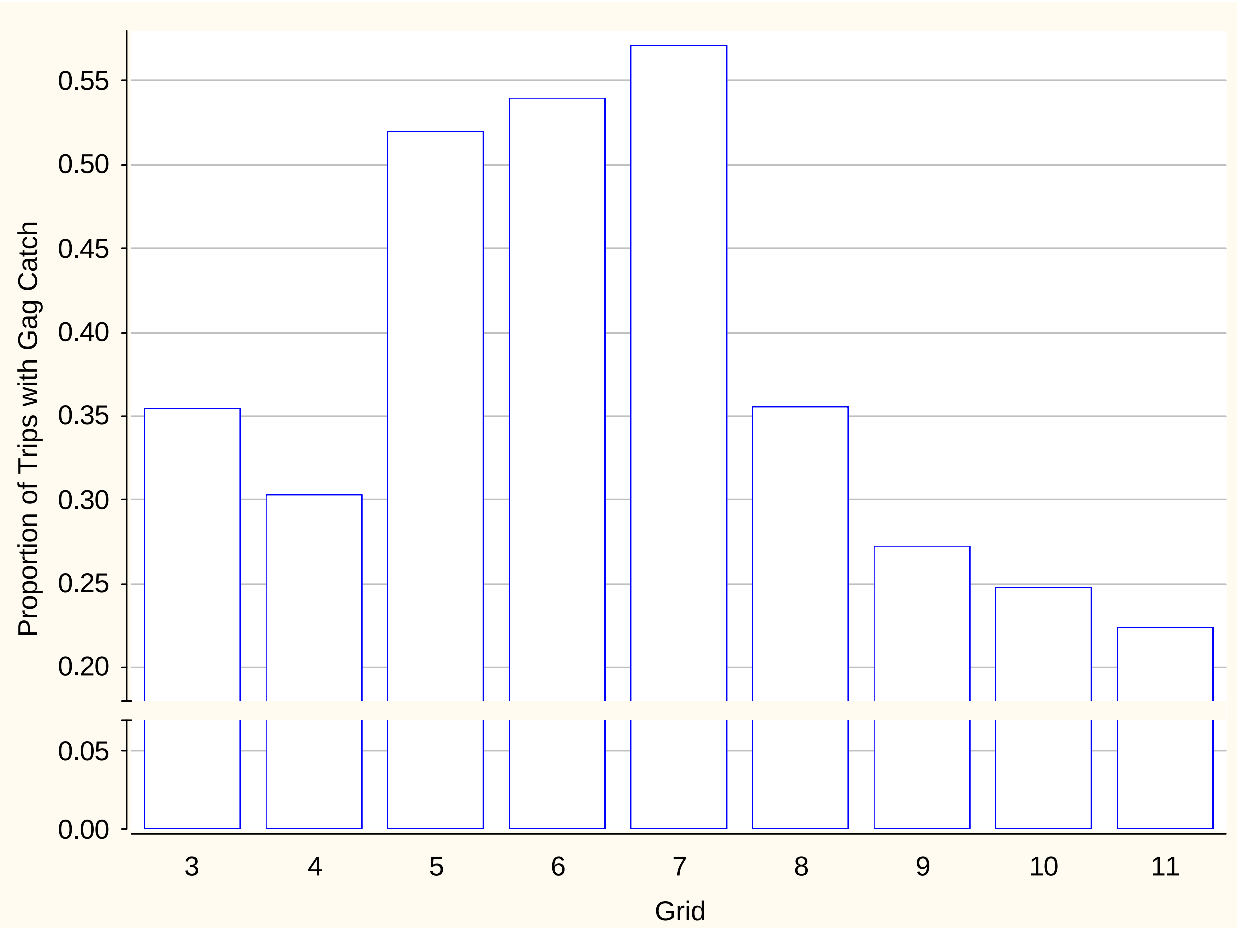

Figure 4. Proportion of trips with gag catch (*ProPos*) for years 1991-2000.

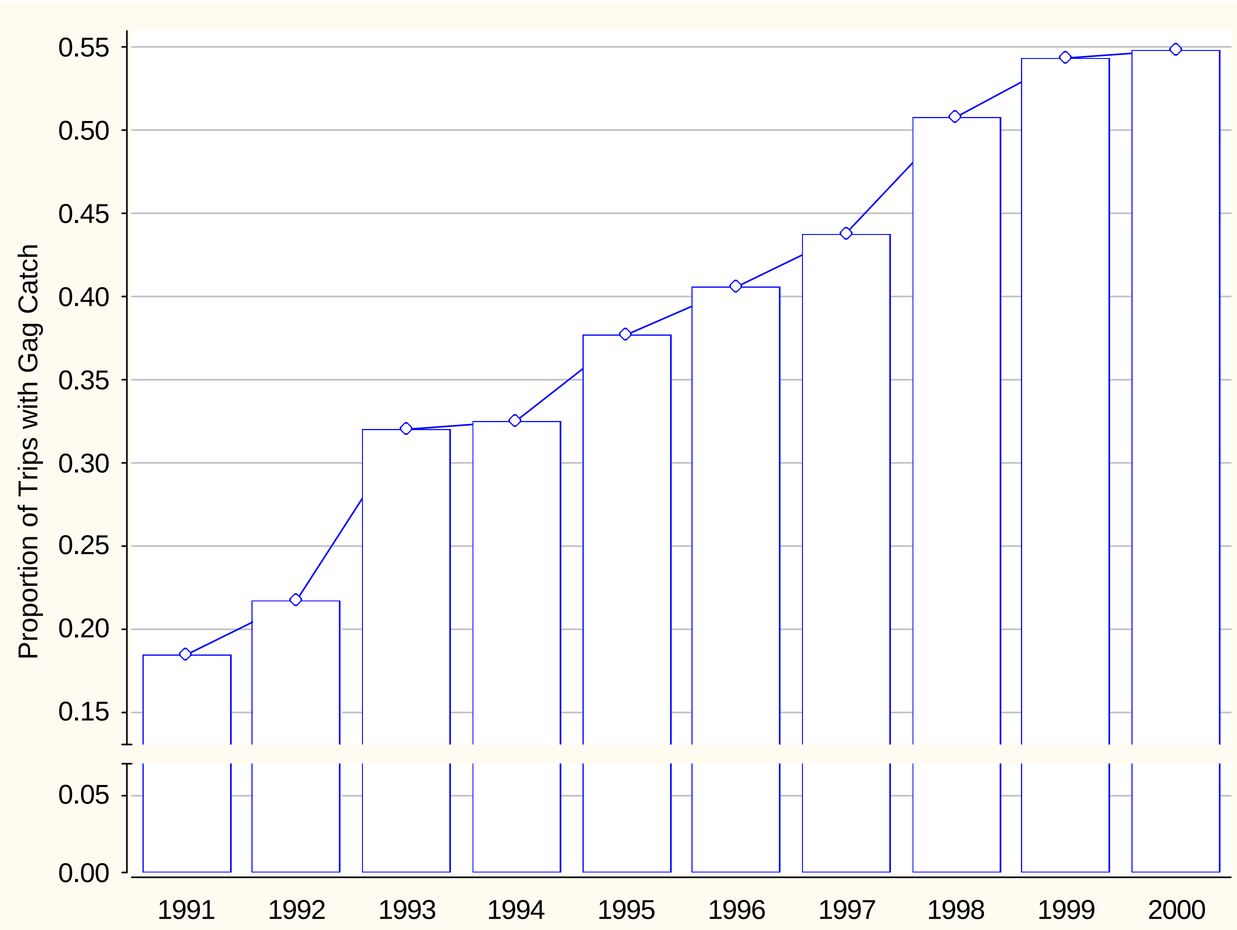

Figure 5. Proportion of trips with gag catch (*ProPos*) vs number of handlines.

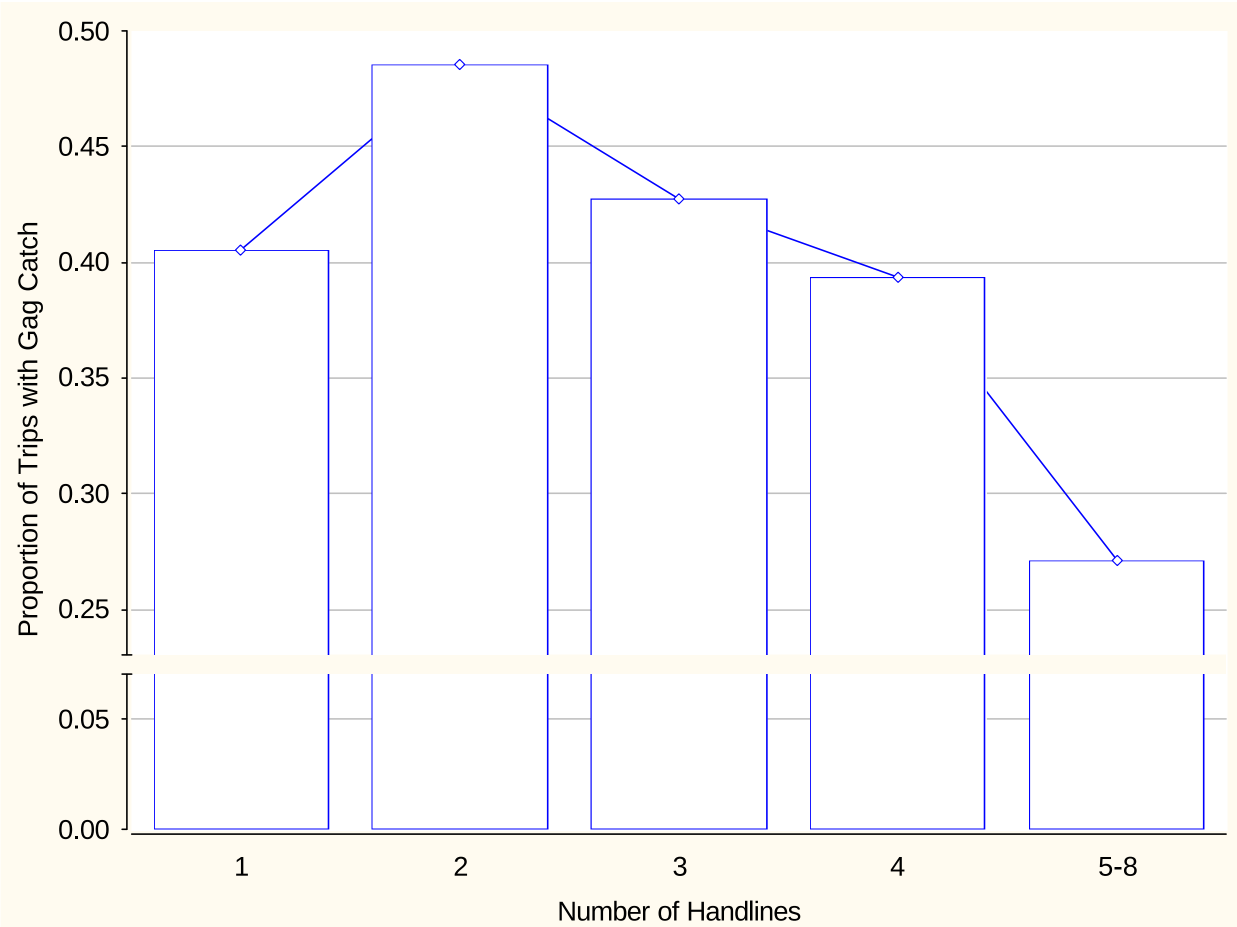

Figure 6. Mean gag catch rate for trips with gag catch (*PosCat*) for grids 3-11.

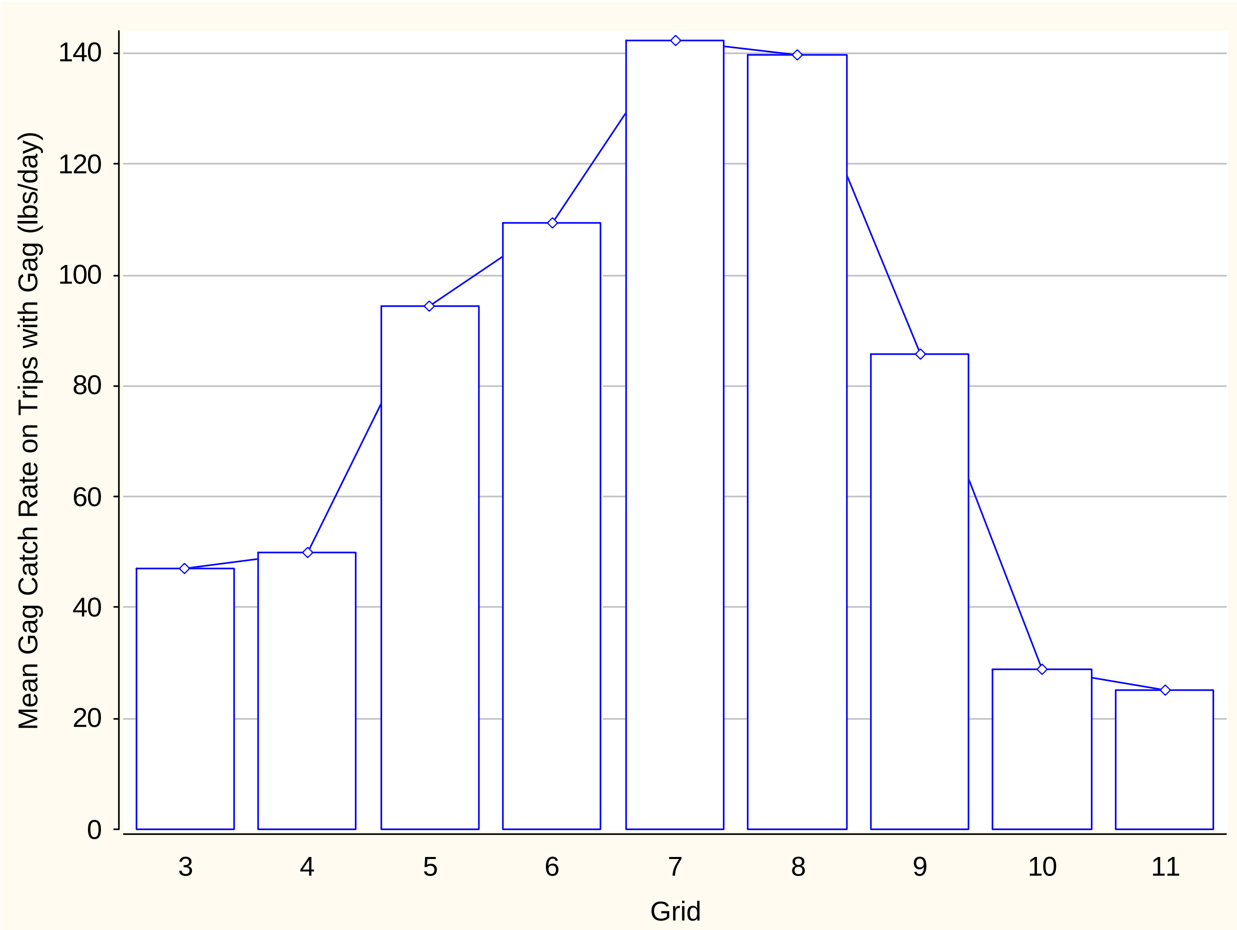

Figure 7. Mean gag catch rate for trips with gag catch (*PosCat*) by months.

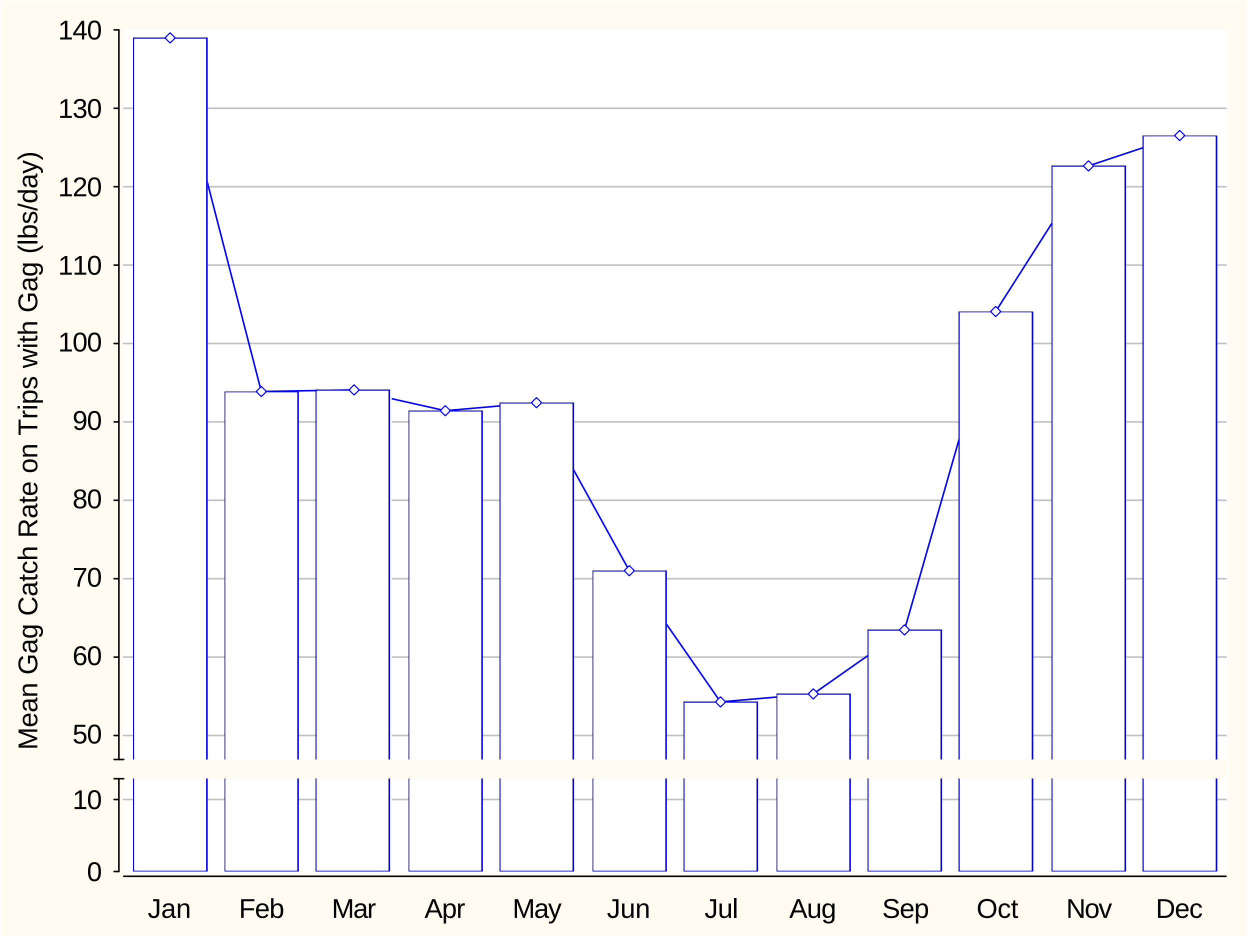

Figure 8. Mean gag catch rate for trips with gag catch (*PosCat*) for years 1991-2000.

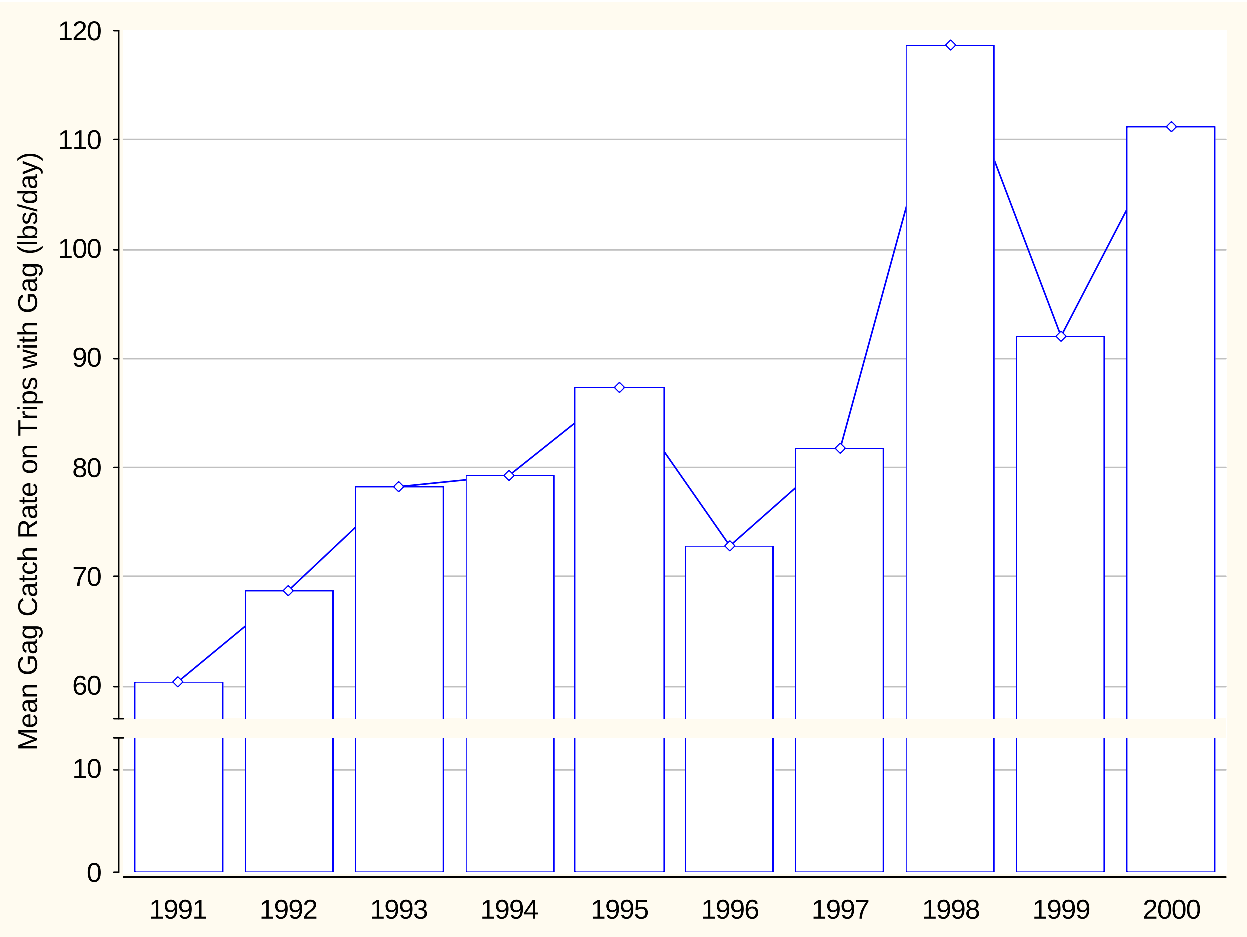

Figure 9. GLM-standardized CPUE (on a relative scale) for years 1991-2000, with 95% confidence limits.

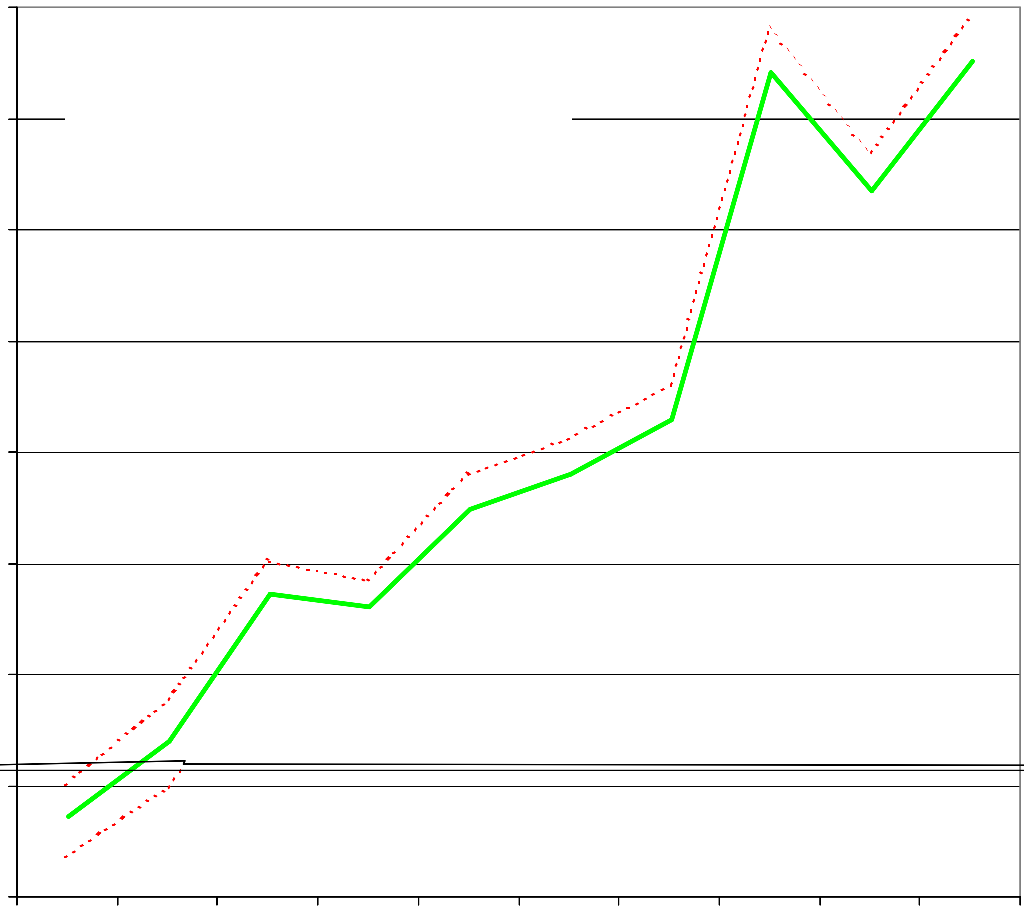

Figure 10. Mean trip length for years 1991-2000.