Catch Rates for Gag Caught in the Trap 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 longline fishery.

Materials 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 2-7 only, which also accounted for virtually all of the trap effort in the Gulf of Mexico. Approximately 95% of gag were caught in the disjoint area covered by grids 2 and 3 (28%) and 6 and 7 (66%), with over 98% of all gag being caught in grids 2-7. Therefore, for the generation of the catch-rate indices we used data from grids 2-7 only, and in some cases dropped the data from grids 4 and 5, which accounted for just 4% of all trips.

A variety of potential measures of effort were considered for use in the generation of trap CPUE estimates. The database contained information on the length of fishing trips (*TripLen*; days), the number of traps used during the trip (*Traps*), the total number of trap hauls made during the trip (*Hauls*), and the total soak time (*SoakTime*; hours). The most obvious effort measure to use in the calculation of trap CPUE, and one that has been used in similar assessments, is the composite measure *trap-hours*, which would be the product of the variables *Hauls* and *SoakTime*. Unfortunately, two problems were discovered in the database. It is apparent that for a significant proportion of trips what was recorded in logbooks was hauls-per-trap (rather than the required total number of trap hauls) and/or soak-time-per-haul (rather than the required total soak time). This meant that any effort measures using the variables *Hauls* and *SoakTime* would be significantly biased. Methods for correcting these problems are being investigated, but the measure *trap-hours* could not be used in these analyses. We examined the effort-measure candidates *TripLen*, *Traps* and *Traps*-by-*TripLen* (*trap-days*) (Figure 2), and found that *TripLen* (days) provided the most stable measure.

In constructing an abundance index using the CPUE measure *Catch-by-TripLen (lbs/day)* we considered the effects of month, grid, and the effort measure *Traps*. The final data restriction involved eliminating records when these variables had missing values, values of zero, or very large values (*TripLen* > 15 days, *Traps* > 100).

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*, and *Traps*, 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): categorized *TripLen* (4.5%) *Year* (3.3%), and *Grid* (3.0%). To overcome numerical fitting problems, we used a pooled categorization of *TripLen* (1-2, 3-4, 5-8, 9-11, 12-15 days), and dropped grids 4 and 5 from *Grid* leaving grids 2, 3, 6 and 7. The interaction between *Year* and *Grid* was found to be important. Following Cooke (1996), we are investigating the use of a random-effects model to enable its contribution to be included in the standardization of catch rate, but for the analyses presented here we used a fixed-effects model without the interaction. The interaction is described to help in interpreting the index presented below.

The relationships between *ProPos* and the variables *TripLen, Year* and *Grid* are shown in figures 3-5. The proportion of trips with gag catch increased with trip length (Figure 3), as would be expected; all other things being equal, the longer the trip the greater probability of catching gag. The proportion of trips with gag catch increased in two phases during the decade (Figure 4), jumping from approximately 8% of trips with gag in 1991 and 1992, to 13-15% from 1993-1996, and then climbing steadily to a peak of 31% in 2000. The probability of catching gag was similar in grids 2, 6 & 7 (0.11-0.14), but roughly two-three times greater in grid 3 (0.31) (Figure 5). The interaction between *Year* and *Grid* can be seen in the presence of different *ProPos* vs *Year* patterns in the different grids (Figure 6). ProPos did not show a trend with time in Grid 2. However, in the other grids, the proportion of trips with gag generally increased from the mid-90's, peaking and then declining in grid 3, but continuing to increase in the northern grids (6 & 7). Thus, we can see that the overall pattern seen for the main effect *Year* was driven by the dynamics occurring in grids 3, 6 & 7. In addition, we can see that the dominance of grid 3 over the other grids was true most of the time, but was breaking down at the end of the decade as the proportion of trips with gag catch in grids 6 and 7 was approaching that seen in grid 3.

Positive Catch. The following main effects were included in the model (percent reduction in deviance/df compared to the null model shown in parentheses): *Grid* (19.8%), *Year* (4.3%), and categorized *Traps* (3.2%). The interactions *Year* by *Grid* and *Year* by *Traps* (categorized) were found to be important. Again, we are investigating the use of a random-effects model, as described by Cooke (1996), to enable the contribution of these interactions to be included in the standardization of catch rate. However, for the analyses presented here we used a fixed-effects model without these interactions. The interaction are described to help in interpreting the index presented below.

The relationships between *PosCat* and the variables *Grid*, *Year*, and *Traps* are shown in figures 7-9. Interestingly the southern-most grid and northern-most grids showed the highest mean gag catch on gag trips (18 and 28 lbs/day, respectively; Figure 7). The central grids showed much lower catch levels (7 and 10 lbs/day). *PosCat* varied considerably during the decade, but did not show a consistent trend, appearing to going through two cycles of increase and decrease, and showing nearly a seven-fold increase between the low (1991) and high (1994) years (Figure 8); the 2.2-fold range of variation from 1993 to 2000 was considerably lower, however. However, this pattern is the result of the summation of very different patterns exhibited in each grid (see below) rather than a common dynamic of the system. Gag catch on gag trips showed an interesting relationship with the number of traps used on a trip, being roughly 20 lbs/day for trap numbers less than 57, much lower for intermediate numbers of traps (58-72), and high again (16 lbs/day) when large numbers of traps (73-100) were used (Figure 9).

The significant interaction between *Year* and *Grid* results because the pattern of change in catch/rate is different in every grid (Figure 10), thus, making the interpretation above of the overall annual pattern of very limited use. Similarly the patterns of annual change in gag catch rate on gag trips was very different for trips using different numbers of traps (Figure 11). These interactions suggest that the trap fishery has differs on a small scale perhaps driven by regional differences in the behavior of the fishery rather than differences in the population of gag.

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 12; CV's are small primarily because of the relatively large number of observations used in the regression. Standardized catch per unit effort has been extremely volatile for the trap fishery, starting with a 17-fold increase in CPUE from 1991 to 1995. This was followed in the next year by a three-fold drop, and then a 3.4-fold increase from 1996 to 1998, after which it has leveled off. The pattern of change in mean *TripLen* (Figure 13) does not particularly help in the interpretation of this pattern. Based on the underlying patterns described above it appears that this complex pattern is driven by different dynamics occurring in the different grids, a possibility that is being examined through further analyses of these and other data.

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	0.092	0.020	0.165	0.401
1992	0.288	0.180	0.395	0.190
1993	0.635	0.488	0.782	0.118
1994	0.750	0.588	0.912	0.110
1995	1.611	1.185	2.038	0.135
1996	0.543	0.349	0.738	0.182
1997	0.789	0.546	1.031	0.157
1998	1.852	1.420	2.284	0.119
1999	1.800	1.297	2.304	0.143
2000	1.640	1.242	2.038	0.124

Acknowledgements

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Figures

Figure 1. Total catch of gag in the trap 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.

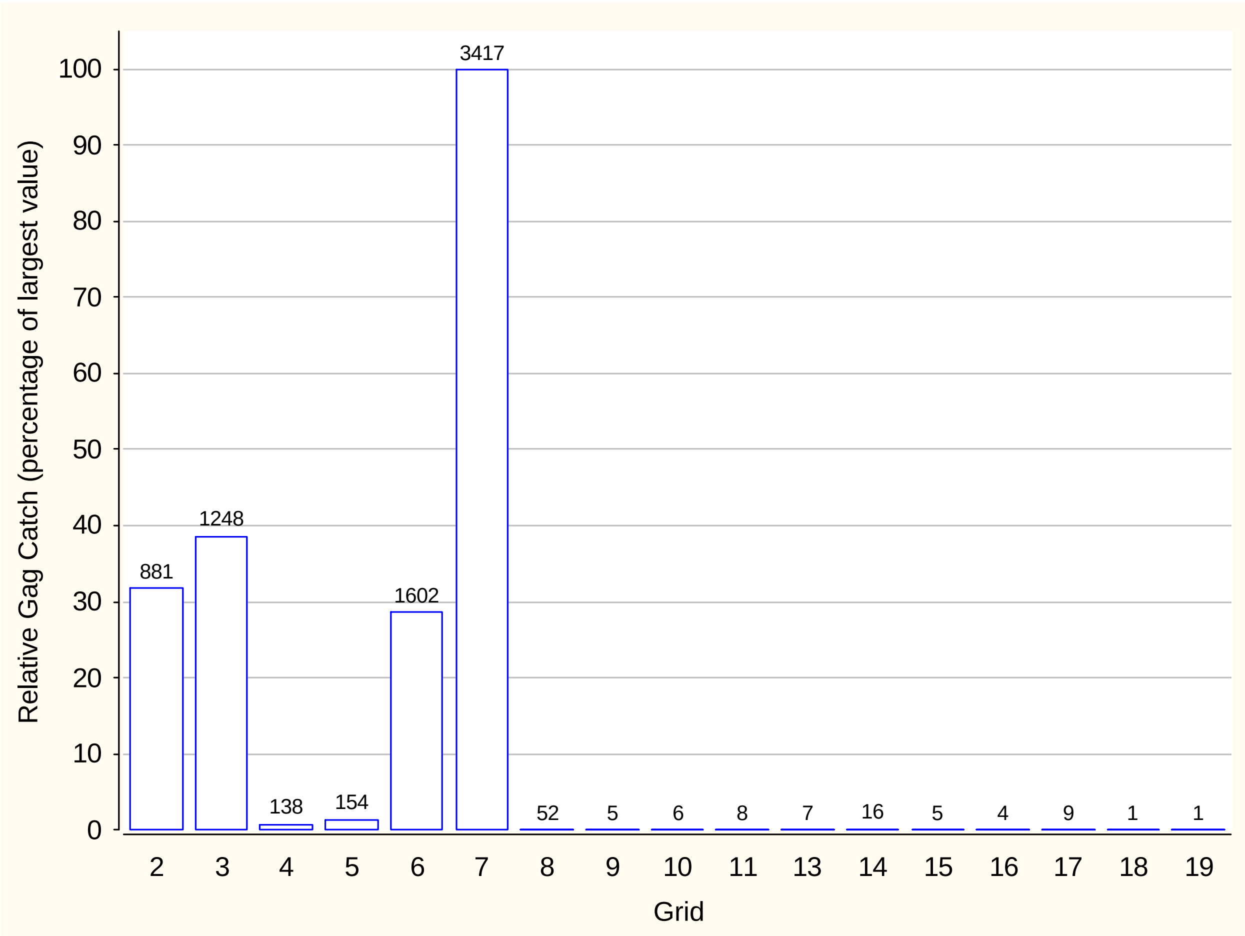

Figure 2. Nominal CPUE indices for 1991 to 2000; shown on a relative scale to facilitate comparison of measures with different units.

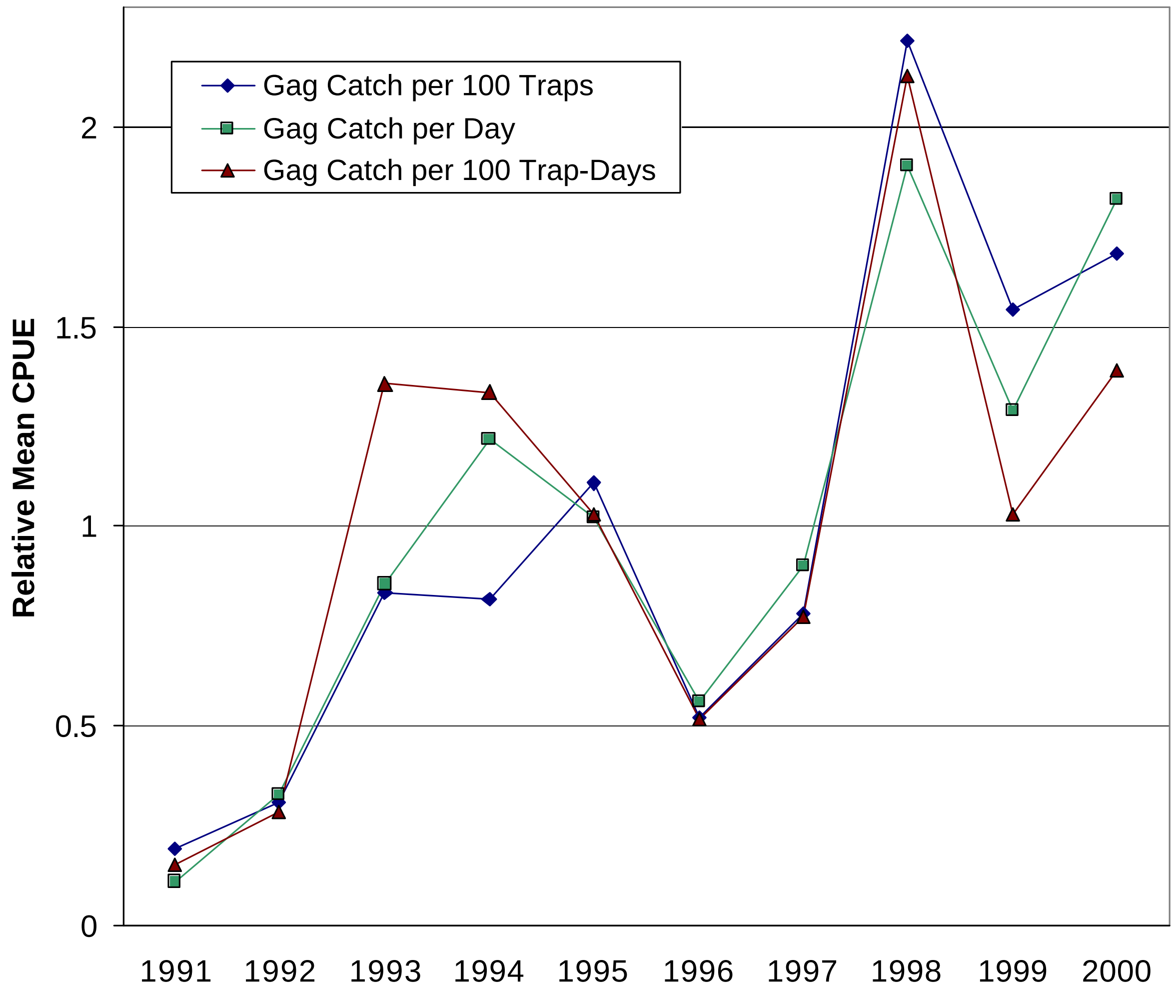

Figure 3. Proportion of trips with gag catch (*ProPos*) vs trip-length categories.

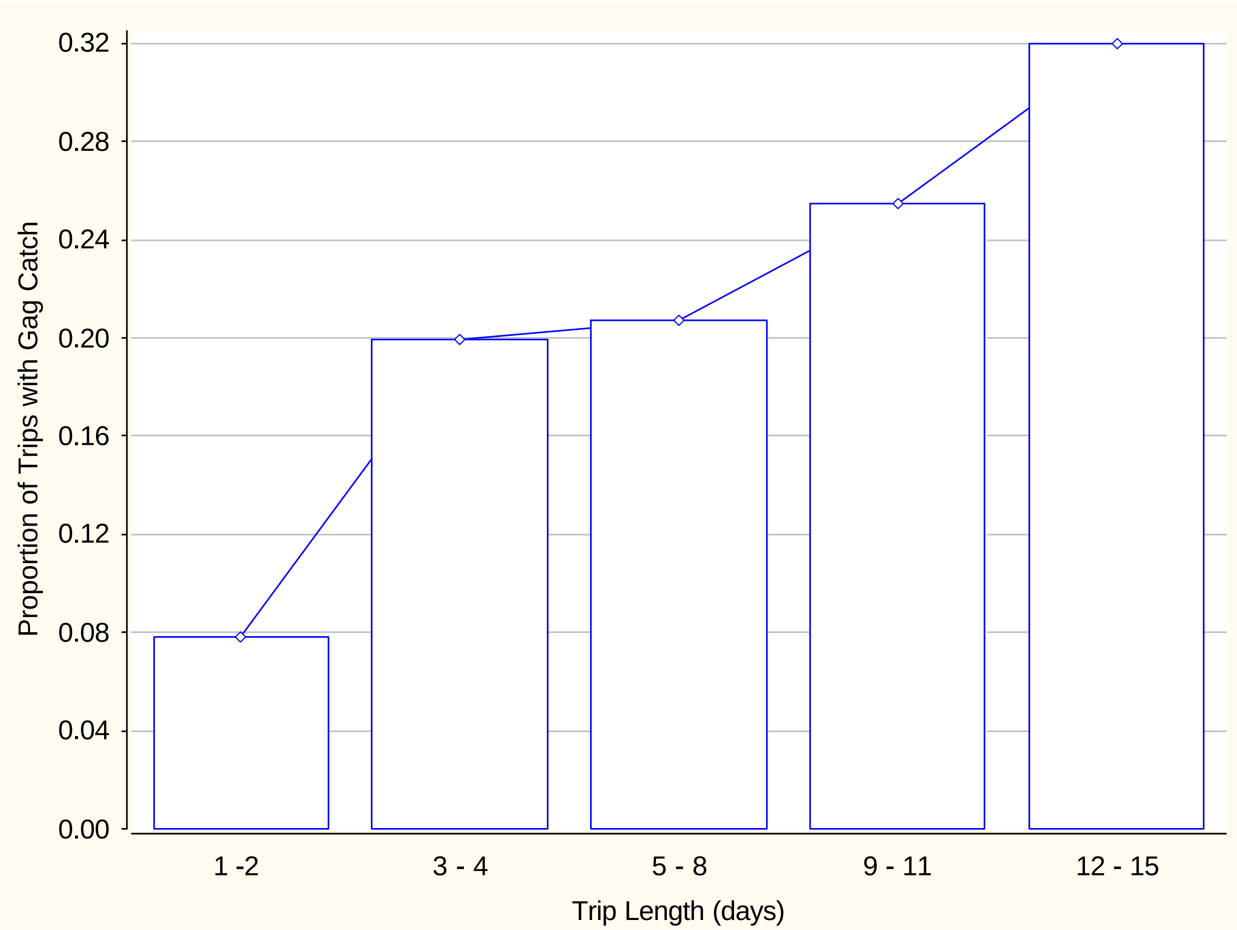

Figure 4. Proportion of trips with gag catch (*ProPos*) for years 1991-2000; values over the bars are the total number of trips run in the given year.

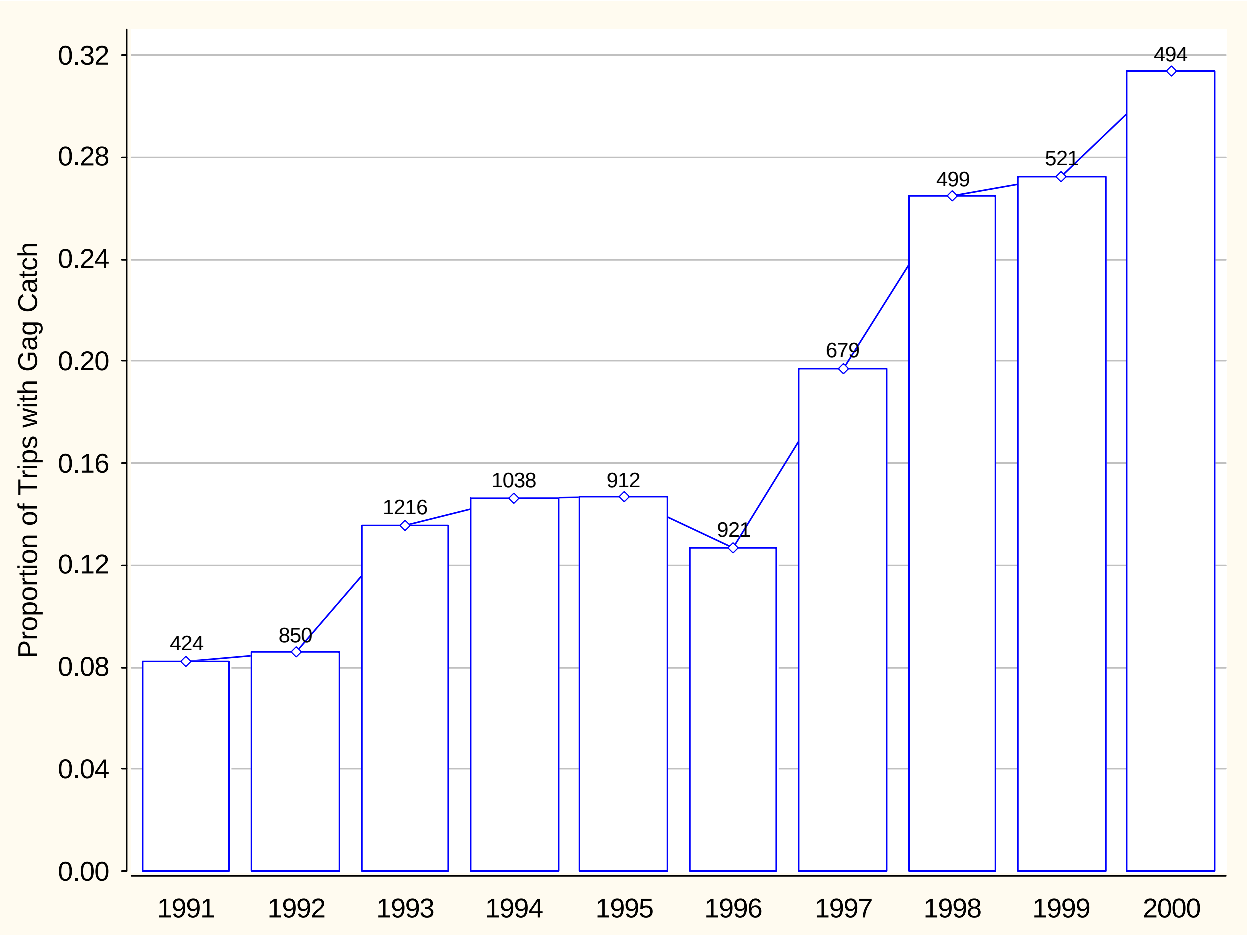

Figure 5. Proportion of trips with gag catch (*ProPos*) for grids 3-11.

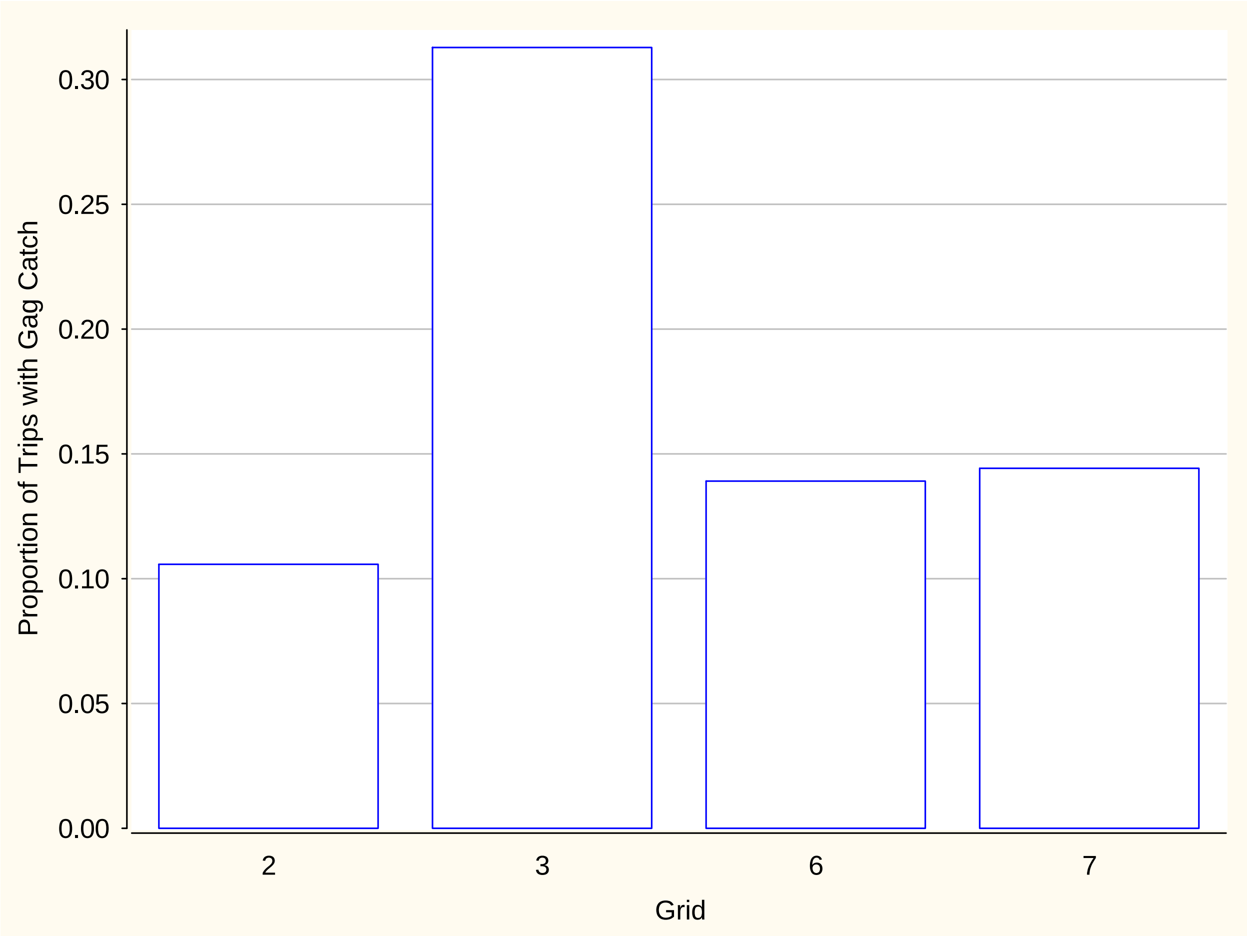

Figure 6. The proportion of trips with gag catch as a function of year for the grids 2, 3, 6 and 7.

Figure 7. Mean gag catch rate on trips with gag (*PosCat*) for grids 2, 3, 6, and 7.

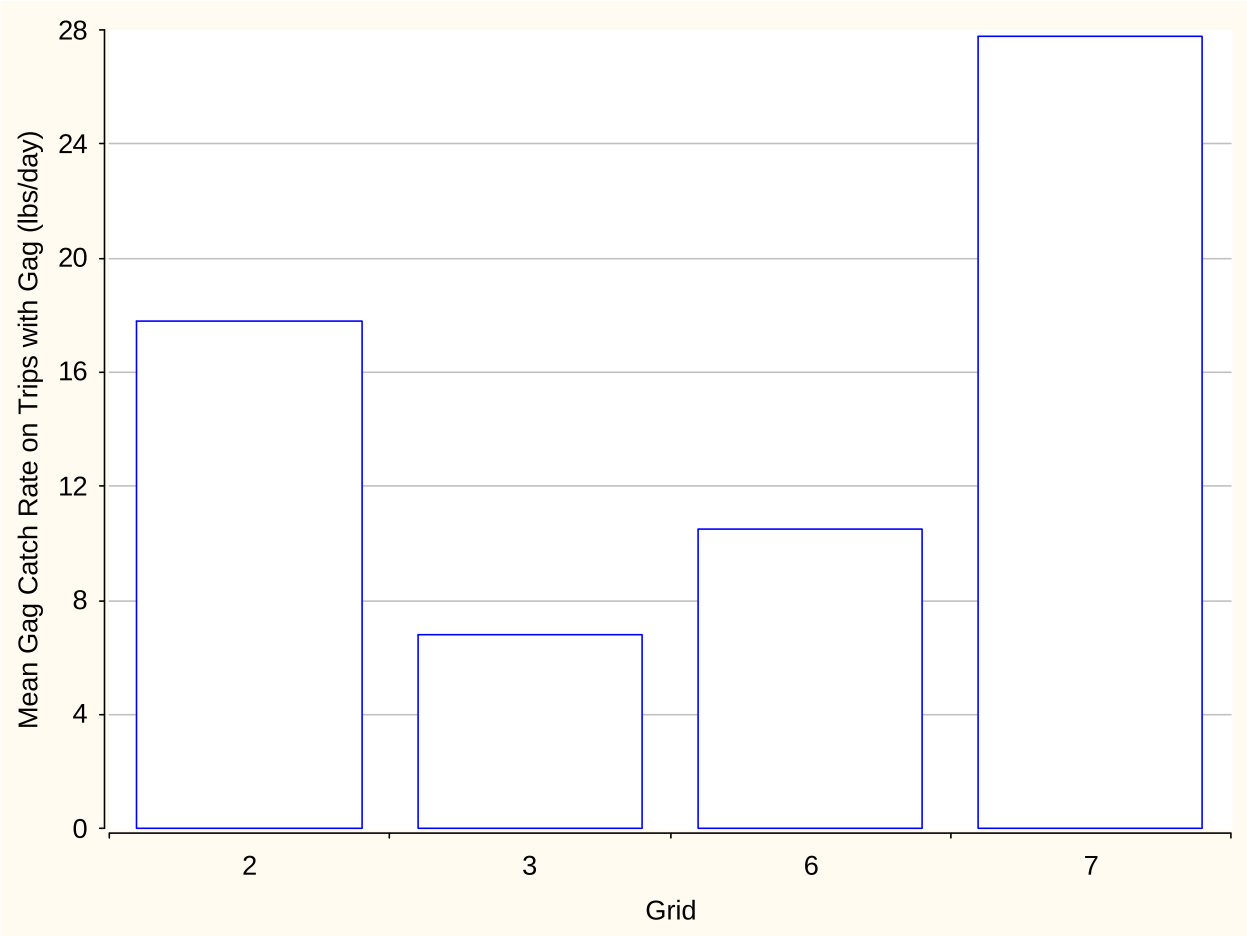

Figure 8. Mean gag catch on trips with gag (*PosCat*) for 1991-2000; values above the bars are the number of gag trips reported in each year.

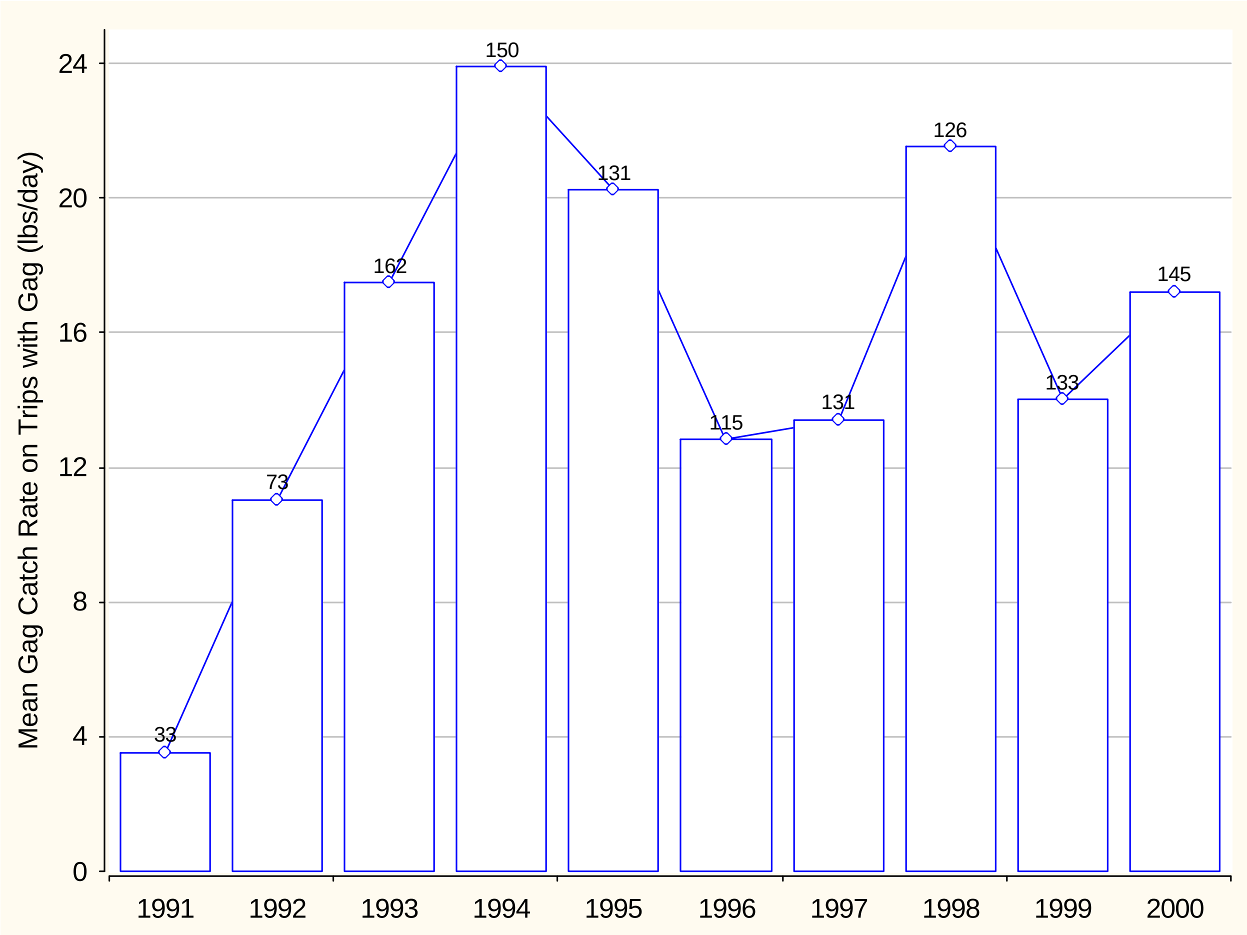

Figure 9. Mean gag catch on trips with gag (*PosCat*) for different numbers of traps used.

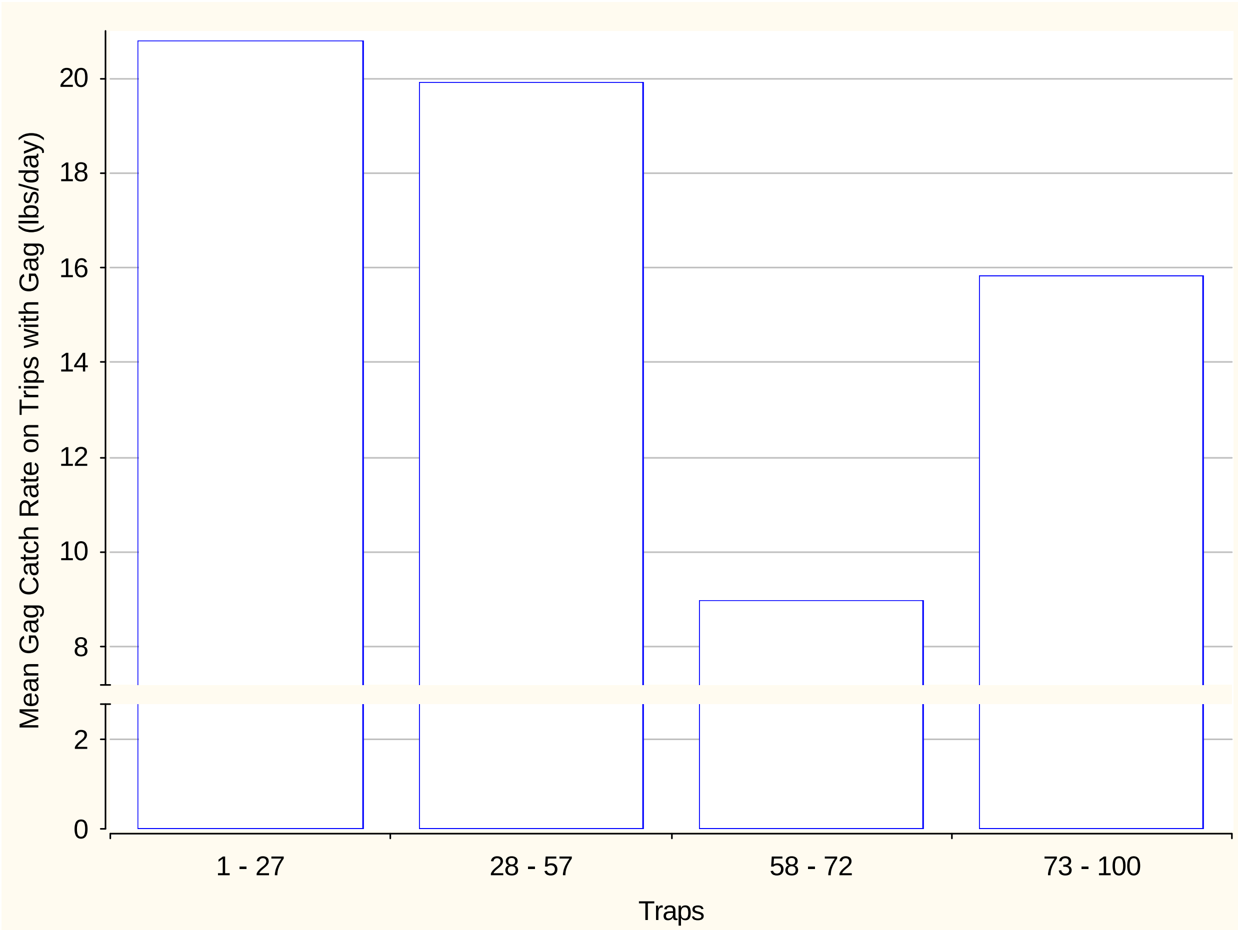

Figure 10. Mean gag catch on trips with gag (*PosCat*) by years 1991-2000 in grids 2, 3, 6 and 7.

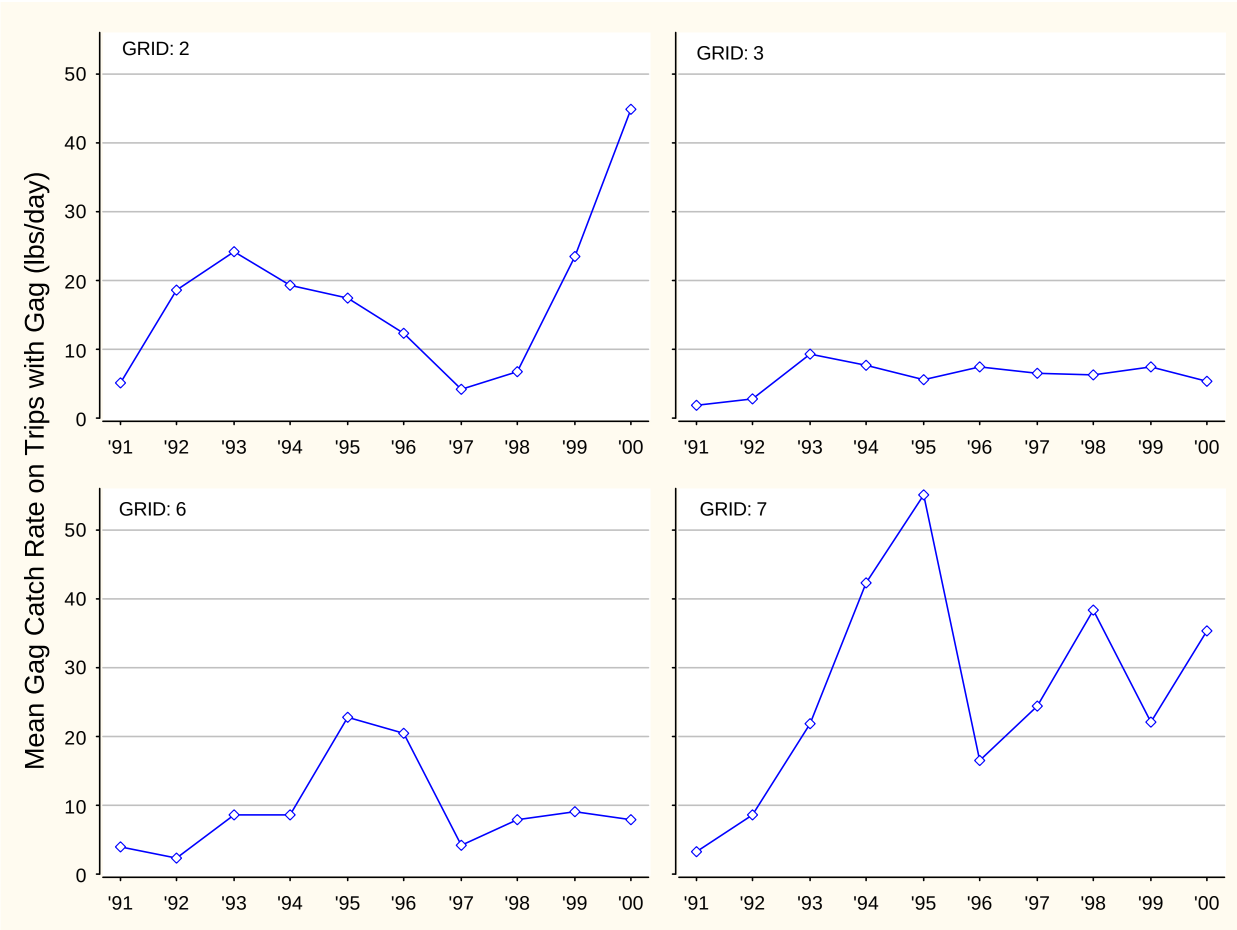

Figure 11. Mean gag catch on trips with gag (*PosCat*) by years 1991-2000 and number of traps.

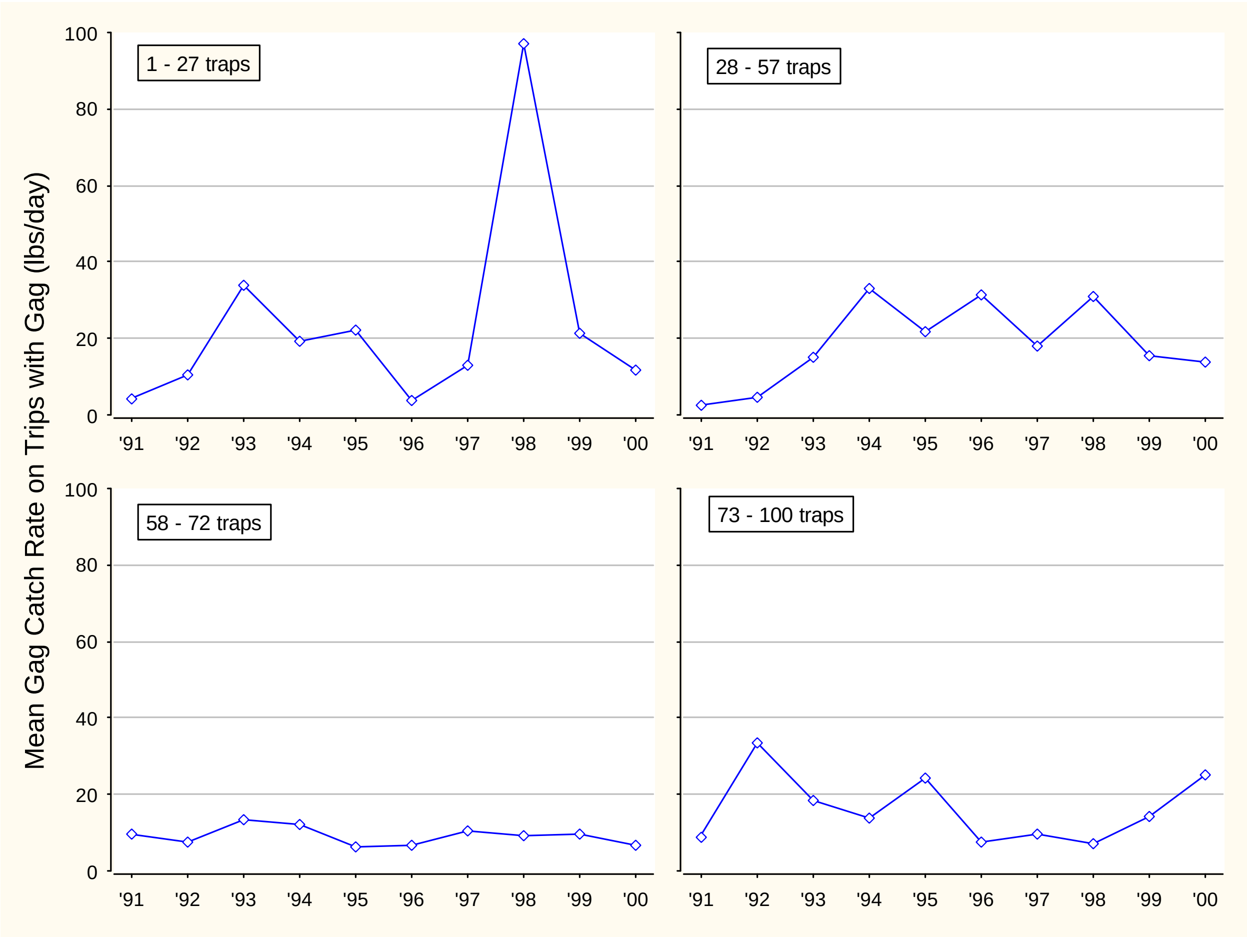

Figure 12. GLM-standardized CPUE (on a relative scale) for years 1991-2000, with 95% confidence limits.

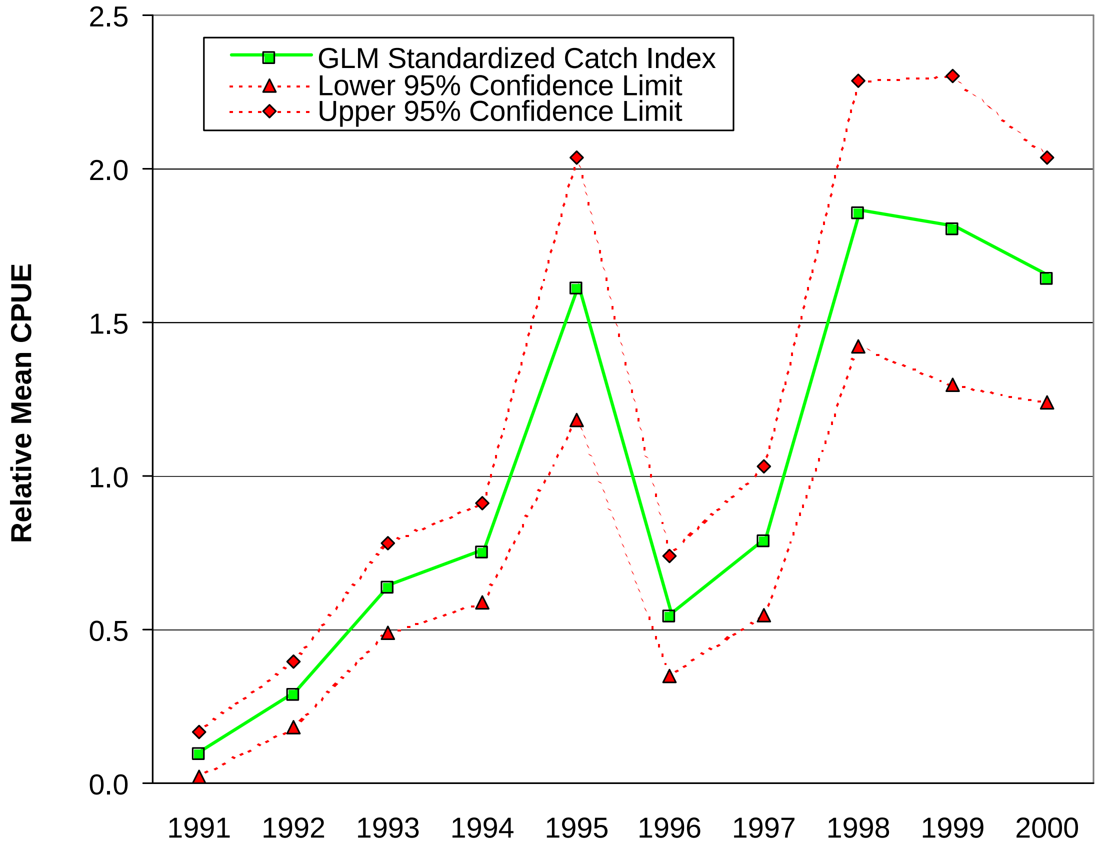

Figure 13. Mean trip length for years 1991-2000.