Catch Rates for Gag Caught in the Longline 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.

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 2-9 only, which also accounted for almost all of the longline effort in the Gulf of Mexico. Approximately 86% of gag were caught in grids 3-6, and over 99% of all gag were caught in grids 2-9, hence for the generation of the catch-rate indices we used data from grids 2-9 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 longline CPUE estimates. The database contained information on the length of fishing trips (*TripLen*; days), the length of the longline (*LineLen*; miles), the number of sets of the longline made during the trip (*Sets*), the average number of hooks per set (*Hooks/Set*), and the total soak time during the trip (i.e. the total amount of time that the longline was fished; *SoakTime*; hours). Actually, prior to 1993 the average soak time per set was recorded; those values have been converted to total soak time in other analyses. The most obvious effort measure to use in the calculation of longline CPUE, and one that has been used in similar assessments, is the composite measure *hook-hours*, which is the product of the variables *Hooks/Set* and *SoakTime*. Unfortunately, a problem was discovered in the database, suggesting that for perhaps 20% of trips, the number of sets-per-day was recorded, rather than the total number of sets for the trip. This compromised our ability to convert *SoakTime* for 1991 and 1992 from the per-day to total scale. Methods for correcting these problems are being investigated, but the measure *hook-hours* could not be used in these analyses. We examined several CPUE candidates that appeared to provided incomplete descriptions of effort, and found that *Catch/Day* 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 measures *SoakTime, Hooks/Set* and *LineLen*. The final data restriction involved eliminating records when these variables had missing values, values of zero, very large values (*TripLen* > 15 days, *Hooks/Set* > 2500, *LineLen* > 40 miles), or logically inconsistent values (records where the derived measure soak-time-per-day, hrs/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, SoakTime, Hooks/Set* and *LineLen*, 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): *TripLen* (3.8%), *Grid* (1.7%), and *Year* (1.1%). No two-way interactions were found to be important. The variable *LineLen* produced a reduction in deviance per df of 1.0% when added to the null model, but did not meet the 1% criterion for inclusion in the model with the more important variables included. The relationships between *ProPos* and the variables *TripLen*, *Grid*, and *Year* are shown in Figures 2-4.

The proportion of trips with gag catch increased steadily with trip length from a low of roughly 0.18 on 1-2 day trips to an apparent plateau of 0.5-0.55 on trips longer than 10 days in duration (Figure 2). The proportion of trips with gag was highest in grid 5 (0.44) and declined steadily to the north and the south, reaching lows of 0.28 in grid 2 and 0.12 in grid 9 (Figure 3). The proportion of longline trips with gag catch was just 0.21 in 1991, jumped to 0.27 in 1992, and then jumped again to 0.4 in 1993 (Figure 4). In the mid-90s *ProPos* was somewhat lower (0.33-0.37), and jumped to 0.41 – 0.45 during 1998-2000. The number of trips was low in 1991-1992, increased by a factor of 2.5 in 1993, and fluctuated at 3-4 times the 1991 level for the remainder of the decade, perhaps indicating some important changes in the behavior of the fishery in the early 90s.

Positive Catch. The following main effects were included in the model (percent reduction in deviance/df compared to the null model shown in parentheses): *Year* (6.2%), categorized *Hooks/Set* (2.9%), categorized *Grid* (1.6%), and categorized *Month* (1.3%). The two-way interaction *Hooks/Set*-by-*Grid* (1.0%) was the only interaction to met the criterion for inclusion in the model. The following categorizations were selected based on the variation of the catch rate over the full range of each variable: *Hooks/Set*: =450, 451-750, 751-1000, 1001-1400, 1401-2500; *Grid*: 2, 3-5, 6-7, 8, 9; and *Month*: Nov-May and June-October (roughly the spawning and non-spawning seasons). The relationships between *PosCat* and the variables *Year*, *Hooks/Set*, *Grid*, and *Month* and the interaction *Hooks/Set*-by-*Grid* are shown in Figures 5-9.

Mean gag catch rate on trips with gag (‘gag trips’) was relatively constant at 35-47 lbs/day from 1991 to 1997, but jumped roughly 85% to 65-85 lbs/day during1998 to 2000 (Figure 5). Mean gag catch on gag trips varied considerably depending on the number of hooks used per line, although effort in terms of the number of trips was not expended in a similar fashion suggesting that hooks/set was not tuned to gag catch (Figure 6). The catch rate was highest (69-72 lbs/day) for small rigs (up to 750 hooks/line), lowest (33-39 lbs/day) for large rigs (1000 hooks/line and up), and intermediate for mid-size rigs. Mean gag catch rate on gag trips showed perhaps four 'regional' levels: 45-52 lbs/day in grids 2-5, 69-71 lbs/day in grids 6 and 7, 97 lbs/day in grid 8, and a low of 44 lbs/day in grid 9 (Figure 7), interestingly, a very different pattern to that shown for the proportion of trips with gag catch (*ProPos*; Figure 3). Mean gag catch rate on gag trips showed a strong seasonal signal (grossly similar to that for *ProPos*), varying roughly from 53-58 lbs/day during the spawning season (November-May), with a very high catch rate of 73 lbs/day in March, and dropping to lower levels of 42-48 lbs/day during the non-spawning season (June-October; Figure 8). Total effort, as indicated by the number of trips, showed little seasonal variation. The cause of the interaction between *Hooks/Set* and *Grid* is evident in the very different patterns exhibited in different grids (Figure 9). Which gear configuration performed best varied among grids (e.g. the smallest number of hooks/set was superior in grids 3 and 8, but slightly larger number of hooks, 450-750, performed better in grids 2 and 5-7, and yet larger rigs, 750-1000, did the best job in grids 4 and 9).

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 10; CV's are small primarily because of the large number of observations used in the regression. Longline CPUE showed relatively little change for much of the decade, although there was a peak in 1993 and a nearly two-fold difference between 1991-1992 and a plateau during 1993 to 1997. However, from the mid-90s plateau to 2000 there was more than a 300% increase in the catch rate, which we saw earlier was contributed to by substantial increases in the proportion of trips catching gag (Figure 4), and, especially, in the amount of gag caught on those trips (Figure 5). The change in effort, *TripLen* (days), is shown in Figure 11. Mean trip length decreased rapidly by approximately 2 days from 1991 to 1995-1996, and then rebounded by approximately 1 day for the remainder of the decade. These changes suggest that the changes in catch rate on gag trips described above were primarily responsible for the overall change seen in overall CPUE.

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	0.309	0.141	0.476	0.277
1992	0.394	0.183	0.605	0.273
1993	0.922	0.680	1.164	0.134
1994	0.563	0.438	0.689	0.114
1995	0.551	0.424	0.678	0.118
1996	0.576	0.467	0.685	0.096
1997	0.721	0.585	0.856	0.096
1998	1.478	1.236	1.719	0.083
1999	1.620	1.318	1.922	0.095
2000	2.867	2.265	3.469	0.107

Acknowledgements

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Figures

Figure 1. Total catch of gag in the longline 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.

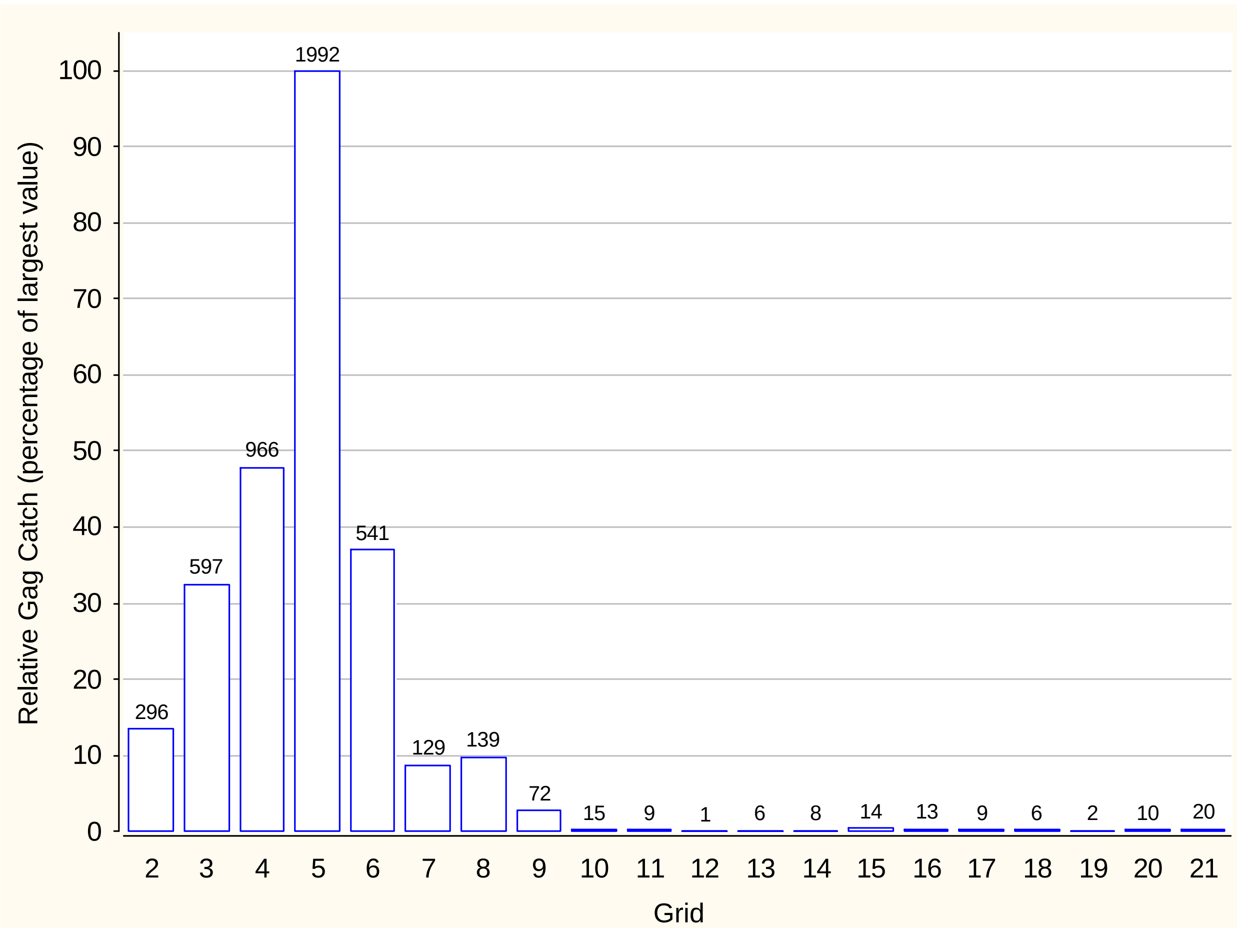

Figure 2. Proportion of trips with gag catch (*ProPos*) for trip lengths of 1-15 days.

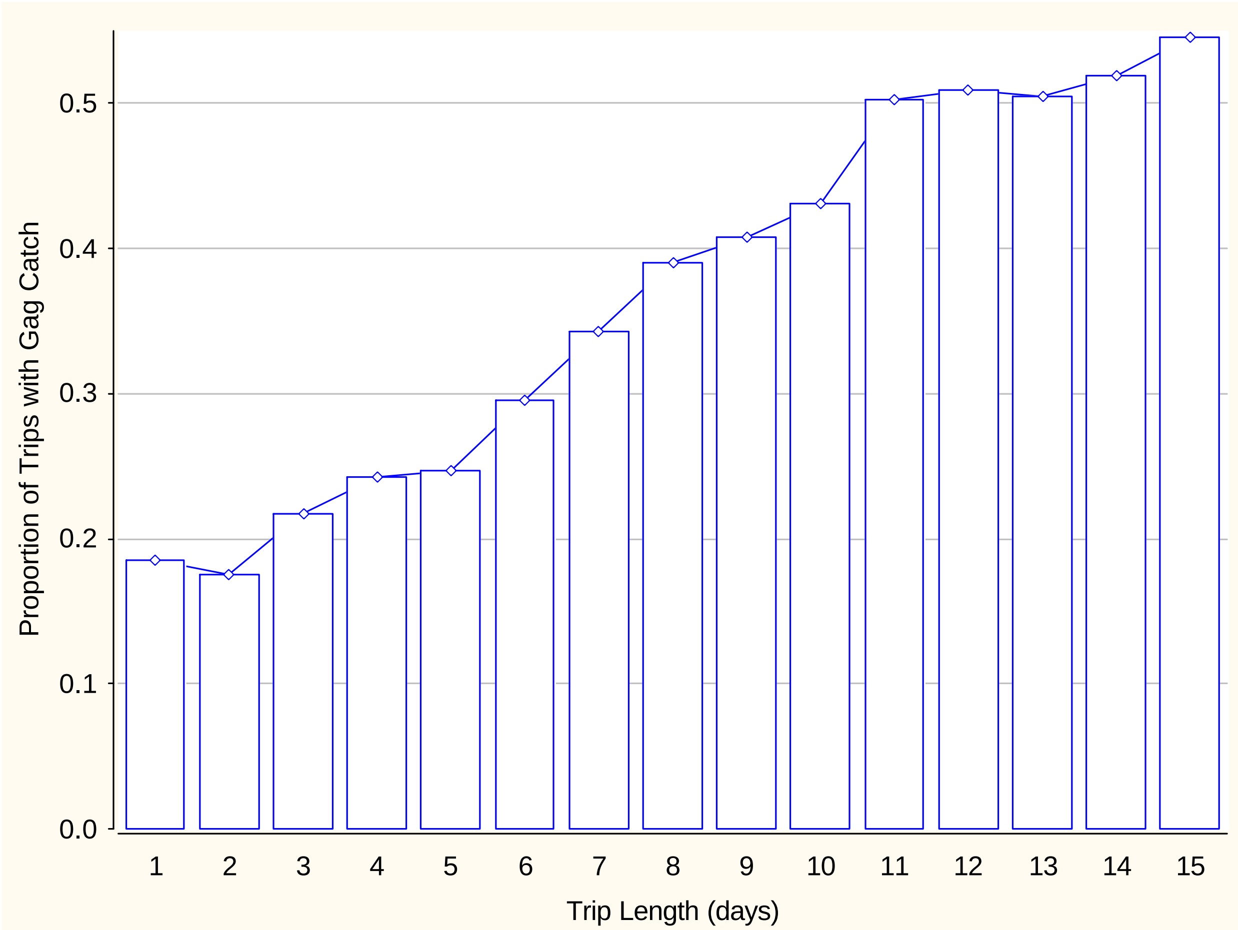

Figure 3. Proportion of trips with gag catch (*ProPos*) for grids 2-9.

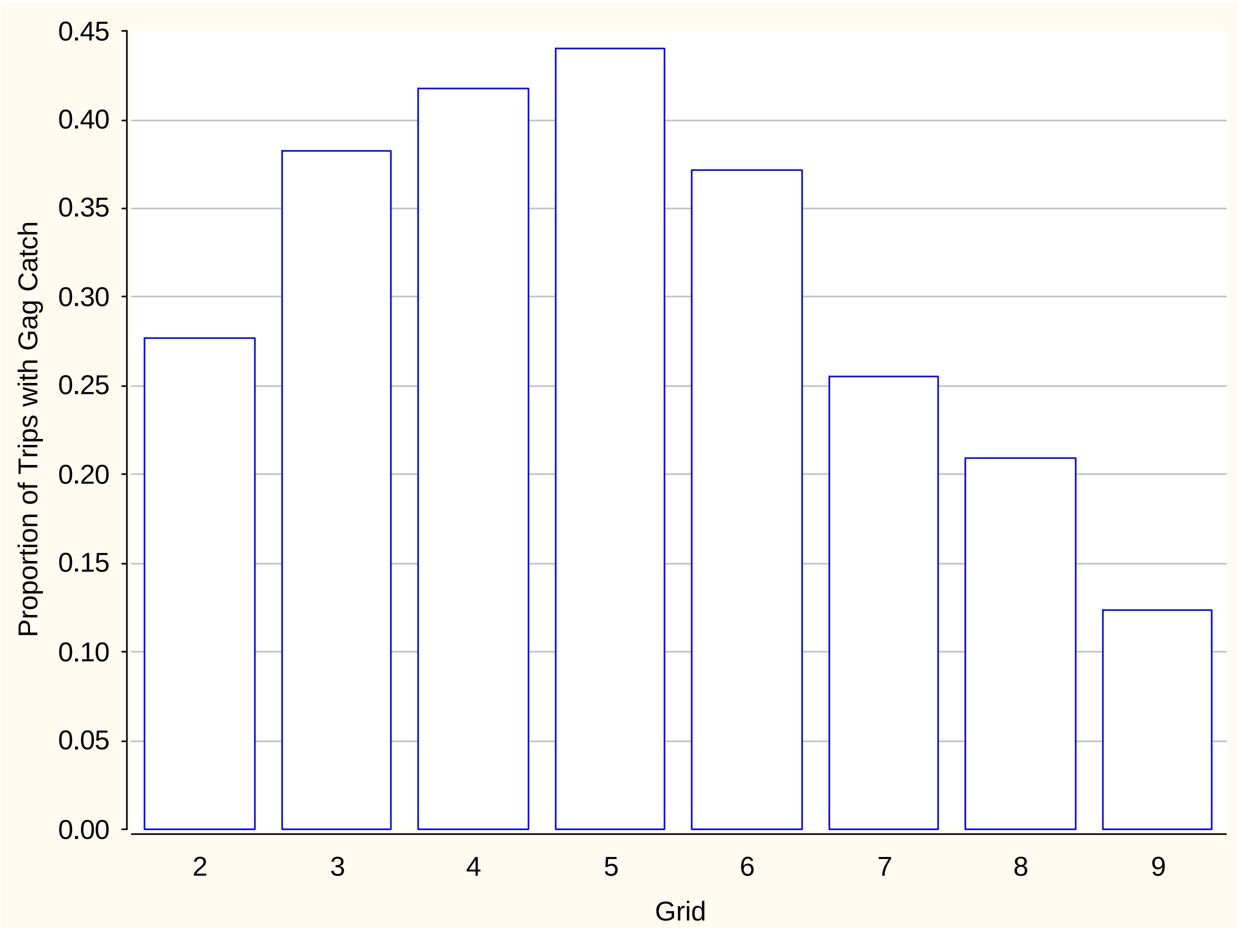

Figure 4. Proportion of trips with gag catch (*ProPos*) for years 1991-2000; values above the bars are the total number of trips recorded in each year.

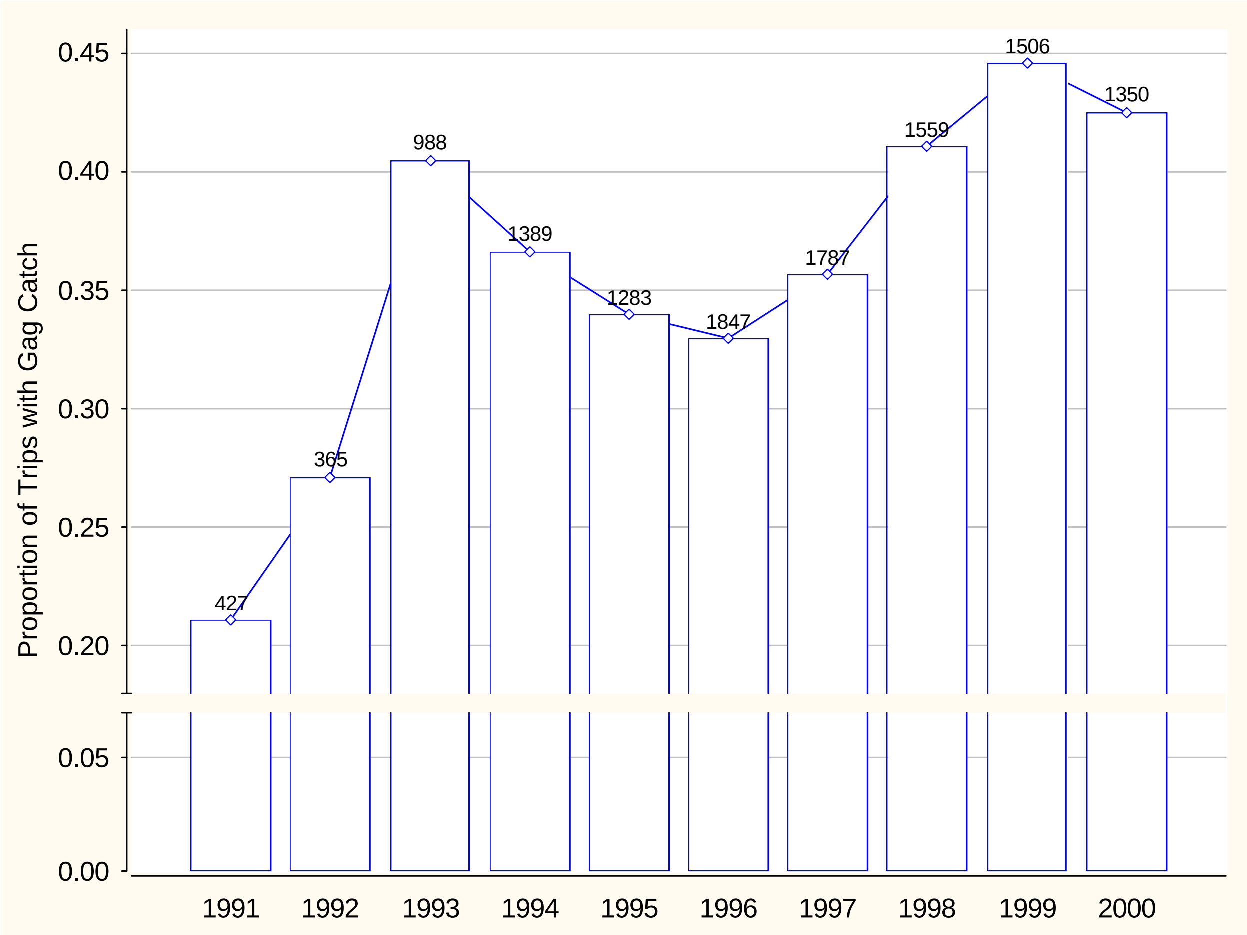

Figure 5. Mean gag catch rate for trips with gag catch (*PosCat*) for years 1991-2000.

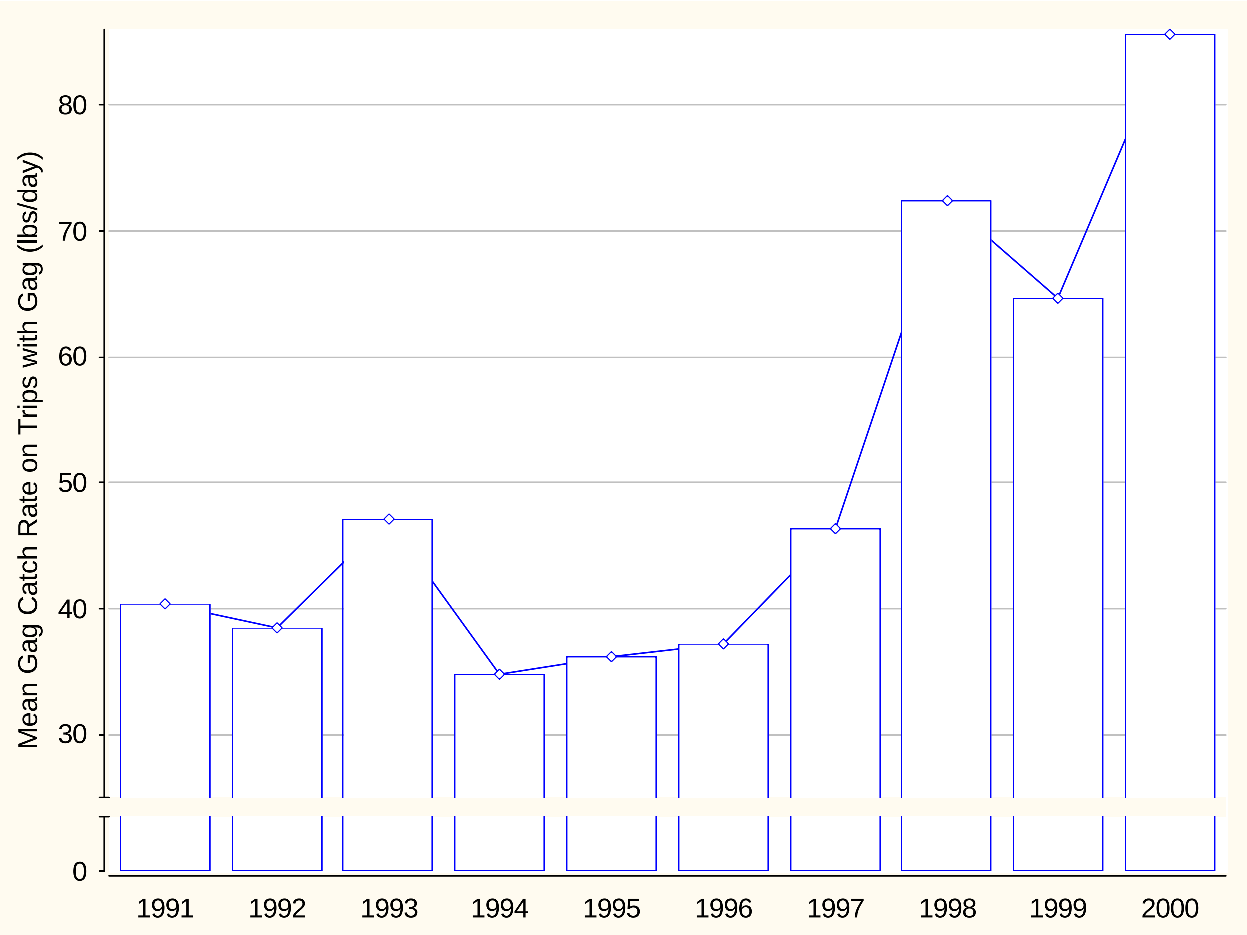

Figure 6. Mean gag catch rate for trips with gag catch (*PosCat*) for hooks/set categories; values above the bars are the number of trips recorded for each category.

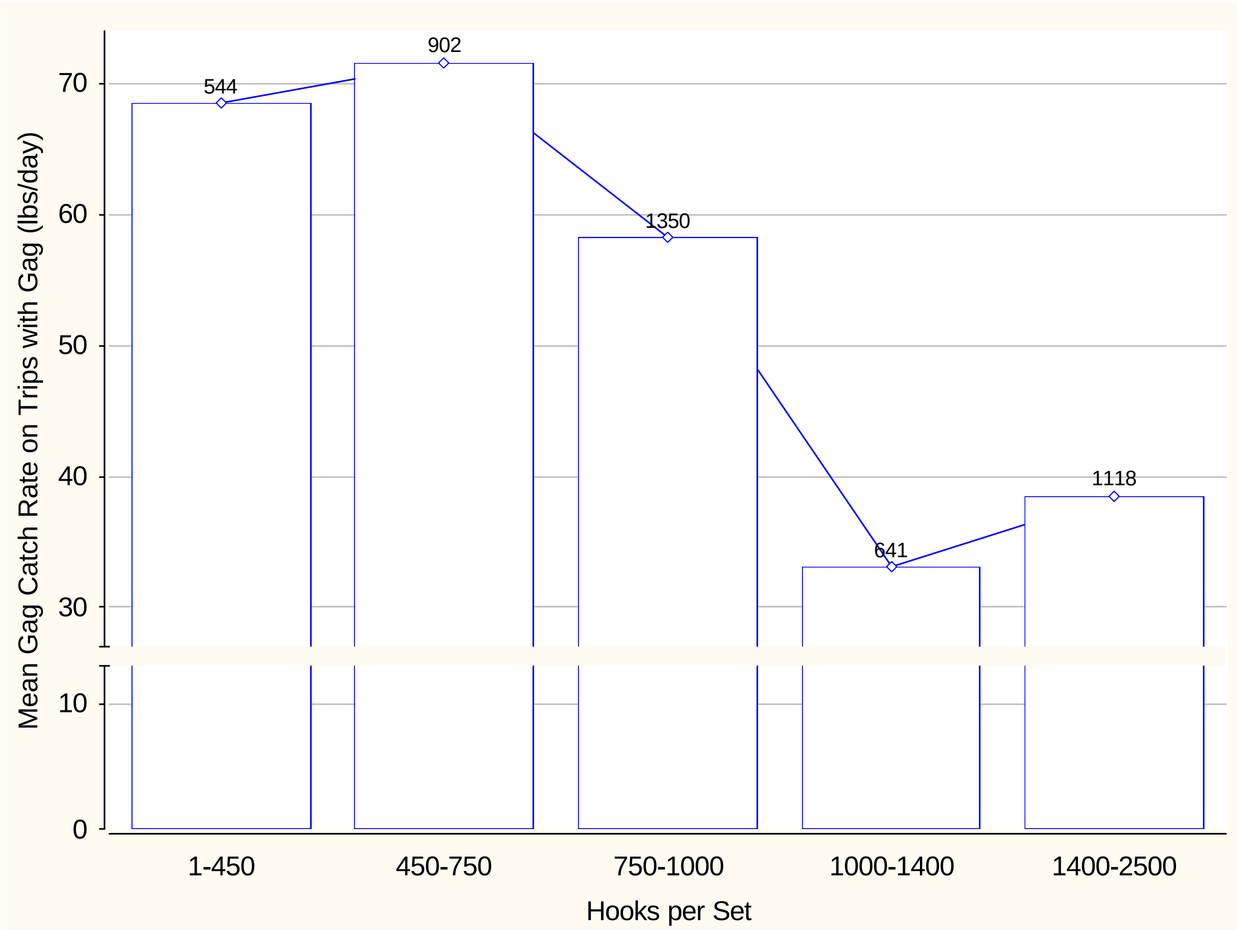

Figure 7. Mean gag catch rate for trips with gag catch (*PosCat*) for grids 2-9; values above the bars are the number of trips recorded in each grid.

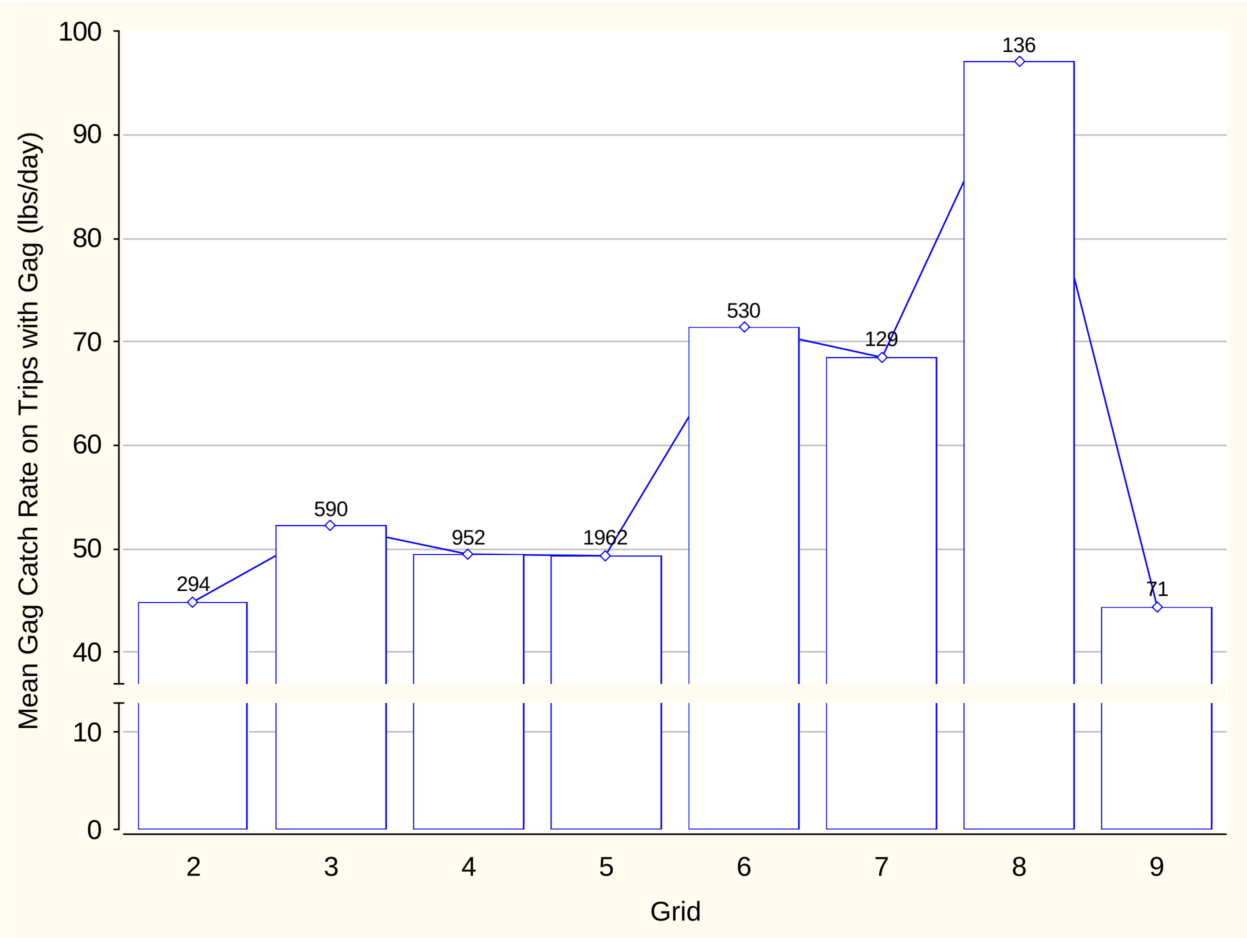

Figure 8. Mean gag catch rate for trips with gag catch (*PosCat*) by months; values above the bars are the number of trips recorded in each month.

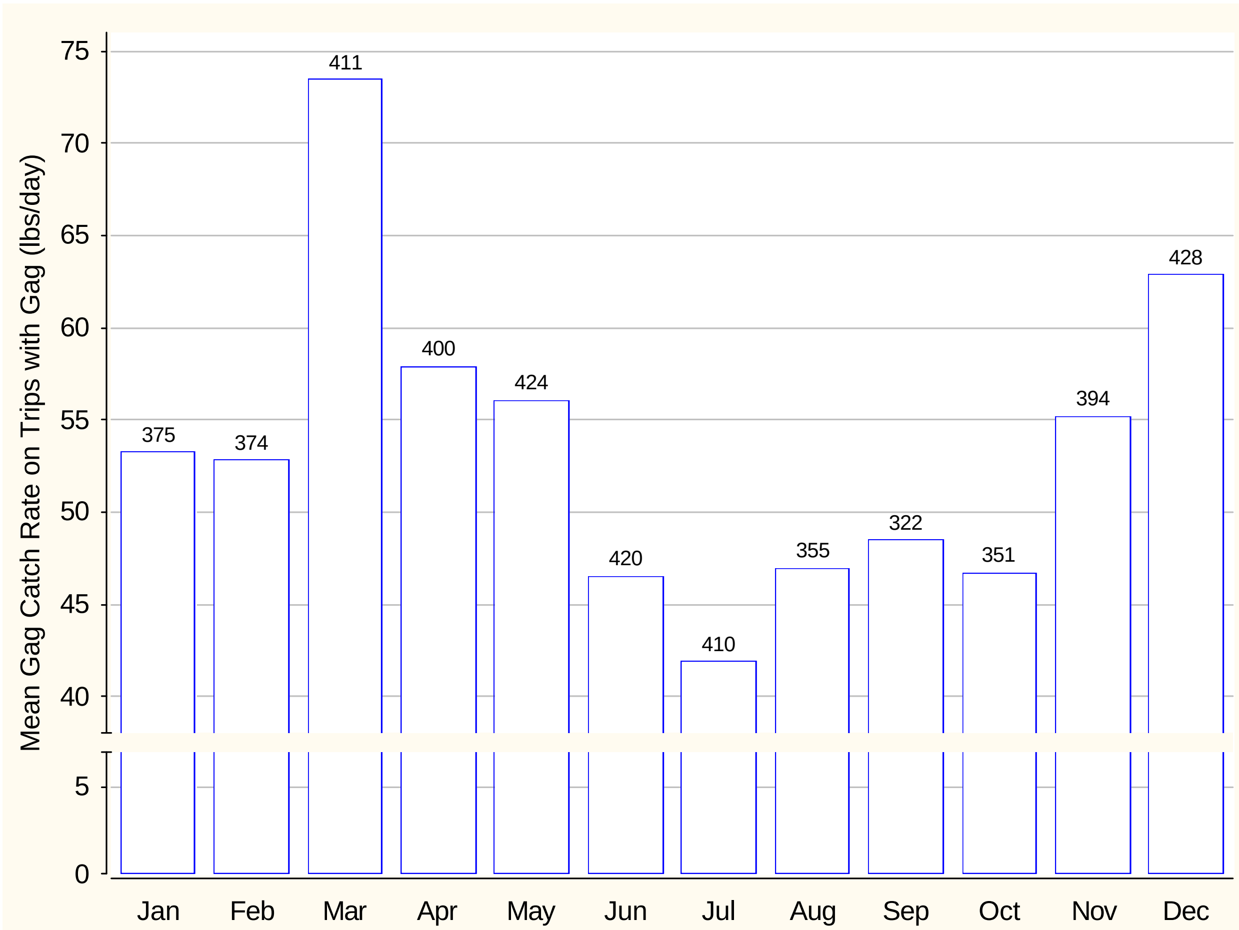

Figure 9. Mean gag catch rate for trips with gag catch (*PosCat*) by grids and hooks/set categories.

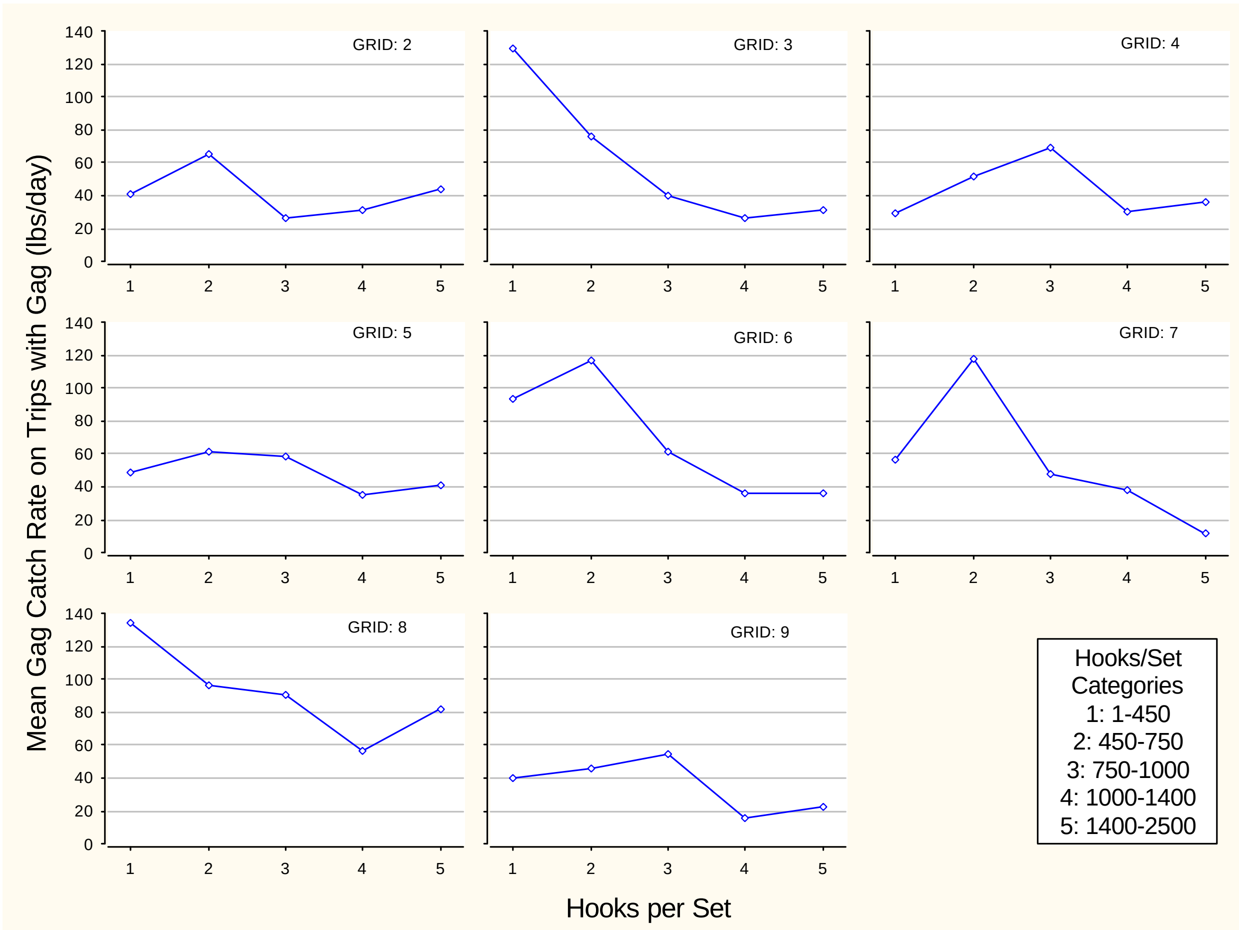

Figure 10. GLM-standardized CPUE (on a relative scale) for years 1991-2000, with 95% confidence limits.

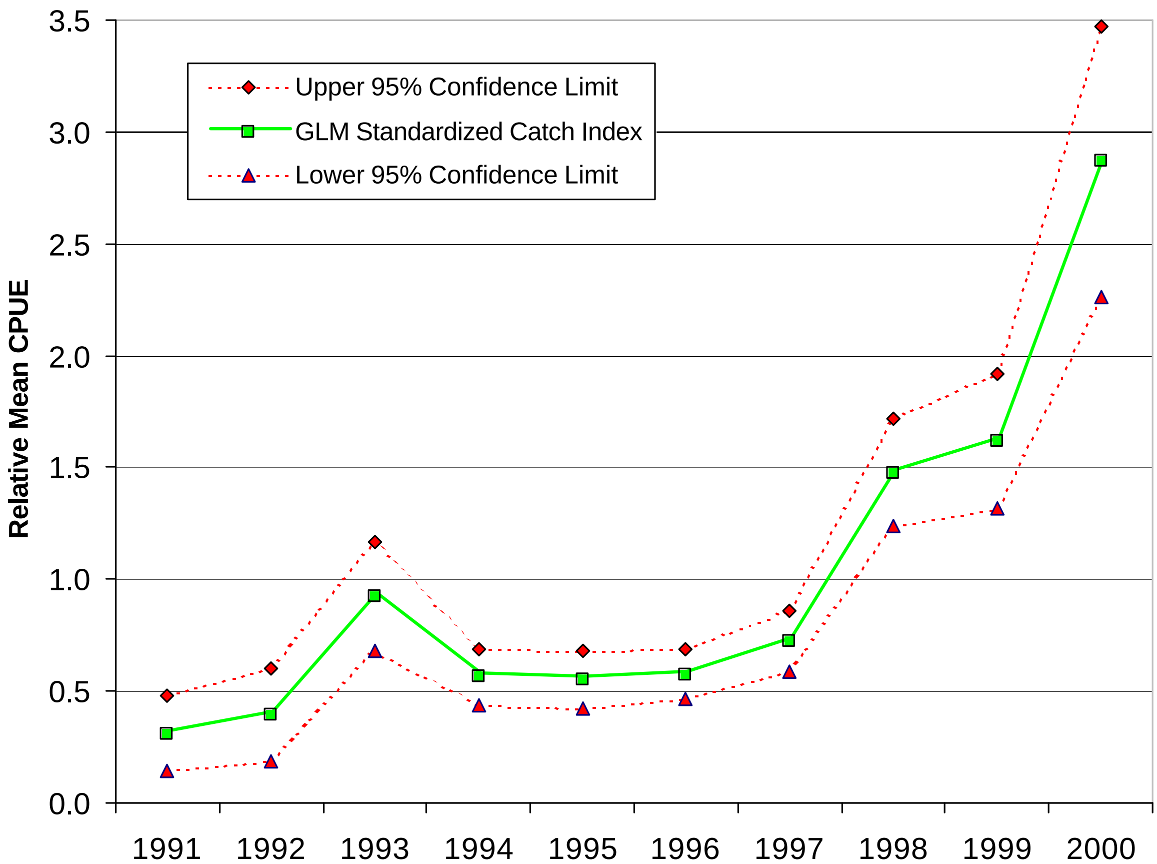

Figure 11. Mean trip length for years 1991-2000.