# Catch Rates of Greater Amberjack Caught in the Headboat Fisheries in the Gulf of Mexico in 1986-1998

Stephen C. Turner

National Marine Fisheries Service
Southeast Fisheries Science Center
Miami Laboratory

Miami Laboratory Document: SFD 99/00 - 107

Indices of abundance of Gulf of Mexico greater amberjack were developed from trip reports by headboats for possible use in an assessment of the status of the resource.

## Materials and Methods

Data were obtained from the Southeast U. S. Headboat Survey. The available data includes information on the landing date and location, vessel identification, the number of anglers on a trip, a single fishing location (10' x 10' rectangle of latitude and longitude) for the entire trip, the type/duration of the trip (various half day types, full day, various night types and several multi-day types), and catch on the trip by species in number and weight as reported by a crew member.

Which trip types to use in developing indices of abundance was determined by examining the proportions of trips with greater amberjack.

Observations were restricted to those which occurred in 10' rectangles in which any species of *Seriola* had been recorded.

To reduce the number of parameters in the index standardization models, months were aggregated into seasons and geographic locations were aggregated into regions based on the distribution of number of observations, the proportion of trips catching greater amberjack and/or the average catch rates on trips which caught greater amberjack.

Catch rate was calculated in number of fish. The number of anglers on a trip was used for effort in the catch rate calculations for the full day and full night trips. For the multi-day trips the effort measure used was hundreds of angler hours under the assumption that 12 hours were fished per day (the length of the trip in days was recorded).

Indices of abundance were developed assuming a delta-lognormal error structure (Lo et al.1992). That approach employs separate analyses of the proportions of positive trips and of the catch rates on trips which caught greater amberjack (positive catch rates), and combines the results of the separate analyses to derive the index. General linear models with fixed and random factors

were used to standardize estimates of annual proportion positive and positive catch rate. A binomial error assumption was used for the proportion positive analyses, and a lognormal error assumption was used for the analyses of positive trips. The dependent variable in the proportion positive analyses was success which indicated whether greater amberjack were caught or not.

The final general linear models included both fixed and random effects. The random effects were used primarily to incorporate year interaction terms and secondarily to explain a greater fraction of the total variation than would have been explained by a fixed effect model alone. Model development was initiated by examining fixed effects in which all main effects and all two way interactions were tested, and only statistically significant (<= 0.05 probability) effects were retained (except for the main effect year which was retained whether significant or not for later annual index estimation). Subsequently all significant two way interactions with year and all other significant two way interactions involving factors included in the year interactions were investigated as random effects. Additional details of the standardization process are provided in a paper submitted to the Gulf of Mexico Fisheries Management Council on greater amberjack catch rates in the Gulf handline fishery (Turner 2000).

For analysis, the basic data set was restricted so that there would be at least 5 observations of each level of a factor (such as year) in at least two levels of each of the other factors (such as season, ie there had to be two seasons with at least 5 observations to include a year) in the analysis. This was done to create a more balanced design to try to minimize the effects of isolated observations on parameter estimates and to maximize the possibilities that interactions would be estimable.

These restrictions were applied to the entire data set (successful and unsuccessful trips combined), but not to the subset of successful trips. Thus the data set of catch rates on successful trips could have had fewer that 5 observations per cell. It was considered sensible to have the successful trip data consist of all of the successful trips in the data set used for the proportion positive analysis. Had the opposite approach been used - first constraining the successful trips to strata with 5 observations in at least 2 levels of each of the other factors and then using the unsuccessful and successful trips from only those selected strata - a substantial reduction would probably have occurred in number of observations available for the proportion positive analysis, especially when the proportion positive was low.

In February of 1990, a size limit of 28" was put in place for Gulf of Mexico greater amberjack. To try to determine whether that limit affected headboat catch rates, the proportion of trips catching greater amberjack was examined.

**Results**

A total of 42,178 trips in the Gulf of Mexico were recorded in the Southeast U.S. Headboat Survey during 1986-1998. Of those almost 26,000 were half day or half night trips which showed low proportions of trips with landings of greater amberjack (Table 1). Full day trips accounted for

most of the remainder (about 16,000 trips), and there were less than 500 multi-day and 500 full night trips recorded. On the latter three types, greater amberjack was reported from about 25% to 70% of the trips (Table 1). Roughly 50%-80% of the multi-day trips reported landings of greater amberjack, while roughly 20%-40% of the full day trips had greater amberjack landings (Figure 1). The proportion of trips on which greater amberjack were caught by vessels classified as full night trips was variable and ranged between the levels for the full day and the multi-day trips.

To reduce the number of parameters to be estimated, observations were aggregated by season and region. To define seasons both the proportion of trips catching greater amberjack and average catch rates were examined. Both visual examination of data aggregated across years and regions (Figures 2 and 3) and regression tree analyses (Venebles and Ripley 1997) of the full day data (including effects for year and region as well as season) for both success and catch rate on successful trips revealed variability without marked patterns especially in catch rates.The proportion positive was relatively stable at the beginning and the end of the year in the full day data; therefore three seasons of four months each were established. The full day information was emphasized in that decision because of the much larger number of observations available.

Trips were restricted to those which occurred within boundaries for the Gulf of Mexico stock recommended by McClellan and Cummings (1997) and through consultation with N. Cummings (pers. comm.). Five regions were defined based on the distribution of trips (Table 2). The regions were off: west central and southwest Florida ('CW+SW FL', 84º59' W and east), northwest Florida and Alabama ('NW FL+AL', 85º-88º30' W), Louisiana ('LA', 88º31'-91º59'W), northeast Texas ('NE TX' 93º-95º59'W, note that no trips were recorded as fishing from 92º-92º59' W) and central and south Texas ('CE+SE TX', 96ºW and west).

*Full Day Index*

The annual proportion of trips catching Gulf of Mexico greater amberjack was examined to see if there were changes before and after 1990 when the 28" size limit became effective (Figure 4). The proportion of positive trips in the CW+SW FL region changed from roughly 20-40% in the late 1980's to 5% or less after 1990; therefore only data from that region from before 1990 were included in the analyses. A less pronounced change can be observed in the NE TX region where proportions positive changed from about 50-60% in the late 1980's to about 20-35% in the 1990's; therefore data from before 1990 were eliminated for analyses. NE TX data were treated differently (1986-1989 eliminated) from the CW+SW FL data (1990-1998 eliminated) because off CW+SW FL after 1989 there were less than 10 positive trips per year while off NE TX in the 1990's there were about 50-120 positive trips per year after 1989, and it was considered desirable to retain the largest number of years with substantial numbers of observations.

After elimination of data from those regions because of possible bag limit effects and elimination of data to create a more balanced design, data from 12,262 full day headboat trips during 1986-1998 were available for analysis (Table 1); a high proportion of the eliminated observations were from NE TX in 1986-1989 and CW+SW FL in 1990-1998. Factors included in the analyses were

year, region and season.

The results of the fixed effects analyses of catch rates on trips which caught greater amberjack are shown in Table 3. The fixed effect year*season interaction could not be tested apparently because the data were too sparse in some years. The model considered for further mixed model analyses included year, region, season, region*season and the year*season interaction (included because its significance could not be determined in the fixed effects analysis). The mixed model analysis indicated that all random effects were significant (Table 4); therefore for standardization the final model for positive catch rates included year, region and season as fixed effects and all two way interactions as random effects.

The analyses of the proportion of positive trips are presented in Tables 5 and 6. The fixed effects analyses indicated that all two way interactions were significant, but the mixed model analysis indicated that none of the random effects year interactions were significant; the region*season interaction was significant, but because there were no significant year interactions it was not necessary to include that interaction as a random effect in the final model for index development. Therefore the final model of proportion positive used in standardization included year, region, season and the region*season interaction all as fixed effects and no random effects.

The estimated index of abundance is presented in Table 15 and Figure 5. The coefficients of variation of the estimated annual values ranged from about 0.43 to about 0.57.

*Multi-day Index*

After restricting the data to create a more balanced design, data from 362 trips by headboats fishing for multiple days were available for analysis (Table 1). Those observations came from all areas except CW+SW FL and all years except 1986, 1987 and 1991. Factors included in the analyses were year, region and season.

The results of the analyses of catch per hundred angler hours on multi-day trips which caught greater amberjack are presented in Tables 7 and 8. The fixed effects model indicated that all factors and all two way interactions were significant, and the mixed effects analysis indicated that the random effects year*region and region*season interactions were significant. The final model for standardization of catch rates on trips which caught greater amberjack included year, region and season as fixed effects and the year*region and region*season interactions as random effects.

The fixed effects analysis of the proportion of multi-day trips with greater amberjack indicated that all main effects were significant, but that none of the interactions could not be tested (Table 9). The mixed effects analysis indicated that none of the random effects interactions were significant whether tested one interaction at a time or two interactions together; the model with all three interactions could not be tested. Therefore the final model for the proportion of multi-day trips with greater amberjack included only year, region and season as fixed effects.

The estimated index of abundance is shown in Table 15 and in Figure 6. The coefficients of variation about the annual standardized catch rates ranged from 0.35 to 0.47.

*Full Night Index*

There were insufficient data to examine in the same analysis the year, region and season effects for headboat trips recorded as occurring throughout the night. Therefore two sets of analyses were conducted: one with year region and the other with year season; the former assumed that there were no seasonal effects and the latter assumed that there were no regional effects (or that the data were similarly distributed across levels of the unrepresented factor in all years and that any effects were consistent across years). After conducting the analyses, one set of analyses (year-region or year-season) was selected for calculating the final standardized catch rates based on the amount of data available and the relative quality of the model fits. For the year-region analysis there were 309 observations after restrictions to create a more balanced design. Those observations came from the LA, NE TX and CE+SE TX regions. There were 319 observations for the year-season analyses, and they occurred in all seasons (Table 1).

The results of the analyses of catch rates on full night trips which caught greater amberjack are presented in Tables 11 and 12. The fixed effects analyses of both the year-region and the year-season sets indicated only that year was a significant factor, and the mixed effects analyses did not change that conclusion (the random effects year interactions were not significant). Therefore year was the only factor included in the final model for standardization of catch rates on full night trips which caught greater amberjack..

The results of the analyses of the proportions of the full night trips which caught greater amberjack are presented in Tables 13 and 14. The fixed effects analyses indicated that both main effects in each model were significant, but that the year interaction was not. In the year-season analysis the season effect was more highly significant (<0.001) than the region effect (0.038) in the year-region analysis. Mixed effects models could not be fit to either data set. Because of the slightly higher number of observations and the higher significance of the season effect in the year-season analysis, that data set was selected for standardization. Therefore the final model for standardizing the proportions of trips which caught greater amberjack included year and season as fixed effects and no random effects.

The estimated index is shown in Table 15 and in Figure 7. The coefficients of variation about the index values ranged from about 35% to more than 300%, even though random effects terms were not included.

The three indices, scaled to their means, are compared in Figure 8. The much lower year to year variability of the full day index, which was based on far more data, is apparent in that figure.

## Discussion

For the assessment it is probably best to use only one index from the headboat fishery because the catch at size and catch at age is not disaggregated by type of headboat trip (half day, full day multi-day etc). Given the substantially larger sample sizes and the occurrence of numerous observations in most cells of the analysis for the full day trips, that index would probably be preferred. The standardized catch rates from trips recorded as being from full night trips may be additionally questioned because of the lack of regional effects in the final model.

## Literature Cited

McClellan, D. and N.J. Cummings. 1997. Preliminary analysis of tag and recapture data of the greater amberjack, *Seriola dumerilli*, in the southeastern United States. Proc. Gulf Carib. Fish. Inst. 49:25-45.

Tuner, S.C. 2000. Catch Rates of greater Amberjack caught in the handline fishery in the Gulf of Mexico in 1990-1998. NMFS Sustainable Fisheries Division Contribution SFD-99/00-95. Miami, FL. 28p.

Venables, W.N. and B.D. Ripley. 1997. Modern Applied Statistics with S-PLUS. Spring-Verlag. New York. 548 p.

Table 1. Number of headboat trips in the Gulf of Mexico recorded in the Southeast U.S. Headboat Survey data base in 1986-1998.

| | before data restrictions | | | after data restrictions | | |
|---|---|---|---|---|---|---|
| trip type | total trips | successful trips | proportion successful | | | proportion successful |
| half day | 24633 | 1322 | 0.05 | | | |
| half night | 1059 | 21 | 0.02 | | | |
| full day | 15656 | 4271 | 0.27 | 12262 | 3169 | 0.26 |
| full night | 348 | 160 | 0.46 | 319 | 143 | 0.45 |
| multi day | 482 | 330 | 0.68 | 362 | 238 | 0.66 |

Table 2. Full day headboat trips by latitude and longitude.

| | 97 | 96 | 95 | 94 | 93 | 92 | 90 | 89 | 88 | 87 | 86 | 85 | 84 | 83 | 82 | 81 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 30 | | | | | | | | | 25 | 282 | 376 | 37 | | | | |
| 29 | | 1 | 9 | 219 | 154 | | 8 | 1124 | 124 | 408 | 278 | 368 | | | | |
| 28 | 1 | 1 | 1296 | 2667 | 466 | | 824 | 1319 | | | | 2 | 1 | 104 | 76 | |
| 27 | 5 | 894 | 23 | 85 | | | | | | | | | 12 | 568 | 353 | |
| 26 | 55 | 1020 | | | | | | | | | | | 2 | 26 | 745 | 2 |
| 25 | 4 | 210 | | | | | | | | | | | | 2 | 49 | 11 |
| 24 | | | | | | | | | | | | | | | 8 | 1410 |

Table 3. Fixed effects analysis of catch rates on trips with greater amberjack by full day headboats. Models with significant probability of the chi square statistic and accounting for at least 5% of the total explained deviance are highlighted.

| positive catch rate model | d.f. for added factor | deviance | change in deviance | maximum model deviance | % total model deviance | *p* |
|---|---|---|---|---|---|---|
| null | 0 | 1803.85 | | | | |
| year | 12 | 1698.58 | 105.27 | | 43.67% | < 0.001 |
| year region | 4 | 1620.50 | 78.08 | | 32.39% | < 0.001 |
| year region season | 2 | 1619.60 | 0.90 | | 0.37% | 0.638 |
| year region season region*season | 8 | 1599.65 | 19.95 | | 8.28% | 0.011 |
| year region season region*season year*region | 31 | 1562.80 | 36.85 | | 15.29% | 0.216 |
| year region season region*season year*season | | na | | | | |
| | | | | 241.05 | | |

Table 4. Mixed effects analysis of catch rates on trips with greater amberjack by full day headboats. Final model used for index development is highlighted. The -2 restricted log likelihood statistic (-2 REM log likelihood) was used in statistical tests.

| positive catch rate model | -2 REM Log likelihood | Akaike's Information Criterion | Schwartz's Bayesian Criterion | Likelihood Ratio | *p* |
|---|---|---|---|---|---|
| year region season | 10361.44 | -5181.72 | -5184.75 | | |
| year region season *year*region* | 10245.44 | -5124.72 | -5130.77 | 116.01 | 0.0000 |
| year region season *year*season* | 10345.29 | -5174.65 | -5180.70 | 16.15 | 0.0001 |
| year region season *region*season* | 10344.83 | -5174.42 | -5180.47 | 16.61 | 0.0000 |
| year region season *year*region year*season* | 10226.71 | -5116.36 | -5125.44 | 18.72 | 0.0000 |
| year region season *year*region region*season* | 10223.00 | -5114.50 | -5123.58 | 22.44 | 0.0000 |
| year region season *year*region year*season region*season* | 10212.62 | -5110.31 | -5122.42 | 10.38 | 0.0013 |

Table 5. Fixed effects analysis of proportion of trips catching greater amberjack by full day headboats. Models with significant probability of the chi square statistic and accounting for at least 5% of the total explained deviance are highlighted.

| proportion positive model | df | deviance | change in deviance | maximum model deviance | % max. model deviance | *p* |
|---|---|---|---|---|---|---|
| null | 0 | 14013.49 | | | | |
| year | 12 | 13918.76 | 94.74 | | 15.54% | < 0.001 |
| year region | 4 | 13712.69 | 206.07 | | 33.80% | < 0.001 |
| year region season | 4 | 13669.74 | 42.95 | | 7.04% | < 0.001 |
| year region season region*season | 8 | 13541.02 | 128.71 | | 21.11% | < 0.001 |
| year region season region*season year*region | 31 | 13309.04 | 231.98 | | 38.05% | < 0.001 |
| year region season region*season year*season | 24 | 13425.61 | 115.41 | | 18.93% | < 0.001 |
| | | | | 704.4535 | | |

Table 6. Mixed effects analysis of proportion of trips catching greater amberjack by full day headboats.The only significant random effect was the region*season interaction. The -2 restricted log likelihood statistic (-2 REM log likelihood) was used in statistical tests.

| proportion positive model | -2 REM Log likelihood | Akaike's Information Criterion | Schwartz's Bayesian Criterion | Likelihood Ratio Test | *p* |
|---|---|---|---|---|---|
| year region season | 285.55 | -143.77 | -145.17 | | |
| year region season *year*region* | 293.43 | -148.71 | -151.50 | -7.88 | na |
| year region season *year*season* | 291.87 | -147.93 | -150.72 | -6.32 | na |
| year region season *region*season* | 278.96 | -141.48 | -144.27 | 6.58 | 0.010 |
| year region season *year*region year*season* | 293.01 | -149.50 | -153.69 | 0.42 | 0.810 |
| year region season *year*region region*season* | 277.41 | -141.71 | -145.89 | 1.55 | 0.460 |
| year region season *year*region year*season region*season* | 276.49 | -142.25 | -147.82 | 0.92 | 0.821 |

Table 7. Fixed effects analysis of catch rates on trips with greater amberjack by headboats fishing for multiple days. Models with significant probability of the chi square statistic and accounting for at least 5% of the total explained deviance are highlighted.

| positive catch rate model | d.f. for added factor | deviance | change in deviance | maximum model deviance | % total model deviance | *p* |
|---|---|---|---|---|---|---|
| null | | 5642.8876 | | | | |
| year | 9 | 5066.2058 | 576.7 | | 24.53% | < 0.001 |
| year region1 | 3 | 4186.9957 | 879.2 | | 37.40% | < 0.001 |
| year region1 season | 2 | 3970.3388 | 216.7 | | 9.22% | < 0.001 |
| year region1 season region1*season | 6 | 3743.8433 | 226.5 | | 9.64% | < 0.001 |
| year region1 season region1*season year*region1 | 13 | 3407.9136 | 335.9 | | 14.29% | < 0.001 |
| year region1 season region1*season year*season | 18 | 3292.3436 | 451.5 | | 19.21% | < 0.001 |
| | | | | 2350.544 | | |

Table 8. Mixed effects analysis of catch rates on trips with greater amberjack by headboats fishing for multiple days. Final model used for index development is highlighted. The -2 restricted log likelihood statistic (-2 REM log likelihood) was used in statistical tests.

| positive catch rate model | -2 REM Log likelihood | Akaike's Information Criterion | Schwartz's Bayesian Criterion | Likelihood Ratio | *p* |
|---|---|---|---|---|---|
| year region1 season | 735.51 | -368.75 | -370.46 | | |
| year region1 season *year*region1* | 730.65 | -367.33 | -370.73 | 4.855 | 0.0276 |
| year region1 season *year*season* | 723.70 | -363.85 | -367.26 | 11.808 | 0.0006 |
| year region1 season *region1*season* | 729.04 | -366.52 | -369.93 | 6.466 | 0.0110 |
| year region1 season *year*region1 year*season* | 720.02 | -363.01 | -368.12 | 10.632 | 0.0011 |
| year region1 season *year*region1 region1*season* | 722.46 | -364.23 | -369.34 | 8.192 | 0.0042 |
| year region1 season *year*region1 year*season region1*season* | 719.72 | -363.86 | -370.67 | 2.741 | 0.0978 |

Table 9. Fixed effects analysis of proportion of trips catching greater amberjack by headboats fishing for multiple days. Models with significant probability of the chi square statistic and accounting for at least 5% of the total explained deviance are highlighted.

| proportion positive model | df | deviance | change in deviance | maximum model deviance | % max. model deviance | *p* |
|---|---|---|---|---|---|---|
| null | | 465.3197 | | | | |
| year | 9 | 433.5065 | 31.8132 | | 56.34% | < 0.001 |
| year region1 | 3 | 400.9925 | 32.514 | | 57.58% | < 0.001 |
| year region1 season | 2 | 377.0383 | 23.9542 | | 42.42% | < 0.001 |
| year region1 season region1*season | 6 | na | | | | |
| year region1 season region1*season year*region1 | 13 | na | | | | |
| year region1 season region1*season year*season | 18 | na | | | | |
| | | | | 88.2814 | | |

Table 10. Mixed effects analysis of proportion of trips catching greater amberjack by headboats fishing for multiple days. The final model for index development is highlighted. The -2 restricted log likelihood statistic (-2 REM log likelihood) was used in statistical tests.

| proportion positive model | -2 REM Log likelihood | Akaike's Information Criterion | Schwartz's Bayesian Criterion | Likelihood Ratio | *p* |
|---|---|---|---|---|---|
| year region1 season | 213.62 | -107.81 | -108.76 | | |
| year region1 season *year*region1* | 213.18 | -108.59 | -110.48 | 0.443 | 0.5056 |
| year region1 season *year*season* | 213.62 | -108.81 | -110.70 | 0.000 | 1.0000 |
| year region1 season *region1*season* | 217.60 | -110.80 | -112.69 | -3.974 | 1.0000 |
| year region1 season *year*region1 year*season* | 213.18 | -109.59 | -112.43 | 0.000 | 1.0000 |
| year region1 season *year*region1 region1*season* | 218.23 | -112.11 | -114.95 | -5.045 | 1.0000 |
| year region1 season *year*region1 year*season region1*season* | | | | | na |

Table 11. Fixed effects analyses of catch rates on trips with greater amberjack by headboats recorded as fishing for a full night. Two sets of analyses were run: one with year and region, the other with year and season. Models with significant probability of the chi square statistic and accounting for at least 5% of the total explained deviance are highlighted.

| positive catch rate model | d.f. for added factor | deviance | change in deviance | maximum model deviance | % total model deviance | *p* |
|---|---|---|---|---|---|---|
| null | | 137.4908 | | | | |
| year | 12 | 84.6264 | 52.8644 | | 94.36% | < 0.001 |
| year region | 2 | 82.1124 | 2.514 | | 4.49% | 0.285 |
| year region year*region | 4 | 81.468 | 0.6444 | | 1.15% | 0.958 |
| | | | | 56.0228 | | |
| null | | 114.2488 | | | | |
| year | 11 | 84.1064 | 30.1424 | | 53.80% | 0.002 |
| year season | 2 | 83.5792 | 0.5272 | | 0.94% | 0.768 |
| year season year*season | 10 | 80.0451 | 3.5341 | | 6.31% | 0.966 |
| | | | | 34.2037 | | |

Table 12. Mixed effects analysis of catch rates on trips with greater amberjack by headboats recorded as fishing for a full night. Two sets of analyses were conducted: one with year and region, the other with year and season. The -2 restricted log likelihood statistic (-2 REM log likelihood) was used in statistical tests.

| positive catch rate model | -2 REM Log likelihood | Akaike's Information Criterion | Schwartz's Bayesian Criterion | Likelihood Ratio | *p* |
|---|---|---|---|---|---|
| year region | 363.15 | -182.57 | -183.98 | | |
| year region *year*region* | 362.35 | -183.17 | -185.98 | 0.7975 | 0.372 |
| | | | | | |
| year season | 400.18 | -201.09 | -202.52 | | |
| year season *year*season* | 400.02 | -202.01 | -204.87 | 0.1603 | 0.689 |

Table 13. Fixed effects analysis of proportion of trips catching greater amberjack by headboats recorded as fishing for a full night. Two sets of analyses were conducted: one with year and region, the other with year and season. Models with significant probability of the chi square statistic and accounting for at least 5% of the total explained deviance are highlighted

| proportion positive model | df | deviance | change in deviance | maximum model deviance | % max. model deviance | *p* |
|---|---|---|---|---|---|---|
| null | | 424.392 | | | | |
| year | 12 | 367.9351 | 56.4569 | | 81.08% | < 0.001 |
| year region | 2 | 361.398 | 6.5371 | | 9.39% | 0.038 |
| year region year*region | 4 | 354.7647 | 6.6333 | | 9.53% | 0.157 |
| | | | | 69.6273 | | |
| | | | | | | |
| null | | 438.808 | | | | |
| year | 11 | 392.3778 | 46.4302 | | 66.68% | < 0.001 |
| year season | 2 | 367.2935 | 25.0843 | | 36.03% | < 0.001 |
| year season year*season | | na | | | | |
| | | | | 71.5145 | | |

Table 14. Mixed effects analysis of proportion of trips catching greater amberjack by headboats fishing for multiple days. Two sets of analyses were conducted: one with year and region, the other with year and season.The -2 restricted log likelihood statistic (-2 REM log likelihood) was used in statistical tests.

| proportion positive model | -2 REM Log likelihood | Akaike's Information Criterion | Schwartz's Bayesian Criterion | Likelihood Ratio Test |
|---|---|---|---|---|
| year region | 14.81374 | -8.40687 | -8.10002 | |
| year region year*region | na | | | |
| | | | | |
| year season | 52.65177 | -27.3259 | -27.5683 | |
| year season year*season | na | | | |

Table 15. Standardized catch rates for Gulf of Mexico greater amberjack developed from Southeast U.S. Headboat Survey data.

| | full day | | | multi-day | | | full night | | |
|---|---|---|---|---|---|---|---|---|---|
| units | index n fish | standard error | coefficient of variation | index n fish | standard error | coefficient of variation | index n fish | standard error | coefficient of variation |
| 1986 | 0.119 | 0.057 | 0.48 | | | | 0.074 | 0.091 | 1.24 |
| 1987 | 0.057 | 0.032 | 0.56 | | | | | | |
| 1988 | 0.077 | 0.038 | 0.50 | 12.703 | 4.569 | 0.36 | 0.274 | 0.170 | 0.62 |
| 1989 | 0.081 | 0.038 | 0.47 | 18.931 | 6.735 | 0.36 | 0.236 | 0.153 | 0.65 |
| 1990 | 0.066 | 0.035 | 0.52 | 16.603 | 7.863 | 0.47 | 0.051 | 0.075 | 1.47 |
| 1991 | 0.082 | 0.041 | 0.50 | | | | 0.797 | 0.419 | 0.53 |
| 1992 | 0.106 | 0.046 | 0.44 | 31.617 | 11.011 | 0.35 | 1.012 | 0.352 | 0.35 |
| 1993 | 0.088 | 0.041 | 0.47 | 25.531 | 9.337 | 0.37 | 0.015 | 0.058 | 3.74 |
| 1994 | 0.108 | 0.050 | 0.46 | 8.680 | 3.896 | 0.45 | 0.036 | 0.063 | 1.73 |
| 1995 | 0.120 | 0.051 | 0.43 | 10.152 | 3.831 | 0.38 | 0.247 | 0.136 | 0.55 |
| 1996 | 0.098 | 0.052 | 0.53 | 11.927 | 5.137 | 0.43 | 0.185 | 0.210 | 1.14 |
| 1997 | 0.074 | 0.042 | 0.57 | 21.704 | 8.661 | 0.40 | 0.266 | 0.130 | 0.49 |
| 1998 | 0.099 | 0.051 | 0.51 | 21.830 | 8.154 | 0.37 | 0.280 | 0.127 | 0.46 |

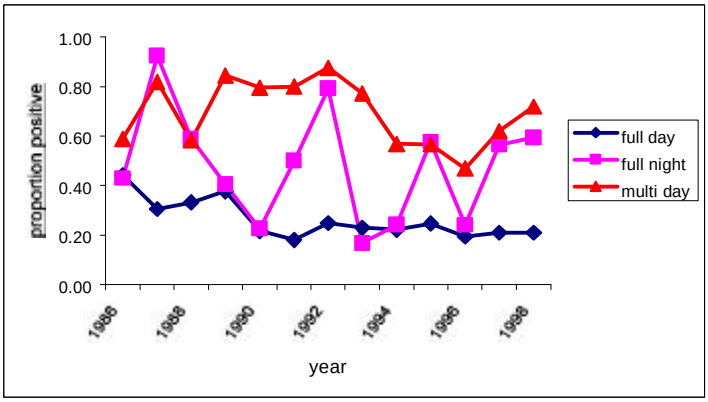


Figure 1. Proportion of headboat trips which caught greater amberjack by trip type and year.

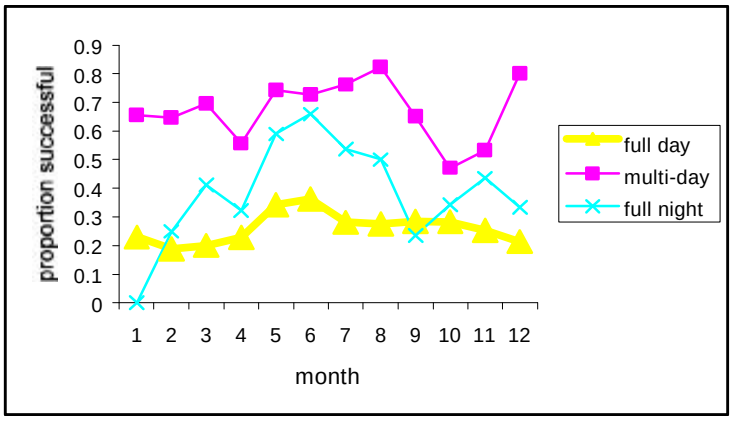


Figure 2. Proportion of headboat trips with greater amberjack by month and trip type.

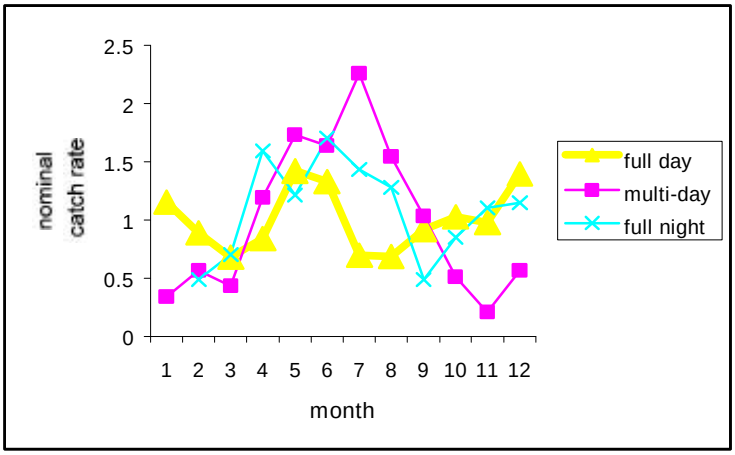


Figure 3. Nominal catch rates by trip type and month scaled to the mean of each series.

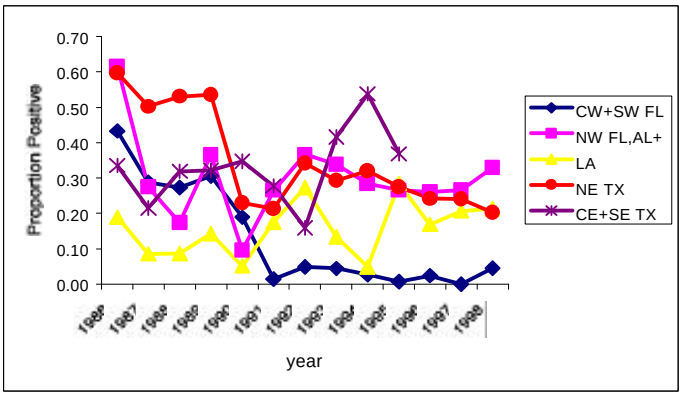


Figure 4. Proportion of full day headboat trips catching greater amberjack by region.

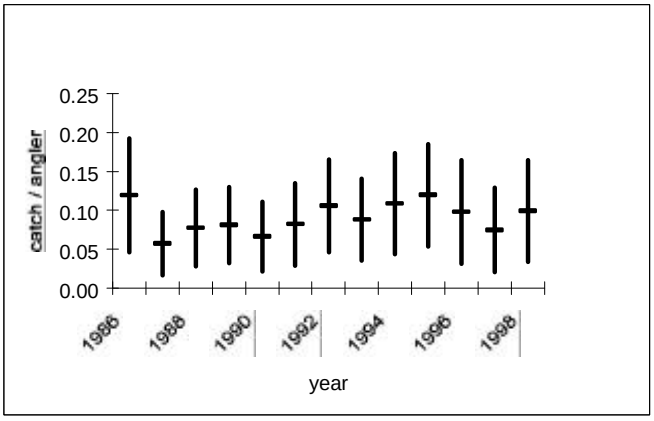


Figure 5. Standardized catch rates from full day headboat trips with 80% confidence intervals.

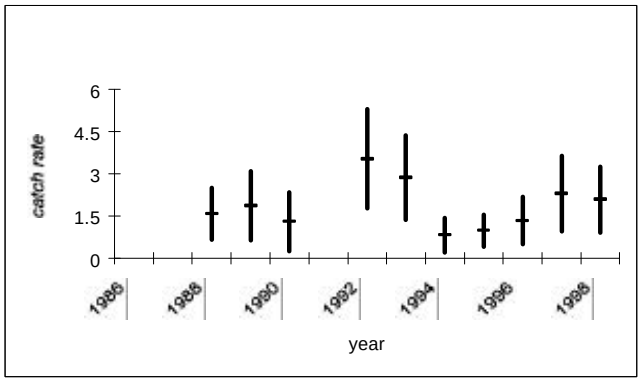


Figure 6. Standardized catch per 100 angler hours from multi-day headboat trips with 80% confidence intervals

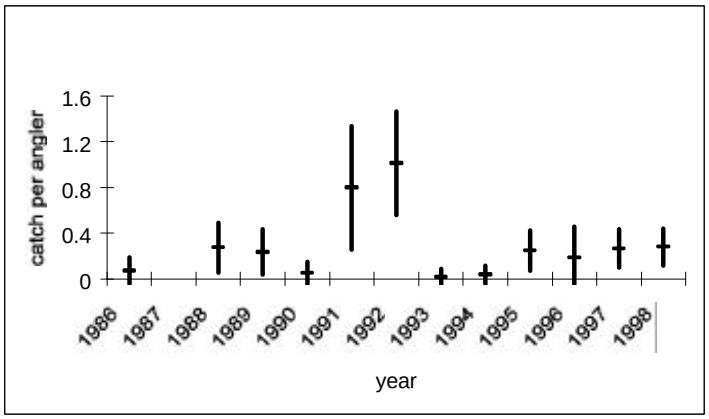


Figure 7. Standardized catch rates from headboat trips recorded as full night with 80% confidence intervals.

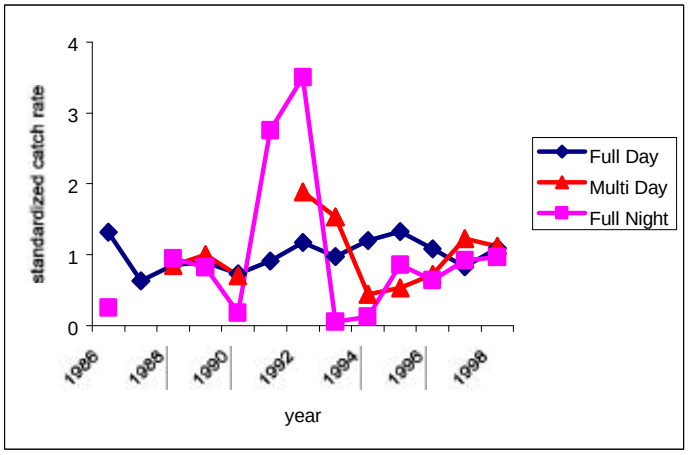


Figure 8. Comparison of standardized catch rates (rescaled to their means) of Gulf of Mexico greater amberjack for headboat fisheries.