# Standardized catch rates of U.S. gray triggerfish (Balistes capriscus) from commercial logbook data

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# Standardized catch rates of U.S. gray triggerfish (Balistes capriscus) from commercial logbook data

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## 1. Introduction

Landings and fishing effort of commercial vessels operating in the southeast U.S. Atlantic have been monitored by the NMFS Southeast Fisheries Science Center through the Coastal Fisheries Logbook Program (CFLP). The program collects information about each fishing trip from all vessels holding federal permits to fish in waters managed by the Gulf of Mexico and South Atlantic Fishery Management Councils. Initiated in the Gulf in 1990, the CFLP began collecting logbooks from Atlantic commercial fishers in 1992, when 20% of Florida vessels were targeted. Beginning in 1993, sampling in Florida was increased to require reports from all vessels permitted in coastal fisheries, and since then has maintained the objective of a complete census of federally permitted vessels in the southeast U.S.

Catch per unit effort (CPUE) from the logbooks was used to develop an index of abundance for gray triggerfish landed with vertical lines (manual handline and electric/hydraulic reel), the dominant gear for this gray triggerfish stock. Thus, the size and age range of fish included in the index is the same as that of landings from this same fleet. The time series used for construction of the index spanned 1993−2011, when all vessels with federal snapper-grouper permits were required to submit logbooks on each fishing trip.

## 2. Data and treatment

### 2.1 Available Data

For each fishing trip, the CFLP database included a unique trip identifier, the landing date, fishing gear deployed, areas fished, number of days at sea, number of crew, gear-specific fishing effort, species caught, and weight of the landings (reported fields described in Appendix 1). Fishing effort data available for vertical line gear included number of lines fished, hours fished, and number of hooks per line. For this southeast U.S. Atlantic stock, areas used in analysis were those between 24 and 37 degrees latitude, inclusive of the boundaries (Figure 1).

Data were restricted to include only those trips with landings and effort data reported within 45 days of the completion of the trip (some reporting delays were longer than one year). Reporting delays beyond 45 days likely resulted in less reliable effort data (landings data may be reliable even with lengthy reporting delays if trip ticket reports were referenced by the reporting fisher). Also excluded were records reporting multiple areas or gears fished, which

prevents designating catch and effort to specific locations or gears. Therefore, only trips which reported one area and one gear fished were included in these analyses.

Clear outliers in the data, e.g. values falling outside the 99.5 percentile of the data, were also excluded from the analyses. These outliers were identified for manual handlines as records reporting more than 20 lines fished, 15 hooks per line fished, 16 days at sea, or 4 crew members, and they were identified for electric reels as records reporting more than 7 lines fished, 13 hooks per line fished, 16 days at sea, or 6 crew members. Records with greater than 2265 pounds or a 32 pounds/hook-hr were excluded.

## 3. Standardization

The response variable, CPUE, was calculated for each trip as,

CPUE = pounds of gray triggerfish/hook-hours

where hook-hours is the product of number of lines fished, number of hooks per line, and total hours fished. Explanatory variables, all categorical, are described below. Estimates of variance were based on 1000 bootstrap runs where trips were chosen randomly with replacement. All analyses were programmed in R, with much of the code adapted from Dick (2004).

### 3.1 Explanatory variables considered

YEAR — Year was necessarily included, as standardized catch rates by year are the desired outcome. Years modeled were 1993−2011. The total number of gray triggerfish trips by year is provided in Table 1.

MONTH — Individual months were included as factors. The total number of gray triggerfish trips by month is provided in Table 2.

REGION — Areas reported in the logbook (Figure 1) were pooled into the broader geographic levels: North Carolina (NC), South Carolina (SC), Georgia and north Florida combined (Ga.NFL), and south Florida (SFL). The break between north and south Florida occurred at 28 degrees latitude, near Cape Canaveral, which has been identified as a zoogeographical boundary (Shertzer et al., 2009). The number of trips per year by area is shown in Table 3.

CREW SIZE — Crew size (crew) was pooled into four levels: one (1), two (2), three (3), or four or more (4plus). The number of trips per year by crew is shown in Table 4.

DAYS AT SEA — Days at sea (sea days) were pooled into three levels: one or two days (1-2), two or three days (3-4), and five or more days (5plus). The number of trips per year by sea days is shown in Table 5.

### 3.2 Positive CPUE model

Two parametric distributions were considered for modeling positive values of CPUE, lognormal and gamma. For both distributions, all explanatory variables were initially included as main effects, and then stepwise AIC (Venables and Ripley, 1997) with a backwards selection algorithm was used to eliminate those variables that did not improve model fit. For both lognormal and gamma distributions, the best model fit included all explanatory variables (lognormal shown in Table 6). The two distributions, each with their best set of explanatory variables (all of them), were compared using AIC: lognormal outperformed gamma and was therefore applied in the final GLM. Diagnostics suggested reasonable fits of the lognormal model (Figures 2, 3).

## Results

Several models were considered during the SEDAR 32 DW. The sequence of models and brief summary of the SEDAR 32 DW consensus opinion is given in Table 7. Nominal CPUE averaged across areas tracked more closely the nominal CPUEs of NC (Figure 4). The standardized index increased through the 1990's then dropped in 2000 and has increased since 2003 (Figure 5, Table 1). Over the past few years, index has increased sharply, culminating in the highest expected value of the full series. There was some concern that the recent increase may be due to increased targeting of gray triggerfish as other fisheries such as black sea bass and vermilion snapper were closed to fishing. However, only anecdotal information was available for a very small number of fishers. Although the index was computed starting in 1993, the assessment might justifiably start the index in 1995, when size-limit regulations were implemented off the coast of Florida.

## Literature cited

Dick, E.J. 2004. Beyond 'lognormal versus gamma': discrimination among error distributions for generalized linear models. Fish. Res. 70:351−366.

Shertzer, K.W., E.H. Williams, and J.C. Taylor. 2009. Spatial structure and temporal patterns in a large marine ecosystem: Exploited reef fishes of the southeast United States. Fish. Res.
100:126−133.

Venables, W. N. and B. D. Ripley. 1997. Modern Applied Statistics with S-Plus, 2nd Edition. Springer-Verlag, New York.

Table 1. Standardized index of gray triggerfish from commercial logbook data.

| Year | N | Relative nominal CPUE | Standardized CPUE | CV |
|---|---|---|---|---|
| 1993 | 625 | 0.624 | 0.700 | 0.059 |
| 1994 | 1061 | 0.937 | 0.787 | 0.049 |
| 1995 | 1139 | 0.914 | 0.927 | 0.041 |
| 1996 | 850 | 1.135 | 1.002 | 0.049 |
| 1997 | 1299 | 1.239 | 1.133 | 0.044 |
| 1998 | 1106 | 1.335 | 1.193 | 0.046 |
| 1999 | 1025 | 1.188 | 1.161 | 0.048 |
| 2000 | 933 | 0.763 | 0.806 | 0.050 |
| 2001 | 1084 | 0.695 | 0.738 | 0.046 |
| 2002 | 1554 | 0.649 | 0.639 | 0.037 |
| 2003 | 1319 | 0.848 | 0.784 | 0.042 |
| 2004 | 1492 | 0.971 | 1.038 | 0.037 |
| 2005 | 1447 | 0.899 | 1.063 | 0.036 |
| 2006 | 1301 | 0.857 | 0.855 | 0.040 |
| 2007 | 1496 | 0.863 | 0.942 | 0.035 |
| 2008 | 1391 | 0.815 | 0.895 | 0.037 |
| 2009 | 1334 | 0.998 | 1.034 | 0.039 |
| 2010 | 1203 | 1.554 | 1.533 | 0.041 |
| 2011 | 1163 | 1.716 | 1.770 | 0.043 |

Table 2. Number of gray triggerfish trips by month for each year.

| | Month | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1993 | | 5 | 45 | 83 | 121 | 102 | 119 | 92 | 8 | | 1 | 49 |
| 1994 | 56 | 75 | 95 | 111 | 93 | 109 | 58 | 110 | 100 | 97 | 74 | 83 |
| 1995 | 84 | 48 | 87 | 113 | 121 | 117 | 125 | 99 | 99 | 90 | 95 | 61 |
| 1996 | 56 | 58 | 29 | 46 | 58 | 79 | 50 | 130 | 77 | 83 | 85 | 99 |
| 1997 | 65 | 67 | 109 | 102 | 128 | 140 | 120 | 114 | 134 | 139 | 102 | 79 |
| 1998 | 85 | 79 | 79 | 70 | 126 | 102 | 79 | 84 | 103 | 119 | 100 | 80 |
| 1999 | 100 | 76 | 74 | 88 | 128 | 88 | 89 | 92 | 63 | 85 | 58 | 83 |
| 2000 | 37 | 66 | 75 | 71 | 83 | 99 | 91 | 98 | 85 | 90 | 91 | 47 |
| 2001 | 67 | 67 | 67 | 83 | 103 | 116 | 98 | 137 | 105 | 86 | 68 | 87 |
| 2002 | 87 | 71 | 126 | 131 | 128 | 155 | 142 | 175 | 134 | 159 | 141 | 104 |
| 2003 | 63 | 69 | 90 | 106 | 130 | 139 | 92 | 111 | 111 | 147 | 145 | 115 |
| 2004 | 95 | 94 | 114 | 136 | 160 | 110 | 147 | 122 | 74 | 179 | 145 | 116 |
| 2005 | 109 | 110 | 105 | 108 | 180 | 139 | 153 | 136 | 135 | 94 | 111 | 67 |
| 2006 | 102 | 80 | 99 | 96 | 136 | 106 | 111 | 121 | 121 | 109 | 122 | 98 |
| 2007 | 74 | 77 | 101 | 111 | 129 | 158 | 142 | 179 | 135 | 136 | 112 | 142 |
| 2008 | 85 | 84 | 76 | 88 | 142 | 163 | 147 | 167 | 108 | 123 | 111 | 97 |
| 2009 | 81 | 87 | 54 | 94 | 132 | 185 | 139 | 162 | 145 | 96 | 99 | 60 |
| 2010 | 142 | 78 | 74 | 46 | 138 | 89 | 130 | 139 | 118 | 113 | 80 | 56 |
| 2011 | 112 | 83 | 33 | 32 | 131 | 92 | 142 | 152 | 176 | 61 | 65 | 84 |

Table 3. Number of gray triggerfish trips by region and year.

| Year | NC | SC | Ga.NFL | SFL |
|---|---|---|---|---|
| 1993 | 173 | 240 | 113 | 99 |
| 1994 | 354 | 427 | 162 | 118 |
| 1995 | 401 | 452 | 198 | 88 |
| 1996 | 260 | 352 | 162 | 76 |
| 1997 | 361 | 633 | 171 | 134 |
| 1998 | 277 | 563 | 145 | 121 |
| 1999 | 254 | 493 | 108 | 169 |
| 2000 | 215 | 516 | 100 | 102 |
| 2001 | 276 | 586 | 104 | 118 |
| 2002 | 449 | 676 | 260 | 168 |
| 2003 | 307 | 625 | 179 | 207 |
| 2004 | 287 | 694 | 212 | 299 |
| 2005 | 283 | 666 | 251 | 247 |
| 2006 | 294 | 671 | 172 | 164 |
| 2007 | 373 | 731 | 238 | 154 |
| 2008 | 371 | 624 | 315 | 81 |
| 2009 | 332 | 479 | 370 | 153 |
| 2010 | 274 | 505 | 289 | 135 |
| 2011 | 253 | 491 | 311 | 108 |

Table 4. Number of gray triggerfish trips by crew size and year.

| Year | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1993 | 78 | 339 | 165 | 43 |
| 1994 | 117 | 597 | 283 | 64 |
| 1995 | 143 | 622 | 279 | 95 |
| 1996 | 92 | 447 | 227 | 84 |
| 1997 | 145 | 691 | 353 | 110 |
| 1998 | 143 | 590 | 278 | 95 |
| 1999 | 132 | 540 | 277 | 75 |
| 2000 | 107 | 478 | 272 | 76 |
| 2001 | 139 | 552 | 315 | 78 |
| 2002 | 170 | 687 | 486 | 210 |
| 2003 | 213 | 615 | 348 | 142 |
| 2004 | 322 | 596 | 394 | 180 |
| 2005 | 233 | 588 | 427 | 199 |
| 2006 | 172 | 555 | 407 | 167 |
| 2007 | 170 | 607 | 529 | 190 |
| 2008 | 116 | 585 | 489 | 201 |
| 2009 | 118 | 545 | 483 | 188 |
| 2010 | 119 | 520 | 417 | 147 |
| 2011 | 110 | 512 | 389 | 152 |

Table 5. Number of gray triggerfish trips by days at sea and year.

| Year | 1-2 | 3-4 | 5plus |
|---|---|---|---|
| 1993 | 353 | 220 | 52 |
| 1994 | 596 | 351 | 114 |
| 1995 | 596 | 452 | 91 |
| 1996 | 391 | 369 | 90 |
| 1997 | 650 | 504 | 145 |
| 1998 | 604 | 370 | 132 |
| 1999 | 587 | 344 | 93 |
| 2000 | 544 | 301 | 88 |
| 2001 | 562 | 441 | 81 |
| 2002 | 642 | 498 | 413 |
| 2003 | 577 | 350 | 391 |
| 2004 | 650 | 363 | 479 |
| 2005 | 572 | 413 | 462 |
| 2006 | 462 | 321 | 518 |
| 2007 | 555 | 420 | 521 |
| 2008 | 502 | 418 | 471 |
| 2009 | 539 | 336 | 459 |
| 2010 | 483 | 328 | 392 |
| 2011 | 428 | 370 | 365 |

Table 6. Model selection results from lognormal model.

| Removed | Df | Deviance | AIC |
|---|---|---|---|
| None | | 74340 | 39895 |
| Crew | 3 | 74493 | 40019 |
| Days at sea | 2 | 74675 | 40302 |
| Region | 3 | 75363 | 40428 |
| Month | 11 | 75922 | 41022 |
| Year | 18 | 76320 | 41297 |

Table 7. Sequence of gray triggerfish index models leading up to the final accepted version.

| Model | Consensus |
|---|---|
| Delta-GLM, Stephens&MacCall, species in at least 1% logbook trips, factors not pooled | Crew and away factor levels need to be pooled, Stephens&MacCall species assemblages questionable North of Cape Hatteras |
| Delta-GLM, pool factor levels for crew size and days at sea, limit to Stephens&MacCall to the snapper-grouper complex and apply North and South of Cape Canaveral (not North of Cape Hatteras) due to small number of samples and unlikely species associations | Excessive loss of positive trips (over half in some years) |
| GLM on positive gray triggerfish trips using the lognormal error distribution | Accepted |

Figure 1. Commercial handline trips (left panel) and positive gray triggerfish commercial handline trips (right panel). The green symbols represent the areas that combined signify fifty percent of the total trips, the red and green circles combined represent seventy-five percent of the total trips, the red, green, and yellow symbols combined represent ninety-nine percent of the total trips, and the gray symbols represent one percent of the trips.

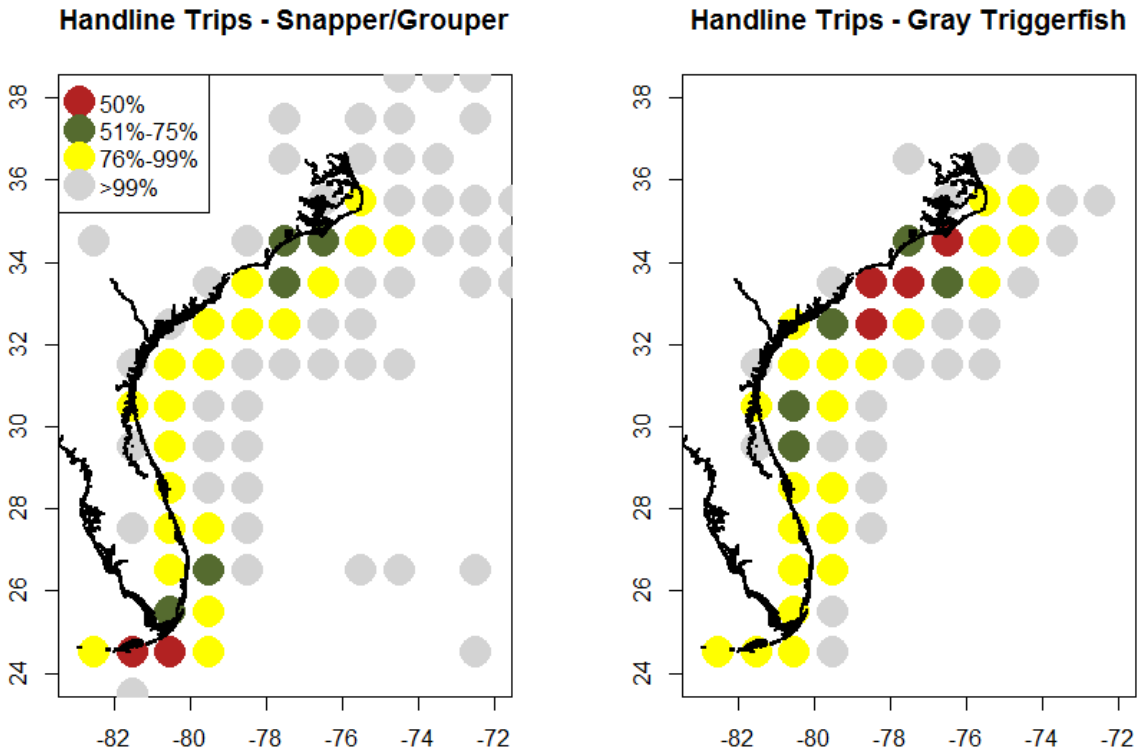
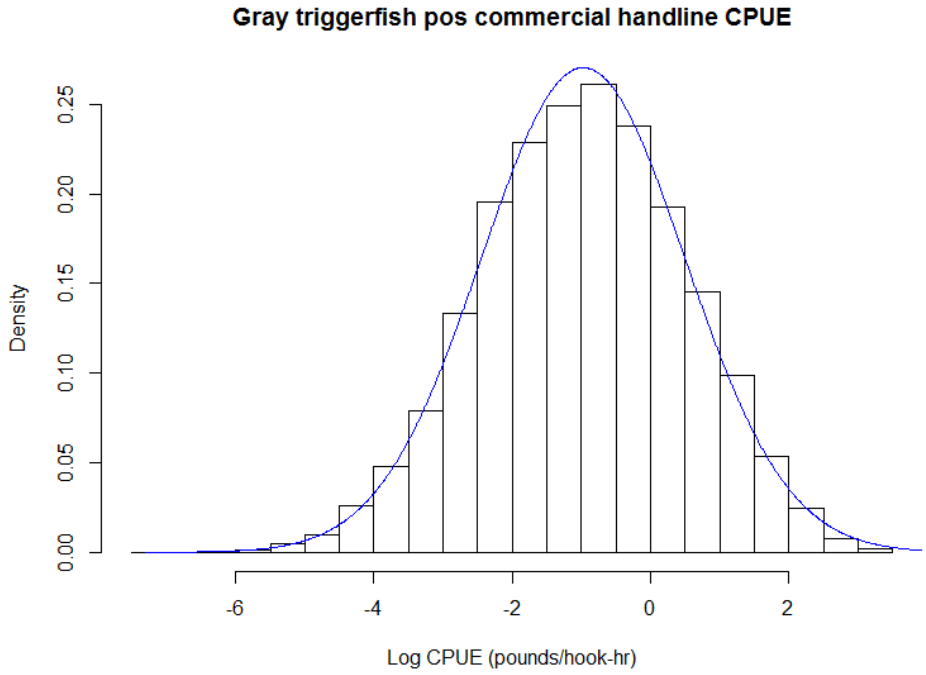


Figure 2. Diagnostics of lognormal model fits to positive CPUE data. Top panel shows the histogram of empirical log CPUE, with the normal distribution (empirical mean and variance) overlaid. Bottom panel shows the quantile-quantile plot of residuals from the fitted model.



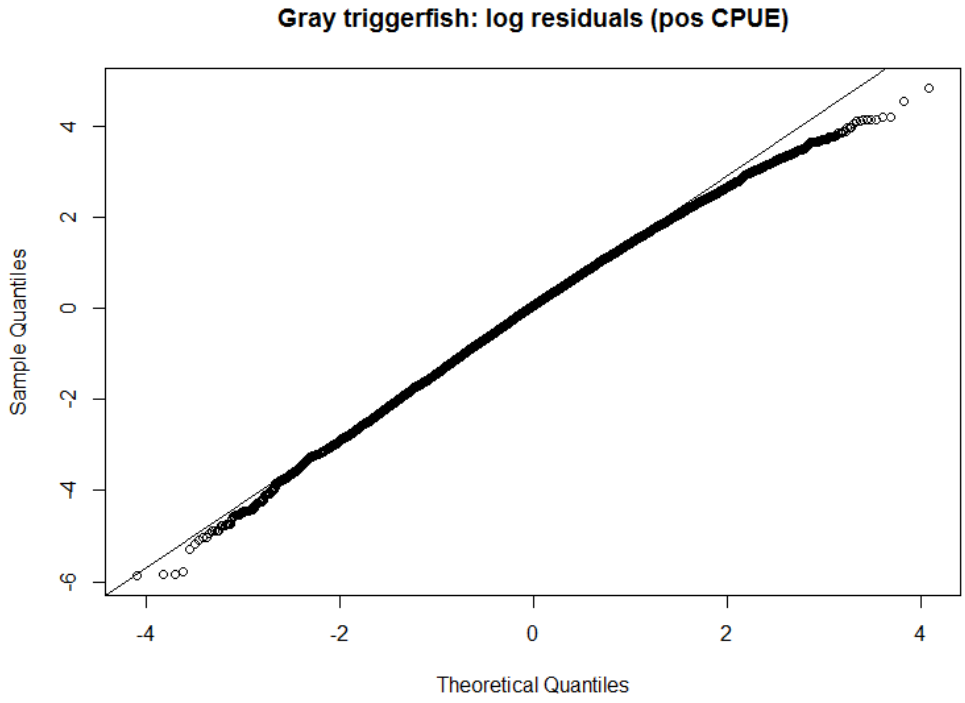
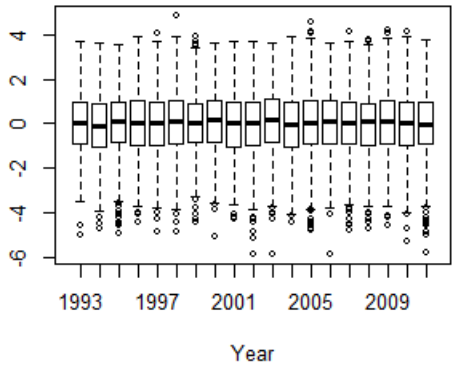
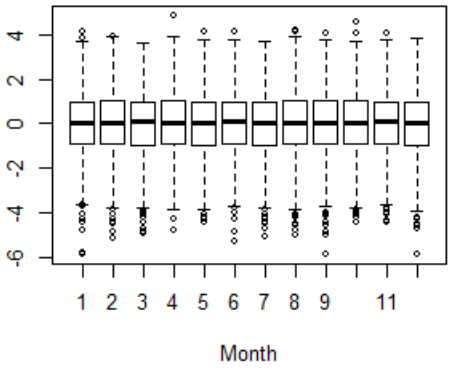
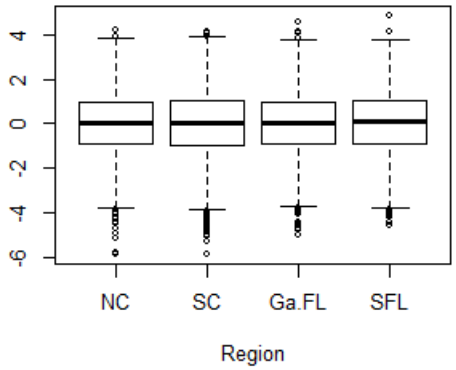
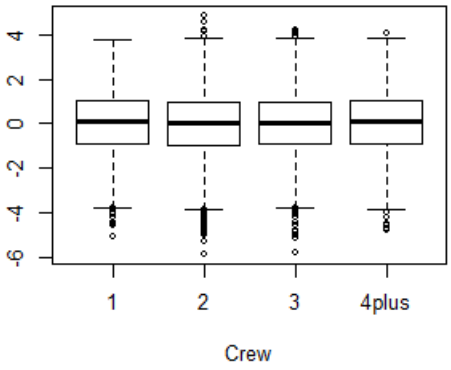



Figure 3. Diagnostics of lognormal model fits to positive CPUE data. Box-and-whisker plots give first, second (median), and third quartiles, as well as limbs that extend approximately one interquartile range beyond the nearest quartile, and outliers (circles) beyond the limbs. Residuals are raw.



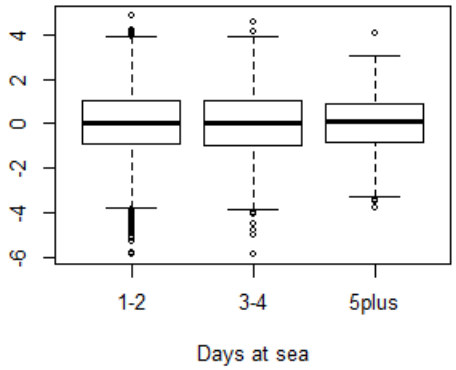



Figure 4. Nominal CPUE by region across all years.

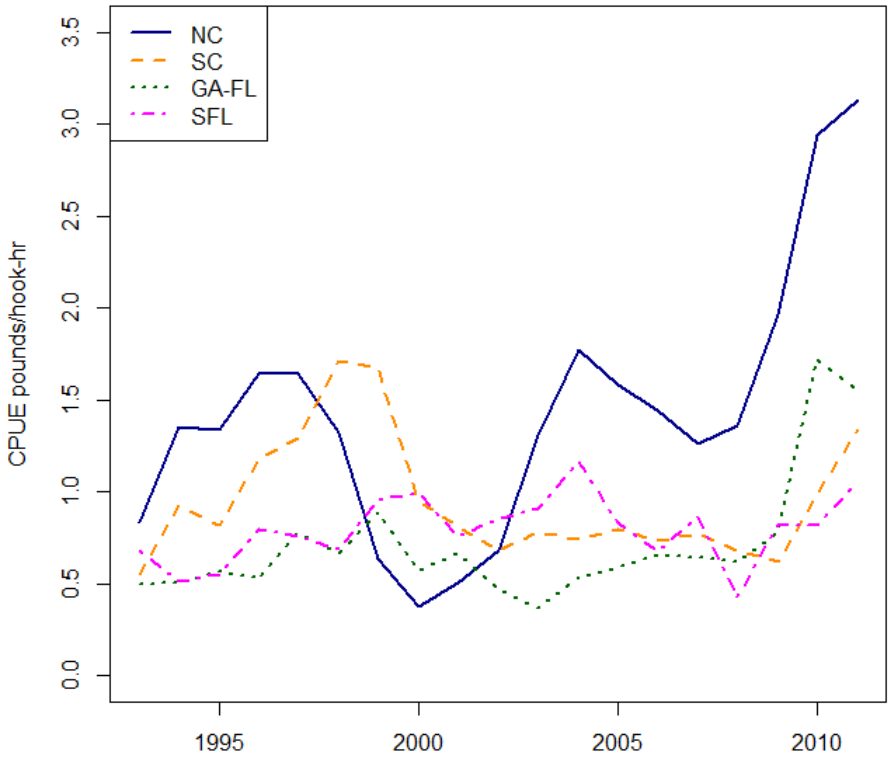


Figure 5. Gray triggerfish standardized CPUE and nominal cpue.