Preliminary standardized catch rates of Southeast US Atlantic black sea bass (*Centropristis striata*) from headboat data

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Abstract
Standardized catch rates were generated from the Southeast headboat survey trip records (logbooks) for 1979-2010. The analysis included areas from central North Carolina through central Florida. The index is meant to describe population trends of fish in the size/age range of fish landed by headboat vessels. Data filtering and subsetting steps were applied to the data to improve the quality of the data and to model trips with directed black sea bass effort.

Background and description

The headboat fishery in the south Atlantic includes for-hire vessels that typically accommodate 11-70 passengers and charge a fee per angler. The fishery uses hook and line gear, generally targets hard bottom reefs as the fishing grounds, and generally targets multiple species in the snapper- grouper complex. This fishery is sampled separately from other fisheries, and the available data were used to generate a fishery dependent index, with the size and age range of fish the same as that of landings from the headboat fishery.

Headboats in the south Atlantic are sampled from North Carolina to the Florida Keys (Figure 1). Data have been collected since 1972, but logbook reporting did not start until 1973. In addition, only North Carolina and South Carolina were included in the earlier years of the data set. In 1976, data were collected from North Carolina, South Carolina, Georgia, and northern Florida, and starting in 1978, data were collected from southern Florida (areas 11, 12, and 17). Variables reported in the data set include year, month, day, area, location, trip type, number of anglers, species, catch, and vessel id. Biological data and discard data were recorded for some trips in some years.

Methods

Headboat records were examined, and the data were explored in order to determine if any confounding factors would have an effect on the ability of the index to reflect relative abundance. Weight-per-unit-effort (WPUE) standardization was then employed, and an index of abundance was computed for 1979-2010.

Data

Data collection

Starting in 1973, the headboat survey initially requested vessel captain's to report black sea bass landings in units of 100-pound boxes by size category (small, medium and large). In the later 1970's small, medium, and large were defined as less than 1-lb, 1- to 2- lbs, and greater than 2 pounds respectively. The logbook form changed in 1979 to request black sea bass in pounds and again in 1992 requesting black sea bass catch in numbers and pounds. All other species requested data in numbers and pounds for the entire survey. Captains and crew were instructed

to combine black sea bass and bank sea bass catch until 1986 when bank sea bass were added to the form. However, this rule was only partially adopted by vessel operators until approximately 1988. The small percentage (<5%) of bank sea bass included in the black sea bass landings was corrected at the trip level (as explained later). Until 1982, vessel personnel were paid to complete logbook forms. Changes to the logbook form over time primarily consist of changes in the species requested and trip type definitions.

Database

A snapshot of the headboat catch record (CR) files was created on March 20, 2011. Years included in the initial data were 1973–2010. Each record represents trip and species level information. Before using the data, several issues had to be resolved including trip identification, duplicated data, and black sea bass data entry errors.

The annual catch record files were combined, selecting trips that caught species in the snapper-grouper complex (Table 1). Only weight was recorded for black sea bass until 1992. Weight values were reassigned to the weight field for 1973-1991 formerly stored in numbers field. A trip identification variable was created using trip identifier variables prior to 1987when a collection number was added to identify trips.

Duplicate values were present at two levels. Complete duplicates of all variables were believed to be erroneous and removed (88 records/748000 total records). Removal of multi-day trips eliminated 16600 records. For records with identical information except for caught and weight (257 records/731312 total records), the caught and weight fields were summed by trip for species recorded more than once per trip. Headboat personnel provided several reasons why species would be entered twice for a given trip record but, indicated they were not likely to have the same value.

Data modifications

A factor was created for the trips that caught any of deepwater complex species (Blueline tilefish, Snowy grouper, Speckled hind, Yellowedge grouper, Cubera snapper, Warsaw grouper) defined using cluster analysis (Shertzer and Williams, 2008).

The black sea bass catch for each trip prior to 1988 was multiplied by the black sea bass to bank sea bass ratio (0.9536) developed during the black sea bass assessment update in 2003. This ratio was developed based on- and applied to- landed fish only.

Data Filtering

Years

Data from 1973-1978 were dropped from the analysis because the logbook forms requested units of small, medium and large 100 pound boxes. A value of 1 on the logbook form was encoded as 100 in the headboat database. A small sample of logbook forms from 1973-1978 were evaluated and revealed other problems with black sea bass reporting. Headboat captains often reported fractions, ¼, ½, and ¾ boxes which were coded correctly as 25, 50, and 75 pounds respectively. There were many records in the database during this time period below the 1/4 box (25 pound) level. Further investigation of a small subsample of these trips revealed inconsistency in data encoding.

The 100-pound boxes for some trips were entered as pounds; 1-(100-lb box) on form encoded as 1 (lb) in database. Sometimes these smaller values were the result of vessel personnel writing in smaller catches in pounds on the form making it impossible to discriminate between data entry errors from accurate data for these small values without evaluating each of the archived hard copies from those trips. The form changed in 1979 to report black sea bass in pounds and again in 1992 to report in numbers and pounds as for other species.

Areas
Data from area 1 (Figure 1) were excluded as this area was not recorded during most of the time series. Areas 11, 12, and 17 representing South Florida, the Florida Keys and the Tortugas were excluded due to very low catches of black sea bass. Georgia was included with North Florida even though there were very few years with headboat catch records before 1994. One headboat captain from Georgia and former headboat personnel agree that very little headboat effort was prosecuted in Georgia prior to the mid-1990's.

Vessels
Vessels that did have at least 250 trips recorded were removed from the analysis. These vessels either did not operate for more than a few years or participated minimally each year. There was concern that CPUE from short term vessels were confounded by business startup, learning locations and developing their niche within the fleet. Vessels that participate minimally may also be operating as commercial or private fishing vessels. These trips were excluded because they likely don't reflect the behavior of headboats in general. This step removed a major percentage of the vessels but, a small portion of the trips (Table 1).

Outliers
Finally, trips defined by the upper 0.5% of black sea bass catch, anglers, and catch per trip hour were dropped as they likely represent misreporting or data entry errors (Table 1, Figure 2).

Management influence on WPUE estimation

Changes in the minimum size limit did not result in changes in the computation of the headboat index. Changes in the size limit can be accounted for with selectivity estimation within the assessment model.

Federal bag limits for black sea bass began in 1999 at 20 fish per angler per day. This limit was reduced in 2006 to 15 fish per angler per day. The bag limit change was explored to determine if bag limits impacted the catch of black sea bass. To determine if change occurred, the percentage of headboat trips where anglers caught 20 or more-(1992-2005) and 15 or more-(2006-2010) black sea bass was compared before and after the bag limit changes. Based on this exploration, harvest of black sea bass did not change after bag limit changes were instituted in 1999 and 2006 (Table 2, Figure 3). Thus, this exploration suggests that CPUE of black sea bass is unlikely to be influenced by bag limit regulations in the south Atlantic.

Subsetting trips

Species assemblage procedures typically used to determine the trips to be included in the computation of the index for SEDAR assessments are difficult to implement for black sea bass. Black sea bass are likely to be associated with a large number of species since it is present in most trips. This is confounded by the likelihood that even deepwater trips outside of black sea bass habitat often include some effort in shallow black sea bass habitat. To partially account for effort outside black sea bass habitat, split-effort trips defined as those that caught any of the deepwater species defined by Shertzer and Williams (2008), were removed from the analysis.

Model Input

Response and explanatory variables
WPUE – weight per unit effort (WPUE) has units of lb/trip-hour and was calculated as the weight (lb) of black sea bass caught divided by trip hours assigned by trip type.

Year - The observed WPUE (pounds/trip-hr) by year for black sea bass decreases from *1979* to the early 1990's and remains relatively stable through 2010 (Figure 4).

Region – Headboat inshore and offshore categories were combined for NC and SC as area is assigned to a vessel and not trip. Most vessels are capable of operating in both habitats. GA and FL do not have inshore and offshore designations. Observed WPUE appears to be similar for NC and SC and lower for GA and North Florida (Tables 3 and 4, Figure 5).

Season – The seasons were defined as winter (Jan-Mar), spring (Apr-Jun), summer (Jul-Sept) and fall (Oct-Dec). Black sea bass WPUE and the number of trips was highest in spring and summer (Figure 6).

Trip type – Trip types for half, ¾ , and full day trips were included in the analysis. Multi-day trips were excluded because most were in Florida and likely targeting deepwater species for some portion of the trip. The codes for first and second half-day trips designation for day or night trips were combined. There were few multi-day trips overall. It is not clear how these were coded prior to the inclusion of an "overnight" field in 1980 and an "other" category in 1992 on the logbook form. The ¾ day trips had higher WPUE and fewer trips (Table 5, Figure 6).

Anglers – Because headboat captain's behavior may change (e.g., fishing locations) as a function of the number of anglers (e.g., revenue to buy fuel, etc.), the number of anglers may be an important variable to consider. The angler factor was created based on quartiles of the data with breaks at 20, 33, and 49 anglers. WPUE increases with angler as expected but, not linearly (Figure 6).

Maximum Anglers – There is no vessel information available from the headboat survey, the maximum number of anglers per vessel/year is used as a substitute for vessel size. Year is included because some vessel codes were retained when vessels were replaced. Observed black sea bass WPUE indicates a slight increase in for the smallest and largest vessels as indicated by maximum anglers (Figure 6).

Standardization

WPUE was modeled using the glm approach of (Lo et al. 1992, Dick 2004, Maunder and Punt 2004). AIC values for lognormal and gamma error distributions were compared for the full model (all factors) to choose the appropriate distribution for black sea bass WPUE. Then, Stepwise AIC (Venables and Ripley1997) with a backwards selection algorithm was used to eliminate those factors that did not improve model fit. All predictor variables were modeled as fixed effects (and as factors rather than continuous variables). Jackknife estimates of variance were computed using the 'leave one out'estimator (Dick 2004). All analyses were performed in the R programming language, with code modified from Dick (2004) for positive trips.

Results

With WPUE as the dependent variable, the lognormal distribution outperformed the gamma distribution with lower AIC (gamma AIC =562848, lognormal AIC=562429) values when all factors were included (year, region, season, anglers, trip type, and maximum anglers). All factors improved model fit and were included.

Index

The distribution of log WPUE for the index (Figure 7), the residuals for factors (Figure 8), and the QQ plot of the residuals (Figure 9) indicate that the model fit the data reasonably well except in the tails of the distribution. The index is presented in Table 6 and Figure 10.

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Lo, N.C., Jacobson, L.D., Squire, J.L. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. Can. J. Fish. Aquat. Sci. 49:2515-2526.

Maunder, M.N., Punt, A.E. 2004. Standardizing catch and effort data: a review of recent approaches. Fish. Res. 70:141-159.

Shertzer, K.W. and E.H. Williams. 2008. Fish assemblages and indicator species: reef fishes off the southeastern United States. Fish. Bull. 106:257-269.

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

Table 1. Number of trips removed from data set for each data filter step beginning with all trips that caught any species in the snapper/grouper management complex. Number of vessels removed from data input.

Data Filter Step	Trips(number)	Vessels(number)
Snapper-grouper complex	143394	
Pos. black sea bass	114922	
n.anglers >0	114911	
Remove DW complex	108217	192
Remove Vessesls <250 trips	100101	113
Remove 1973-78	93863	
black sea bass catch <596	93395	
anglers < 115	92953	
black sea bass catch/hr <80 lbs/hr	92494	

Table 2. Black sea bass trips at/above and below the bag limit for each year. We expect to see an increase in the percent trips at or above the bag limit if a bag limit is limiting the catch and influencing the WPUE.

Year	Bag limit	Trips At Bag	Trips Below Bag	Percent at Bag
1992	None	34	3147	1.08%
1993	None	27	2970	0.91%
1994	None	19	2546	0.75%
1995	None	10	2803	0.36%
1996	None	48	3440	1.40%
1997	None	38	2660	1.43%
1998	None	20	2918	0.69%
1999	20	32	3935	0.81%
2000	20	20	3745	0.53%
2001	20	31	3230	0.96%
2002	20	39	3060	1.27%
2003	20	68	2749	2.47%
2004	20	64	2050	3.12%
2005	20	24	3410	0.70%
2006	15	33	3400	0.97%
2007	15	57	2731	2.09%
2008	15	17	2758	0.62%
2009	15	37	3347	1.11%
2010	15	124	4064	3.05%

Table 3. Areas assigned to headboat vessels. For computing CPUE, several areas were combined: areas 2,3,9,10=NC, area 4 and 5=SC, and areas6,7,8=GFL

ID	area	Region (zone)	Definition
1	1	NC	NC/VA line to Ocracoke inlet offshore
2	2	NC	Topsail Island NC to NC/SC line inshore
3	3	NC	Topsail Island NC to NC/SC line offshore
4	4	SC	South Carolina inshore
5	5	SC	South Carolina offshore
6	6	GFL	Georgia
7	7	GFL	North Florida
8	8	GFL	Central Florida
9	11	SFL-excluded	South Florida
10	12	KEYs-excluded	Florida Keys
11	17	TOR-excluded	Dry Tortugas
12	9	NC	Central North Carolina inshore
13	10	NC	Central North Carolina offshore

Table 4. The total number of trips with positive black sea bass catch per year for each region.

Year	NC	SC	GFL	Year Total
1979	145	1413	910	2468
1980	225	1653	1391	3269
1981	203	1521	891	2615
1982	289	1598	1045	2932
1983	254	1344	1205	2803
1984	214	1558	1138	2910
1985	216	1527	1068	2811
1986	210	1724	1714	3648
1987	240	1928	1572	3740
1988	281	1663	1625	3569
1989	131	1388	1441	2960
1990	152	1380	1312	2844
1991	239	1433	1078	2750
1992	277	1557	1841	3675
1993	213	1637	1598	3448
1994	272	1487	1085	2844
1995	315	1392	981	2688
1996	328	1254	860	2442
1997	167	1017	597	1781
1998	265	1358	1243	2866
1999	238	1267	1433	2938
2000	391	1419	1156	2966
2001	303	1228	1143	2674
2002	278	1188	950	2416
2003	353	1173	1156	2682
2004	419	1296	1512	3227
2005	287	1039	1233	2559
2006	259	1267	1295	2821
2007	159	1316	1109	2584
2008	235	1174	994	2403
2009	239	1401	1352	2992
2010	395	1510	1698	3603

Table 5. Trip duration from headboat sampling. For computing CPUE, trip duration was used as a factor, with levels as in column labeled “tripFACTOR.”

Code	tripHRS	tripFACTOR
1	5	half
21	5	half
9	5	half
29	5	half
3	7	threeQ
23	7	threeQ
2	10	full
Multi-day trips not included in analysis		
25	18	fullplus
5	24	fullplus
6	36	fullplus
7	48	fullplus
8	60	fullplus
10	72	fullplus
11	84	fullplus

Table 6. Black sea bass WPUE.

Year	N	Relative nominal CPUE	Standardized index	CV (index)
1979	2468	1.845	2.125	0.019
1980	3269	1.842	2.004	0.018
1981	2615	2.201	2.243	0.019
1982	2932	2.112	2.188	0.020
1983	2803	1.930	1.991	0.021
1984	2910	1.741	1.797	0.020
1985	2811	1.745	1.888	0.019
1986	3648	1.436	1.629	0.018
1987	3740	1.423	1.572	0.018
1988	3569	1.357	1.534	0.018
1989	2960	1.154	1.227	0.020
1990	2844	1.013	1.172	0.019
1991	2750	1.001	1.021	0.020
1992	3675	0.681	0.676	0.019
1993	3448	0.465	0.434	0.020
1994	2844	0.563	0.486	0.021
1995	2688	0.585	0.470	0.022
1996	2442	0.656	0.491	0.025
1997	1781	0.762	0.549	0.026
1998	2866	0.572	0.502	0.021
1999	2938	0.594	0.545	0.020
2000	2966	0.531	0.414	0.020
2001	2674	0.563	0.453	0.020
2002	2416	0.545	0.411	0.023
2003	2682	0.557	0.462	0.022
2004	3227	0.676	0.668	0.019
2005	2559	0.594	0.567	0.021
2006	2821	0.648	0.605	0.021
2007	2584	0.513	0.386	0.025
2008	2403	0.437	0.306	0.024
2009	2992	0.469	0.465	0.021
2010	3603	0.789	0.720	0.021

Figure 1. Area designations assigned to headboat vessels.

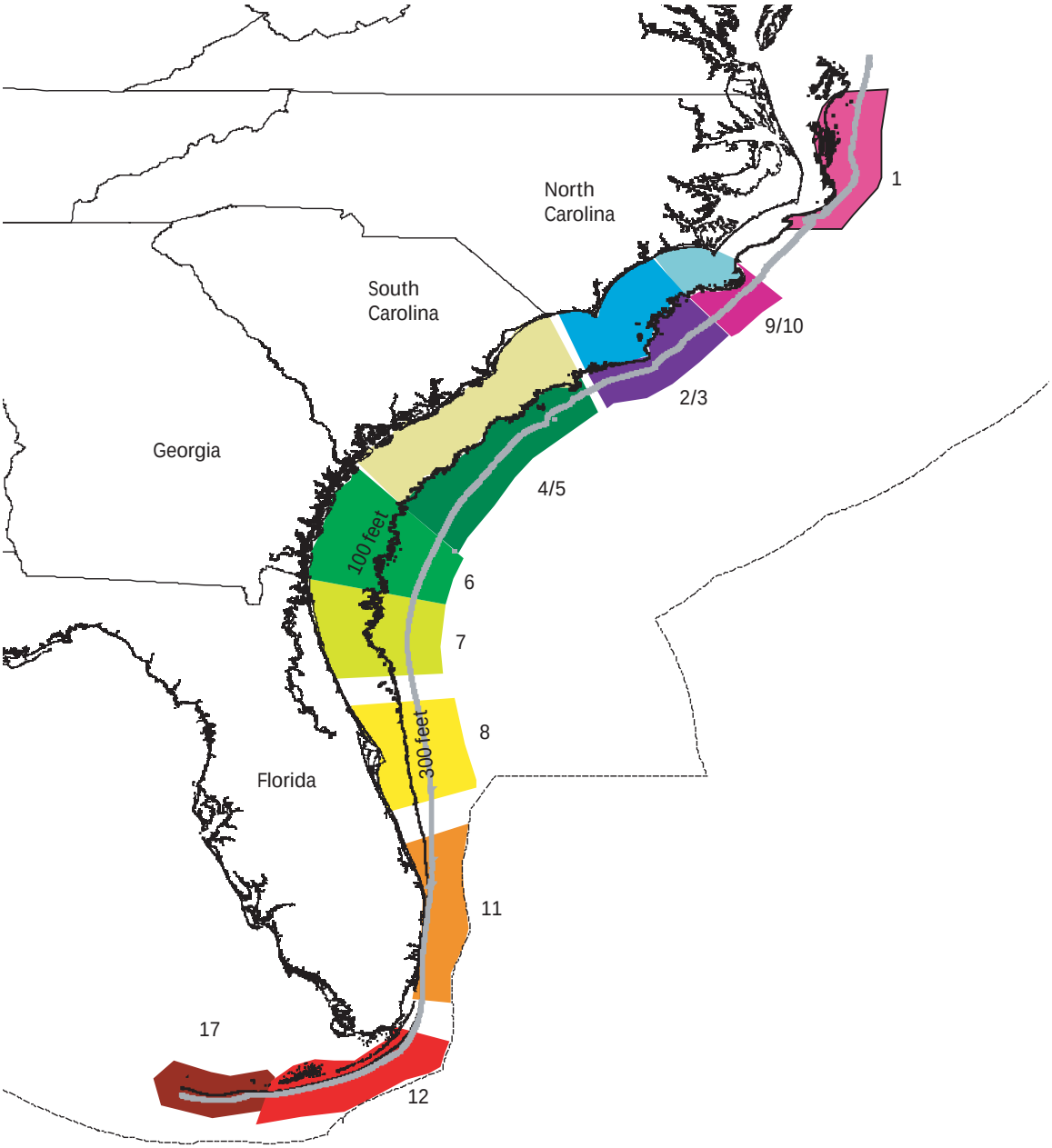


Figure 2. Definition of extreme values removed from black sea bass WPUE analysis.

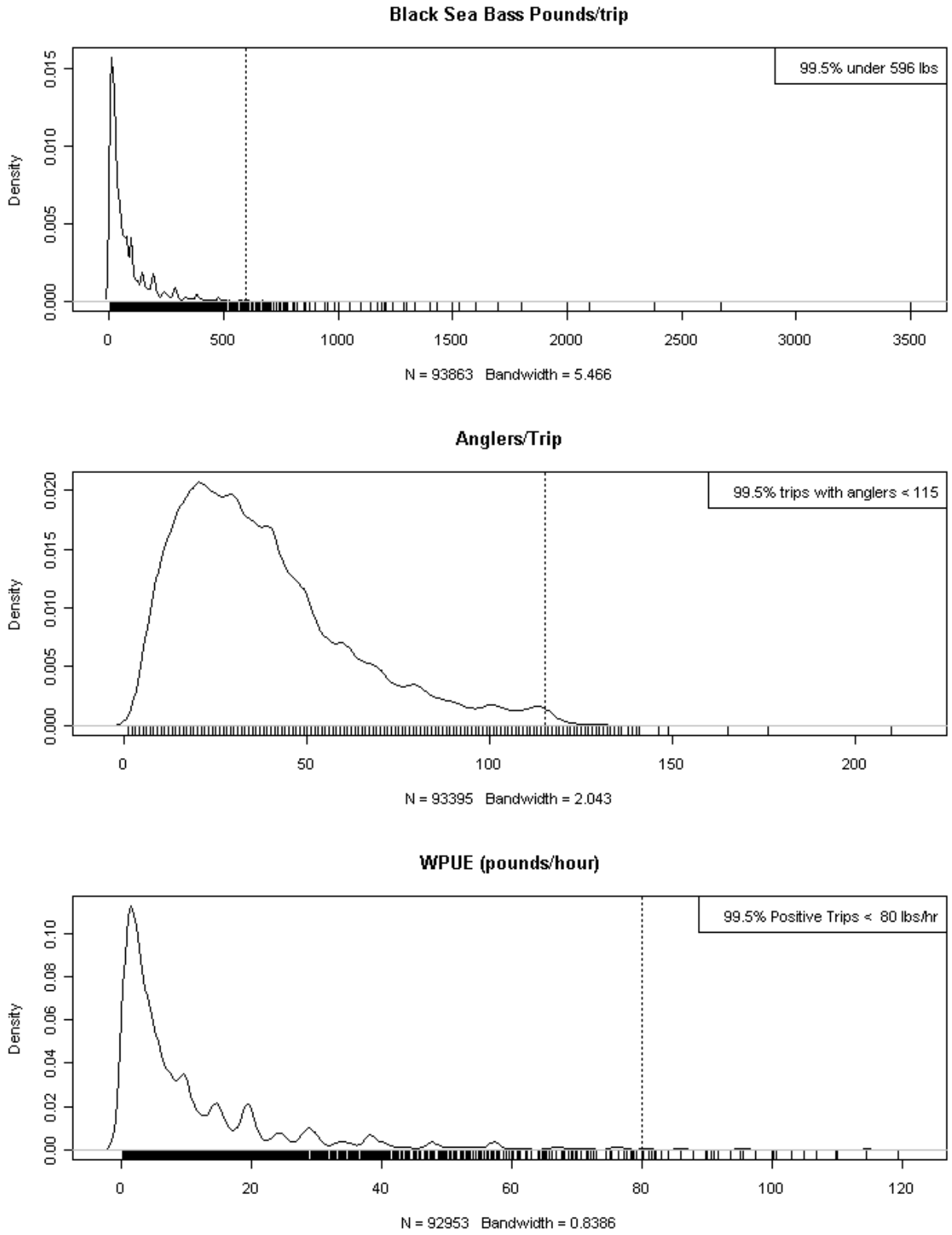


Figure 3. Black sea bass catch (numbers)/angler with bag limits defined.

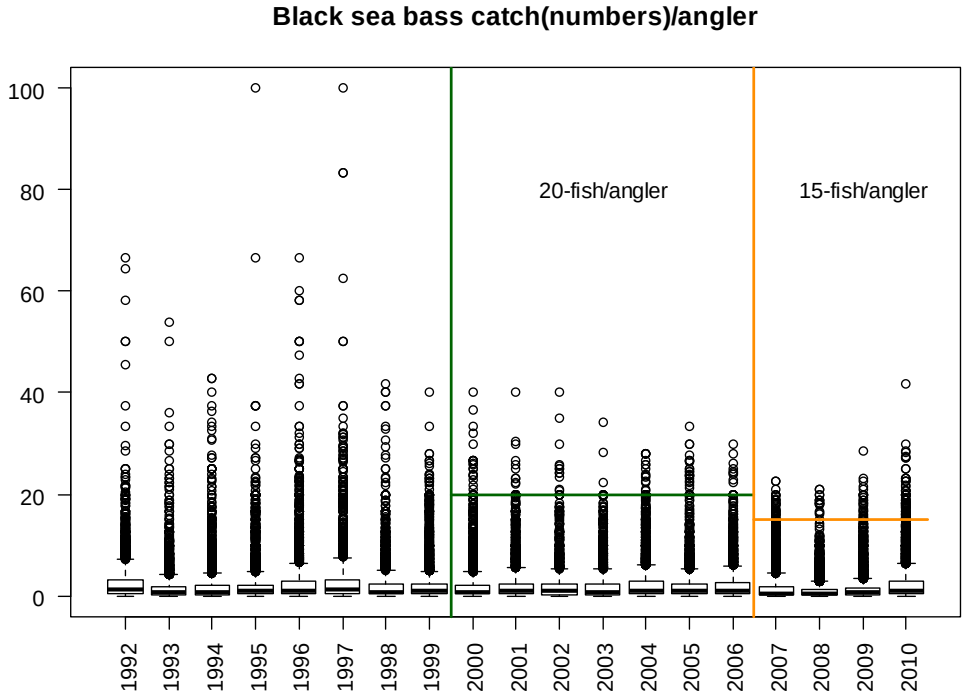


Figure 4. Observed WPUE for black sea bass by year with sample sizes above plot.

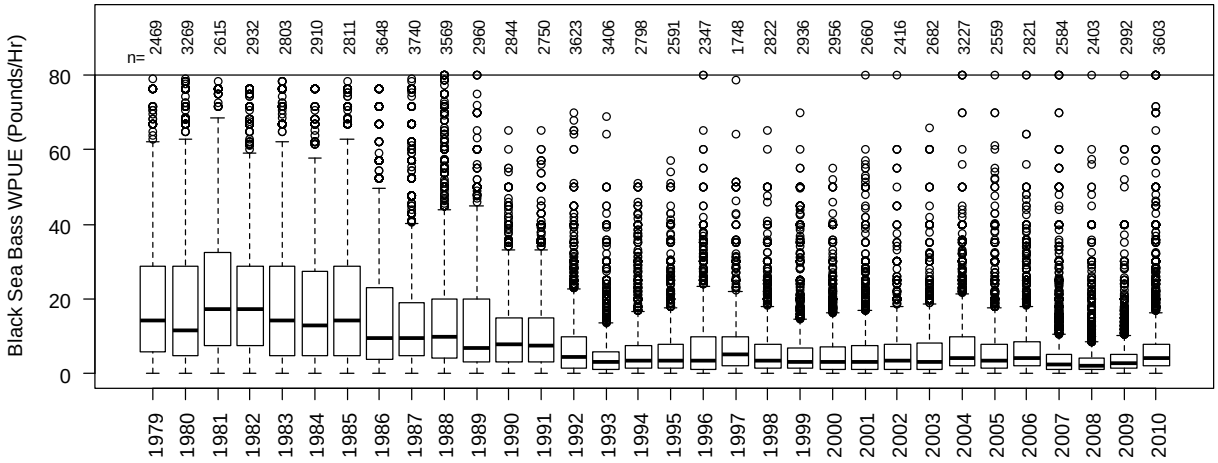


Figure 5. WPUE of black sea bass by region.

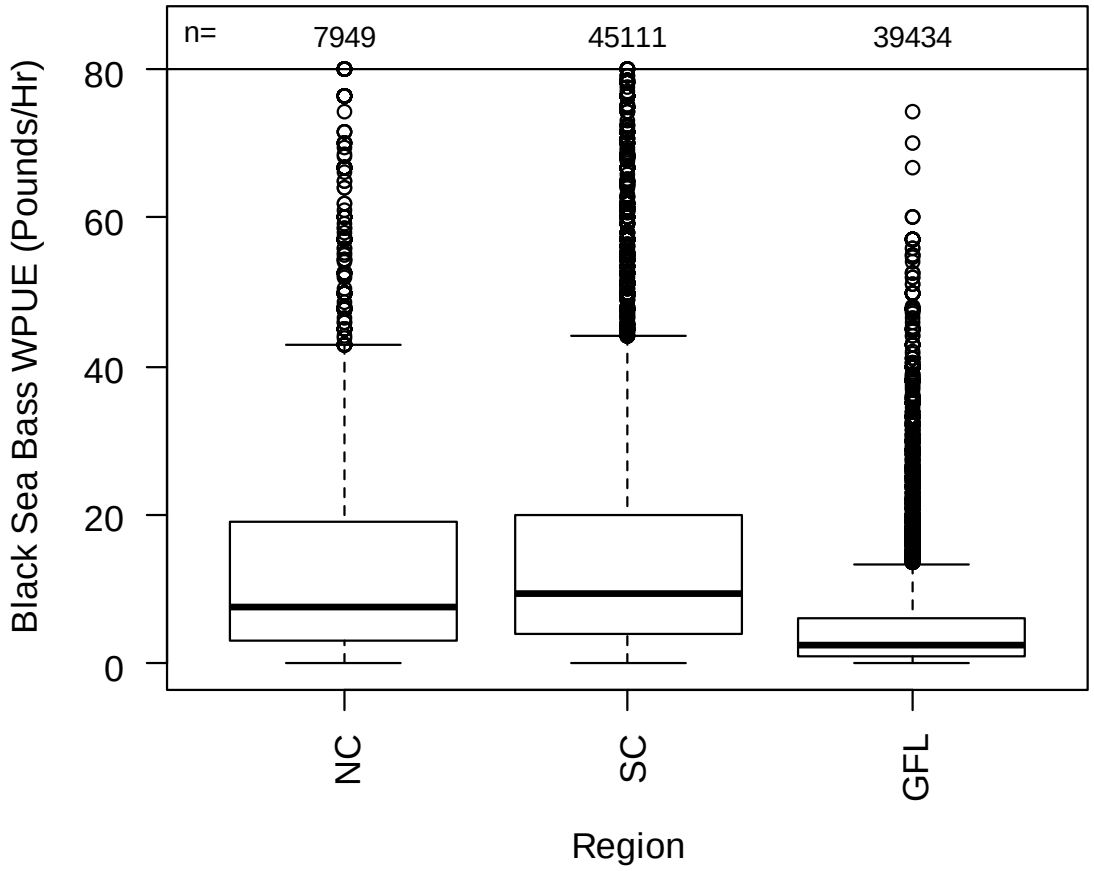


Figure 6. Black sea bass WPUE for anglers, trip type, season, and maximum anglers.

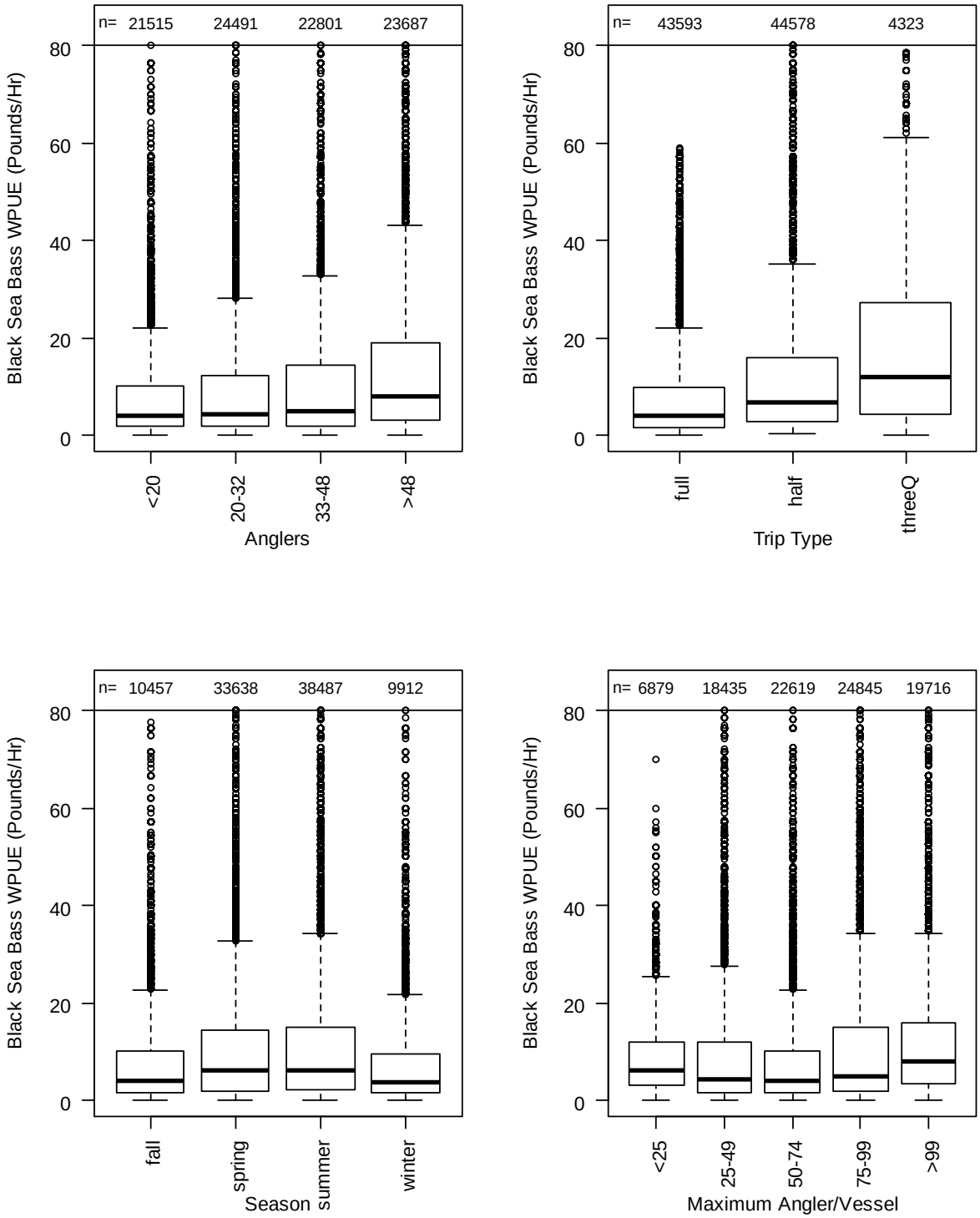


Figure 7. Distribution of log WPUE for black sea bass with the normal distribution (empirical mean and variance) overlaid.

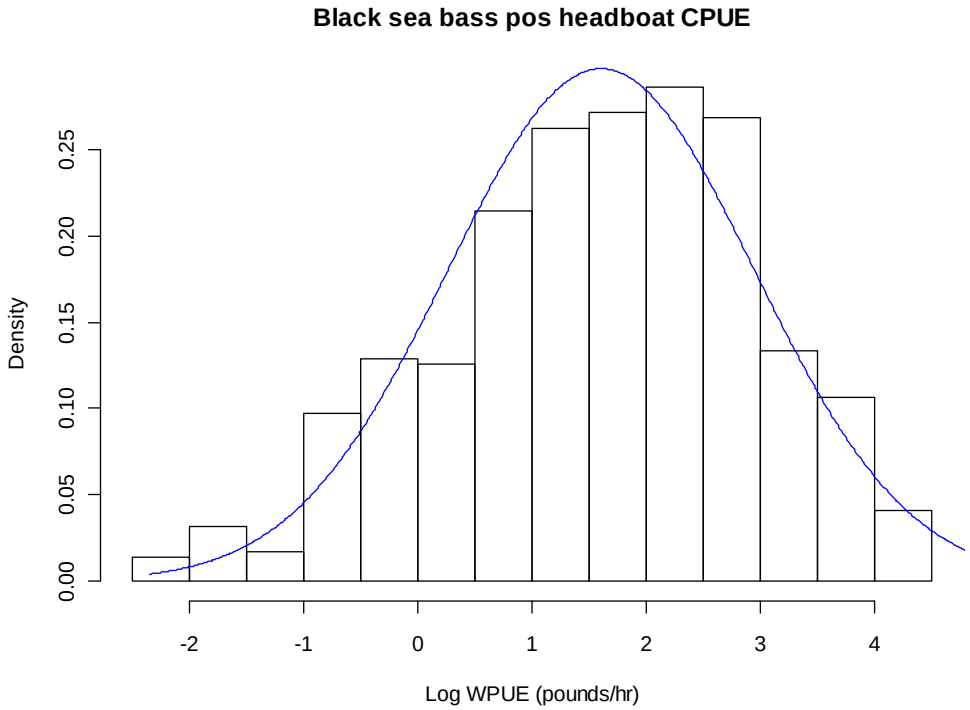
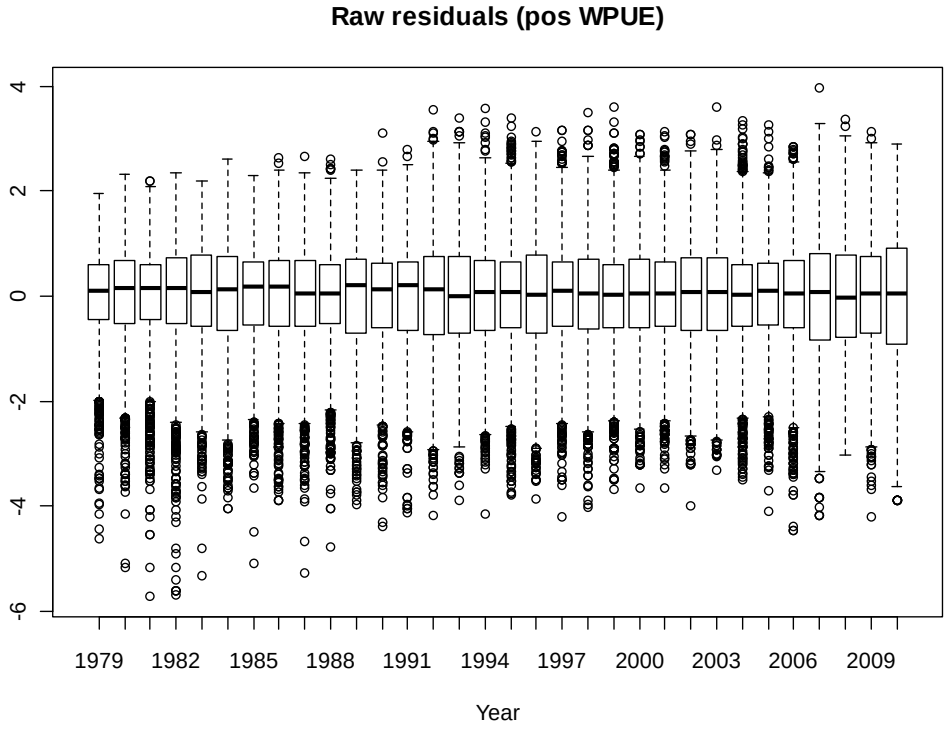
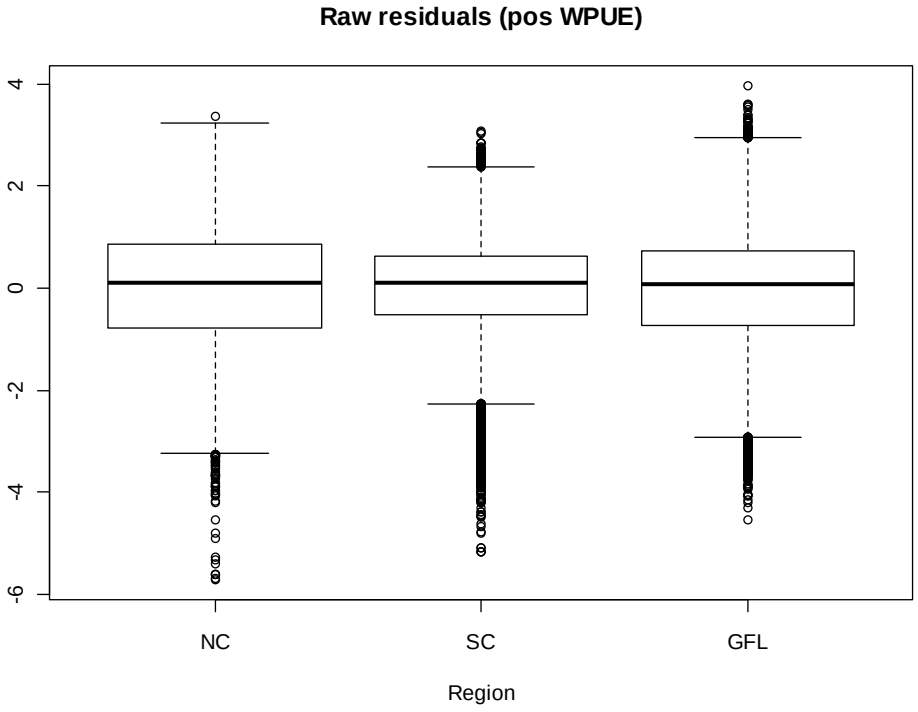


Figure 8. Residuals for year, region (zone), season, trip type, anglers, or maximum anglers.





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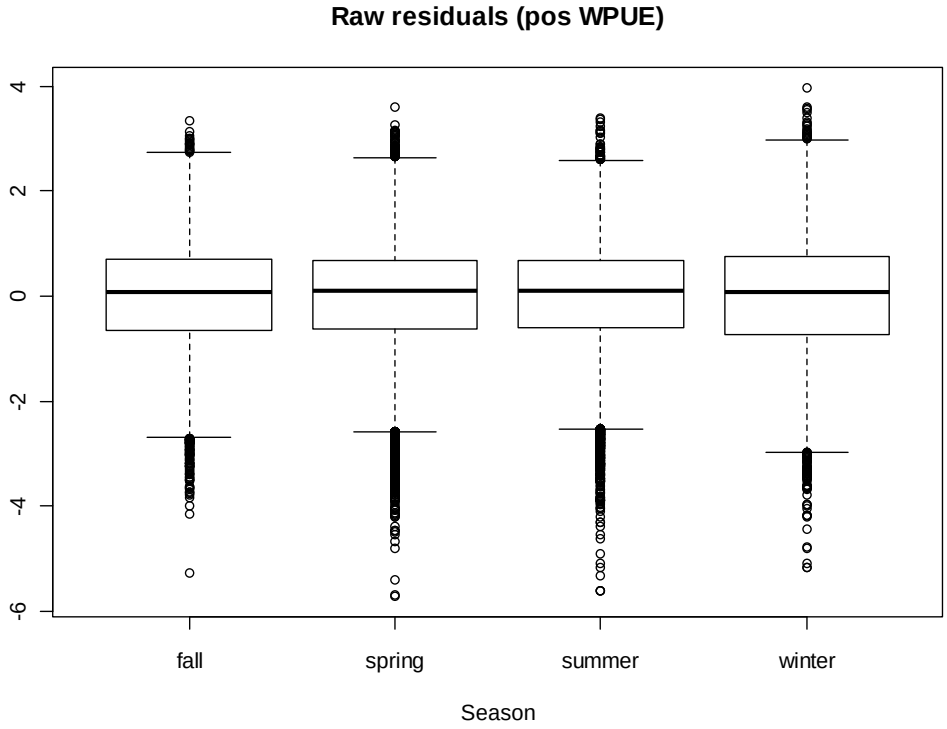

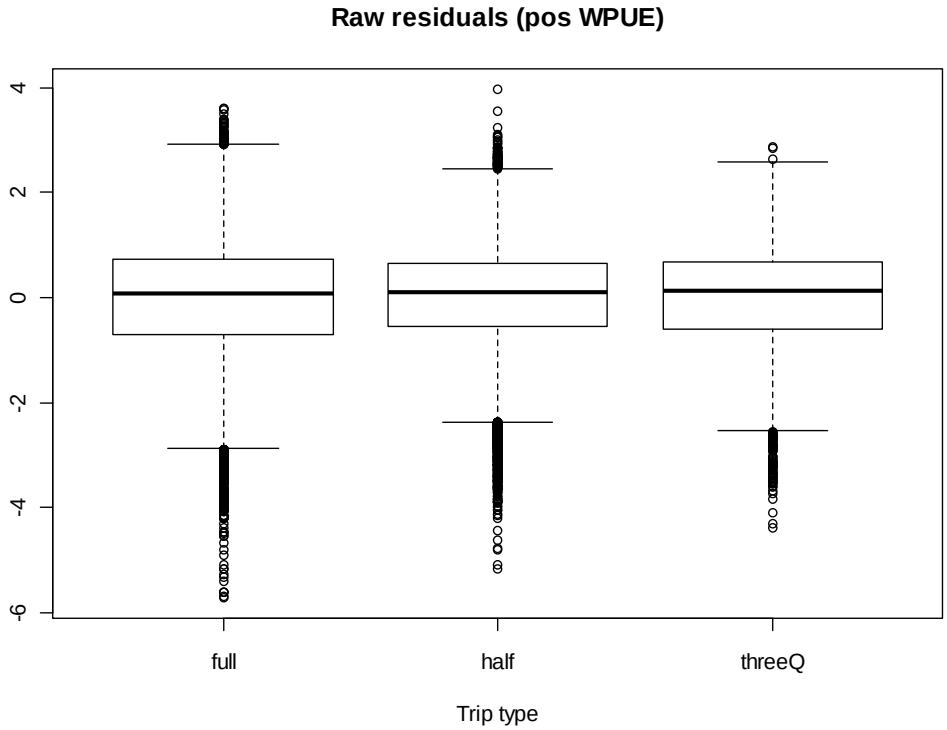

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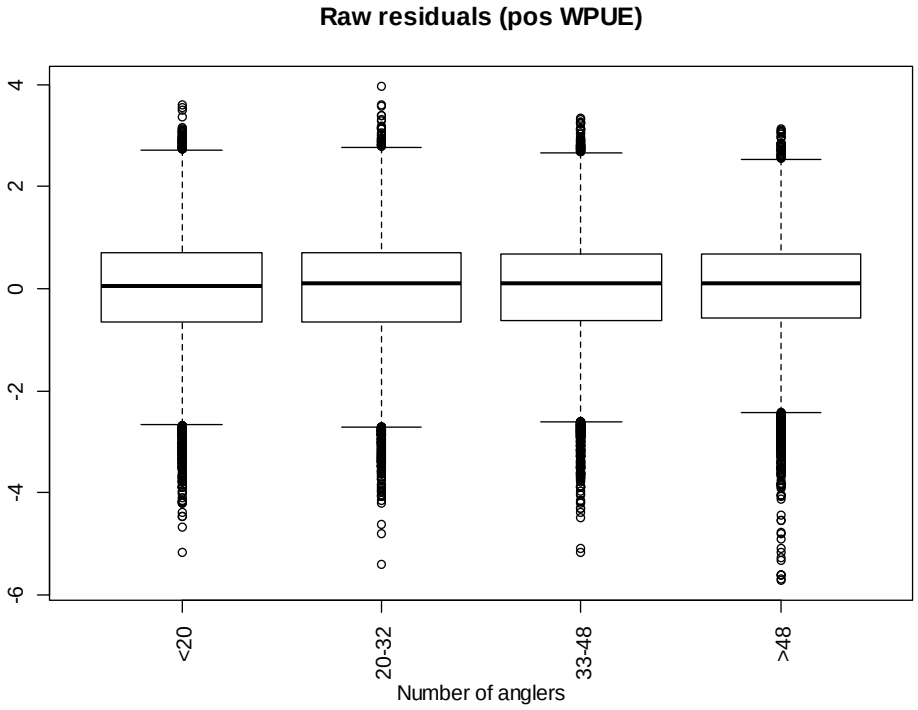


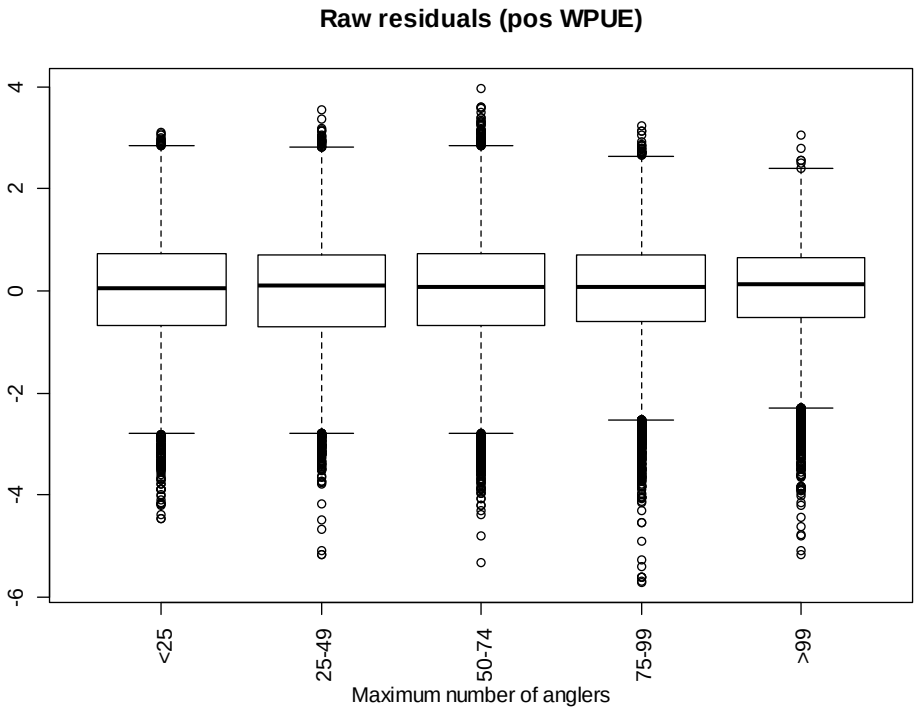


Figure 9. QQ plot of log residuals for black sea bass WPUE.

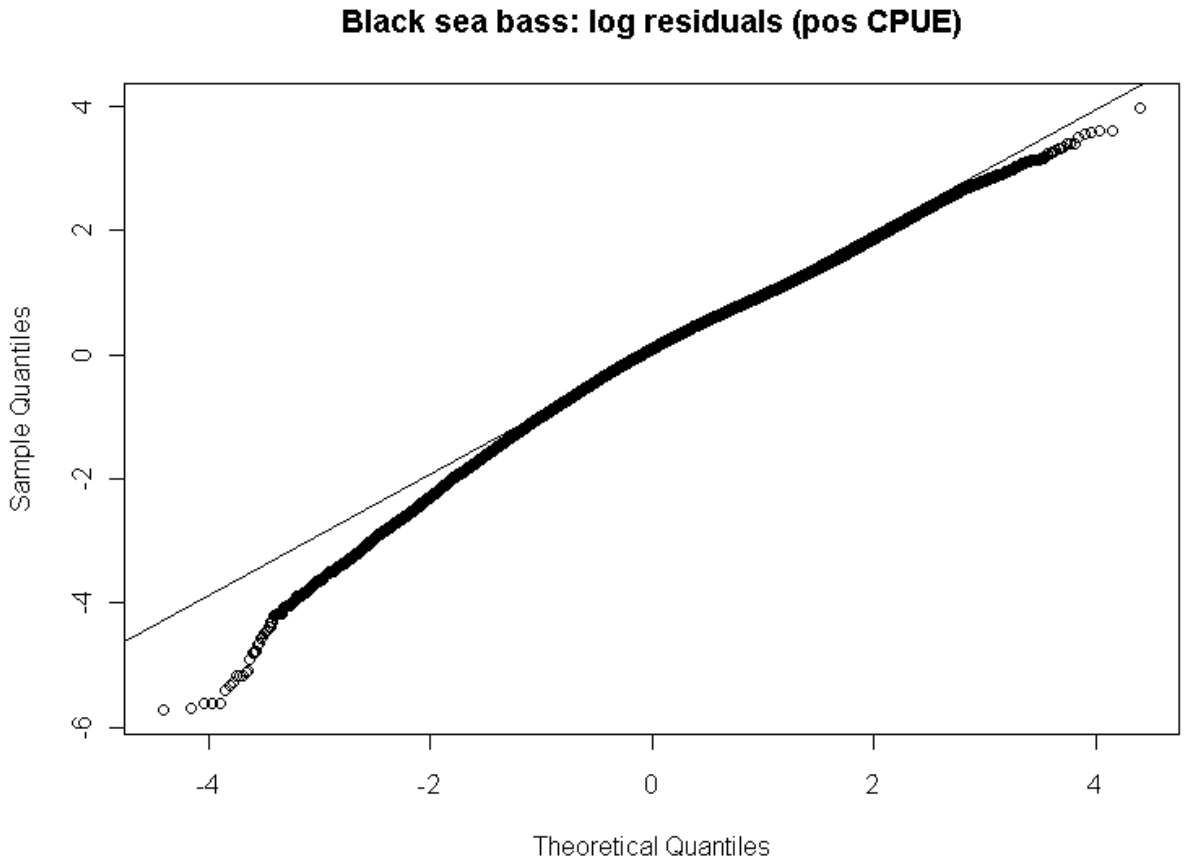
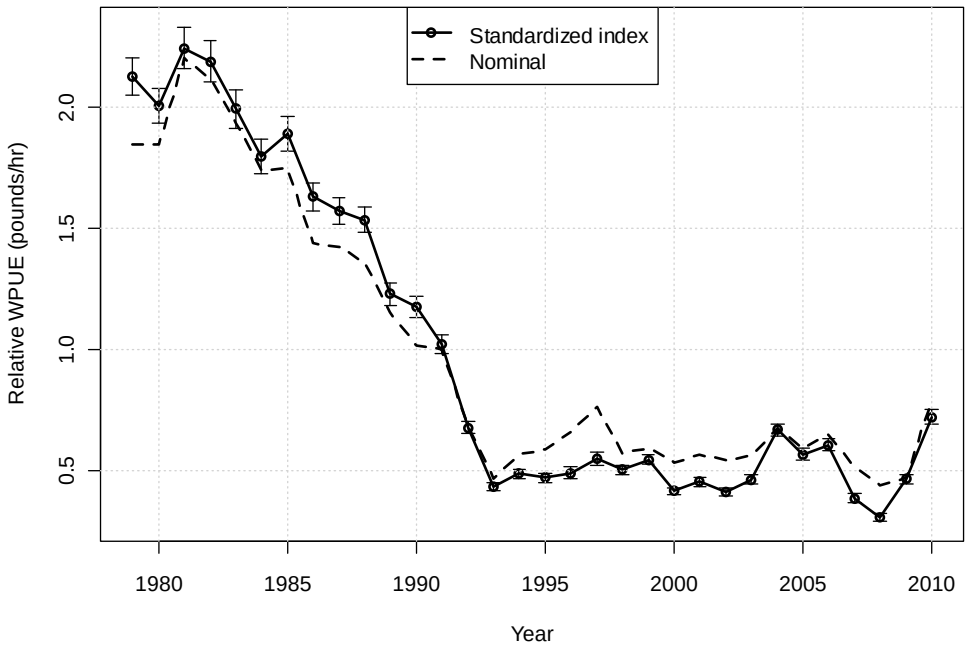


Figure 9. Relative Black sea bass WPUE scaled to the mean.



Appendix 1. Updated headboat logbook index based on SEDAR 25 DW decisions.

The SEDAR 25 index working group evaluated the data and analysis of the headboat index and recommended changes to the data input to the model. In addition, the proportion of black sea bass to black and bank sea bass combined was verified for 1988-90 and applied to the to the total bank and black sea bass in weight prior to 1988 for each trip.

SEDAR 25 index working group decisions:

1. The frequency of trips reporting less than 25 pounds of black sea bass catch prior to 1979 were evaluated to determine if a method could be developed to account for database or reporting errors (Figure A1). Prior to 1979 black sea bass landings were requested in 100 pound units (box). Captains often reported fractions of boxes based on ¼ box increments. Given the large number of black sea bass trips, the working group was interested in possibly using a similar cutoff used for the maximum black sea bass catch applied to the minimum black sea bass catch. The group determined that this would need to be applied to the entire time series to maintain consistency. A 0.5% rule applied to smallest black sea bass catch for the entire series only removed a portion of the 1 pound values. Approximately 20% of the trips reported less than 10 pounds. Based on this analysis the group determined the index should start in 1979 and recommended the black sea bass headboat trip reports and database records be examined (1974-78) prior to the next benchmark assessment. The years presented 1979-2010 were retained.
2. The frequency of anglers per trip was plotted to evaluate the 0.5% angler cutoff (Figure A2). Other methods to remove outliers were discussed. The 0.5% rule removed approximately 450 trips from 13 vessels. The group concluded the 0.5% rule was preferred to selecting outliers based on subjective criteria. The 0.5% rule was retained.
3. Trip type factors were unbalanced with 43,593 half-day trips, 44,578 full-day trips, and only 4,323 3/4-day trips. The working group decided to follow the SEDAR-2 update precedent of excluding the 3/4 -day trips.
4. A plot of nominal WPUE by region (NC, SC, and GA-FL) was requested within the working group (Figure A3-A). A question was asked during plenary about model's ability to fit spatial differences in WPUE, based on the figure nominal WPUE by region the index working group had examined (Figure A3-A). An additional plot was generated after the DW that scales each region's nominal index to its own mean to compare patterns on the same scale (Figure A3-B). The model accounts for spatial differences in WPUE by including region as a factor. Residual patterns did not suggest problems with the model structure (Figure A8-B). No changes were recommended by the group or in plenary based on spatial differences in WPUE.
5. The index working group agreed that the error in the fit to the glm did not reflect the full uncertainty. The working recommended the assessment workshop panel consider methods to scale the error to reflect more realistic uncertainty. One example used in a previous SEDAR assessment, to scale the error to a maximum coefficient of variation of 0.3, was discussed briefly within the index working group (Figure A10, Table A4).

The generalized linear model was run with the removal of the 3/4-day trips as recommended by the SEDAR 25 index working group (Figures A4-10 and Tables A1-A4). The exclusion of 3/4-day trips changed the cutoff value for black sea bass catch per trip from 596 to 570 pounds per

trip. The angler and WPUE cutoff values remained at 115 anglers and 80 pounds/hour respectively.

Table A1. Number of trips removed from data set for each data filter step. Number of vessels before and after removing vessels with less than 250 trips from data input. (*reported as vessels removed (113) in Table 1)

Data Filter Step	Trips(number)	Vessels(number)
Snapper-grouper complex	143394	
Pos. black sea bass	114922	
n.anglers >0	114911	
Remove trips with any Deepwater complex species present	108217	192
Remove Vessesls <250 trips	100101	79*
Remove 1973-78	93863	
Remove 3/4 day trips	89476	
black sea bass catch <570	89037	
anglers < 115	88596	
black sea bass catch/hr <80 lbs/hr	88166	

Table A2. The total number of trips with positive black sea bass catch per year for each region.

Year	NC	SC	GFL	Year Total
1979	140	1141	905	2186
1980	222	1216	1390	2828
1981	198	1140	890	2228
1982	287	1361	1045	2693
1983	243	1176	1205	2624
1984	214	1300	1138	2652
1985	216	1366	1068	2650
1986	206	1633	1680	3519
1987	239	1818	1569	3626
1988	281	1566	1625	3472
1989	131	1386	1434	2951
1990	151	1342	1310	2803
1991	239	1352	1076	2667
1992	276	1433	1780	3489
1993	212	1515	1552	3279
1994	272	1385	1039	2696
1995	250	1262	936	2448
1996	249	1133	839	2221
1997	133	947	594	1674
1998	214	1267	1242	2723
1999	234	1167	1429	2830
2000	378	1355	1155	2888
2001	288	1175	1143	2606
2002	277	1120	950	2347
2003	352	1137	1156	2645
2004	419	1217	1508	3144
2005	287	970	1232	2489
2006	259	1190	1288	2737
2007	152	1241	1097	2490
2008	233	1108	901	2242
2009	238	1325	1313	2876
2010	384	1362	1697	3443

Table A3. Trip duration from headboat sampling. For computing CPUE, trip duration was used as a factor, with levels as in column labeled "tripFACTOR."

Code	tripHRS	tripFACTOR
1	5	half
21	5	half
9	5	half
29	5	half
2	10	full
Multi-day and 3/4-day trips not included in analysis		
3	7	threeQ
23	7	threeQ
25	18	fullplus
5	24	fullplus
6	36	fullplus
7	48	fullplus
8	60	fullplus
10	72	fullplus
11	84	fullplus

Table A4. Black sea bass WPUE.

Year	N	Relative nominal CPUE	Standardized index	CV (index)	Scaled CV (index)
1979	2186	1.827	2.170	0.020	0.229
1980	2828	1.690	1.848	0.020	0.225
1981	2228	2.029	2.128	0.021	0.244
1982	2693	2.058	2.186	0.021	0.239
1983	2624	1.988	1.980	0.022	0.251
1984	2652	1.765	1.839	0.020	0.232
1985	2650	1.813	1.986	0.018	0.211
1986	3519	1.460	1.627	0.017	0.198
1987	3626	1.428	1.557	0.017	0.198
1988	3472	1.284	1.501	0.016	0.181
1989	2951	1.190	1.231	0.019	0.218
1990	2803	1.043	1.224	0.017	0.200
1991	2667	0.982	1.006	0.019	0.222
1992	3489	0.698	0.685	0.019	0.212
1993	3279	0.474	0.438	0.018	0.209
1994	2696	0.589	0.485	0.021	0.241
1995	2448	0.620	0.500	0.021	0.238
1996	2221	0.693	0.522	0.023	0.263
1997	1674	0.770	0.565	0.026	0.300
1998	2723	0.590	0.504	0.021	0.239
1999	2830	0.608	0.561	0.019	0.216
2000	2888	0.536	0.413	0.020	0.225
2001	2606	0.564	0.433	0.020	0.233
2002	2347	0.558	0.415	0.023	0.258
2003	2645	0.566	0.475	0.021	0.241
2004	3144	0.688	0.656	0.019	0.216
2005	2489	0.603	0.579	0.021	0.236
2006	2737	0.660	0.618	0.021	0.241
2007	2490	0.521	0.376	0.026	0.293
2008	2242	0.444	0.300	0.025	0.286
2009	2876	0.475	0.462	0.022	0.249
2010	3443	0.786	0.728	0.021	0.239

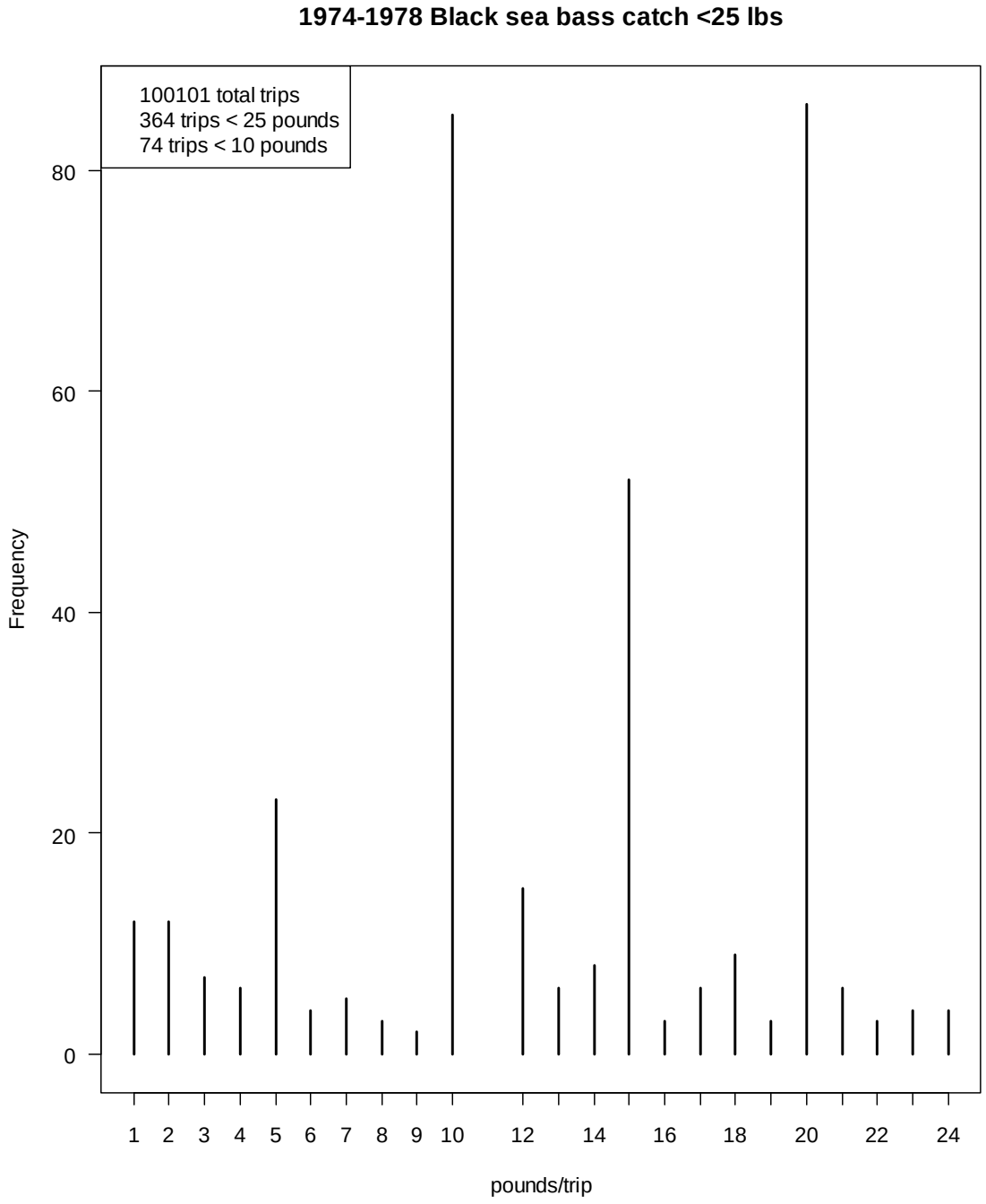


Figure A1. Frequency of trips with less than 25 pounds of black sea bass reported from 1974 to 1978.

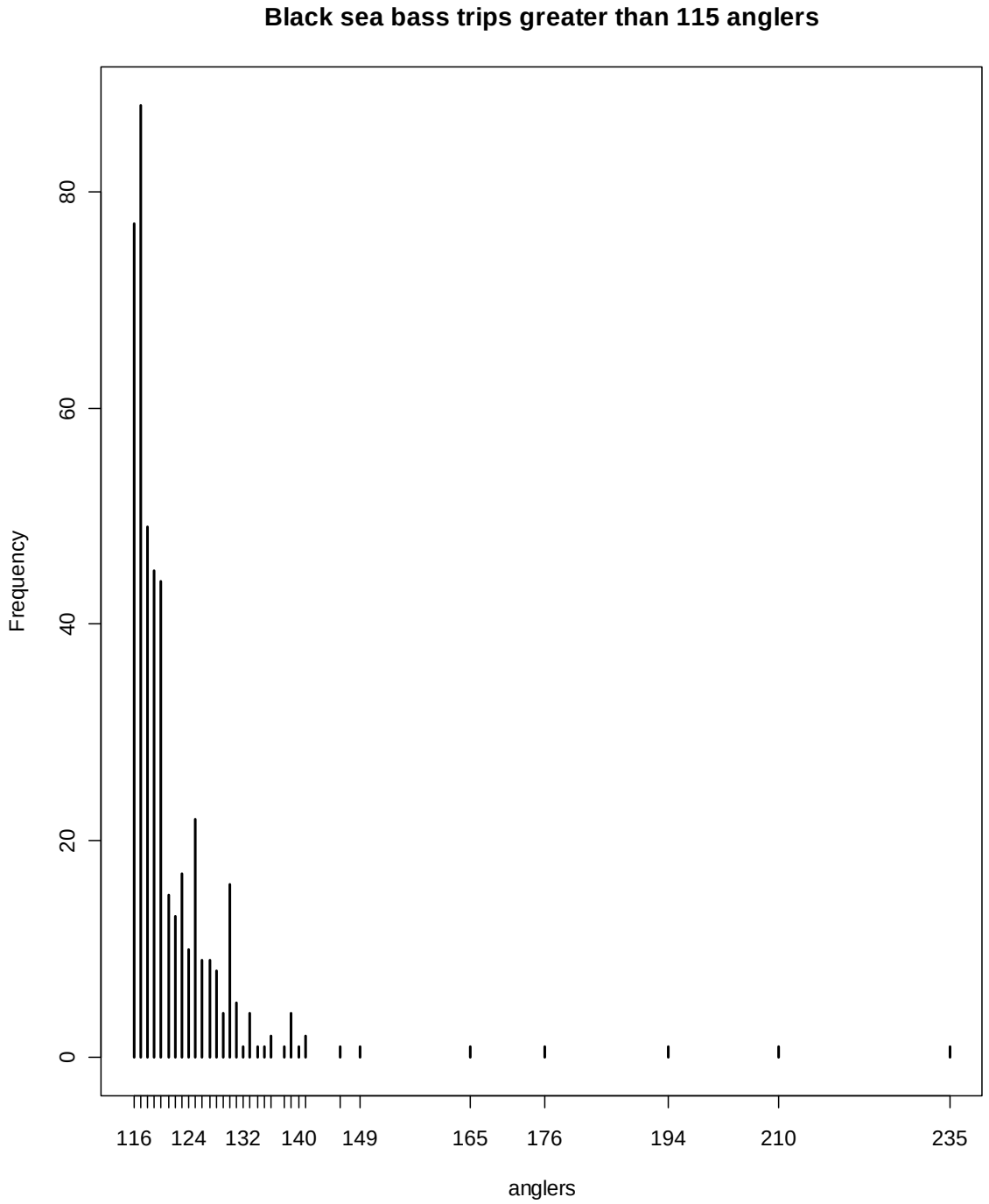


Figure A2. Frequency of values above the 0.5% or 115 angler cutoff for positive black sea bass trips.

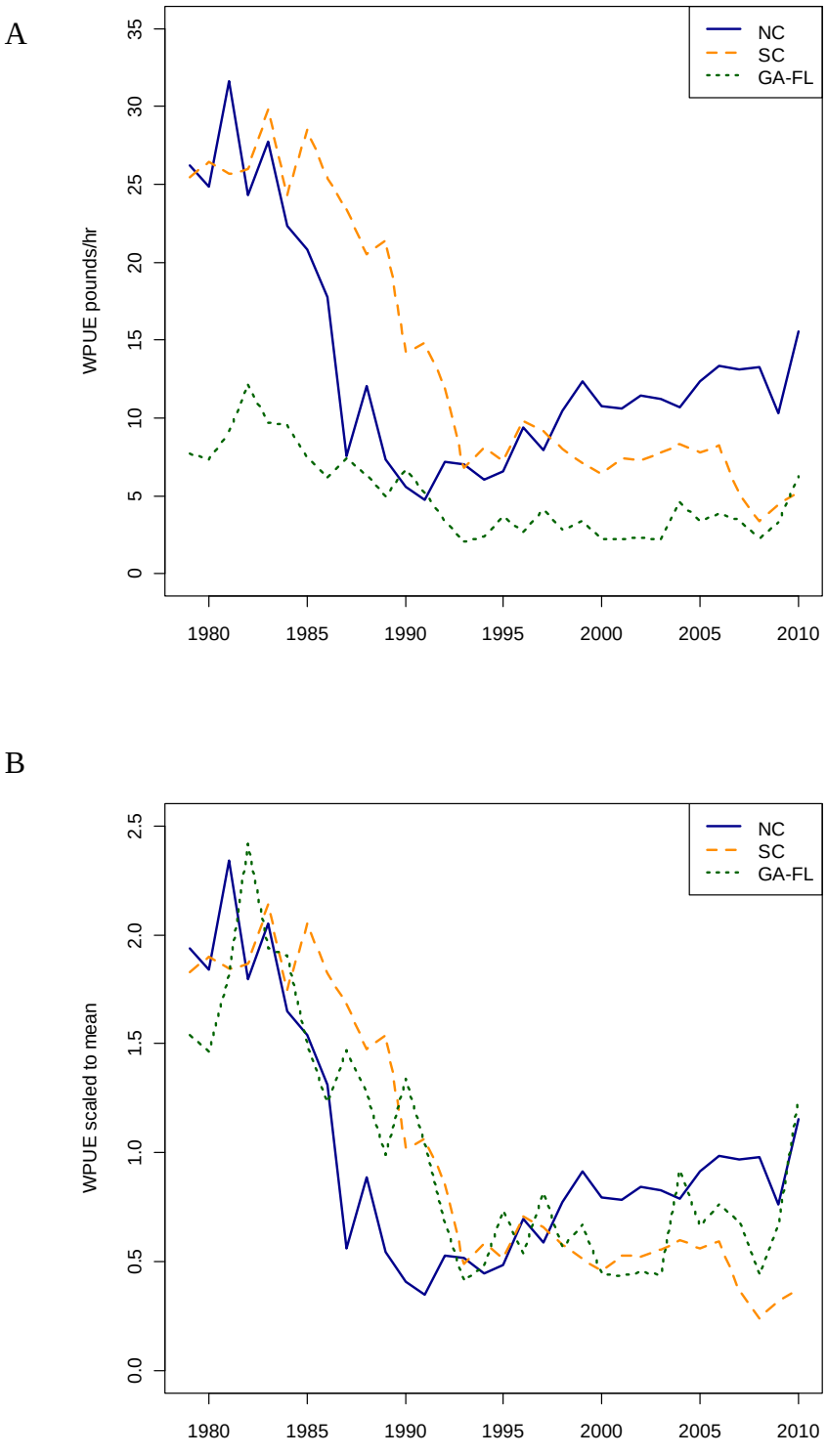


Figure A3. Nominal WPUE (pounds/trip-hour) for black sea bass by region (A) and with each region scaled to its own mean (B).

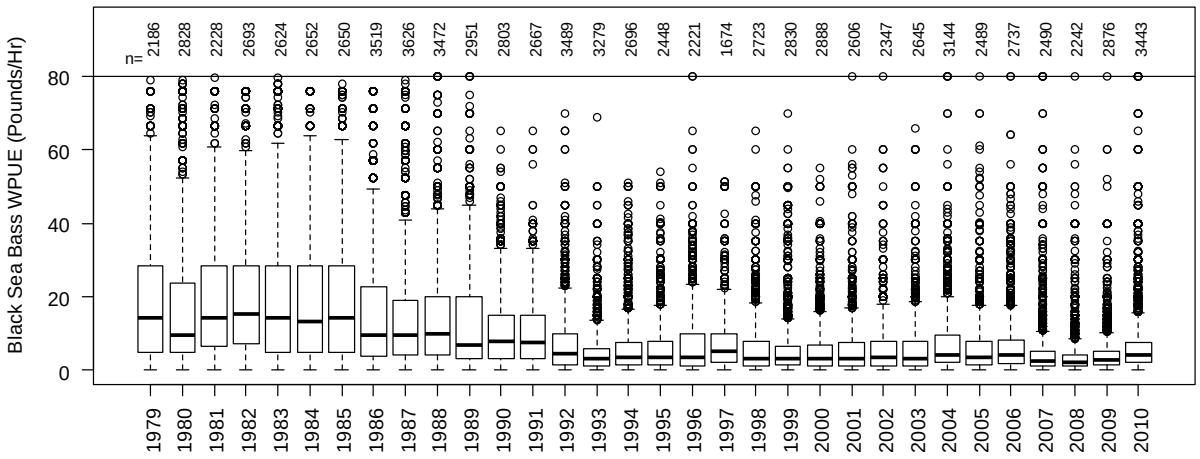


Figure A4. Observed WPUE for black sea bass by year with sample sizes above plot.

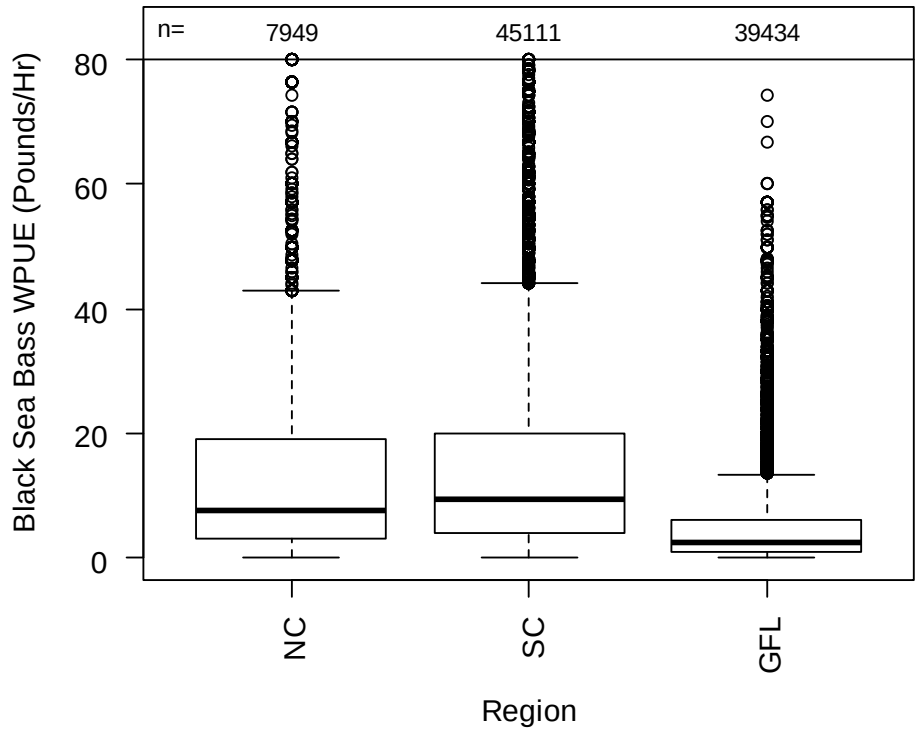


Figure A5. WPUE of black sea bass by region.

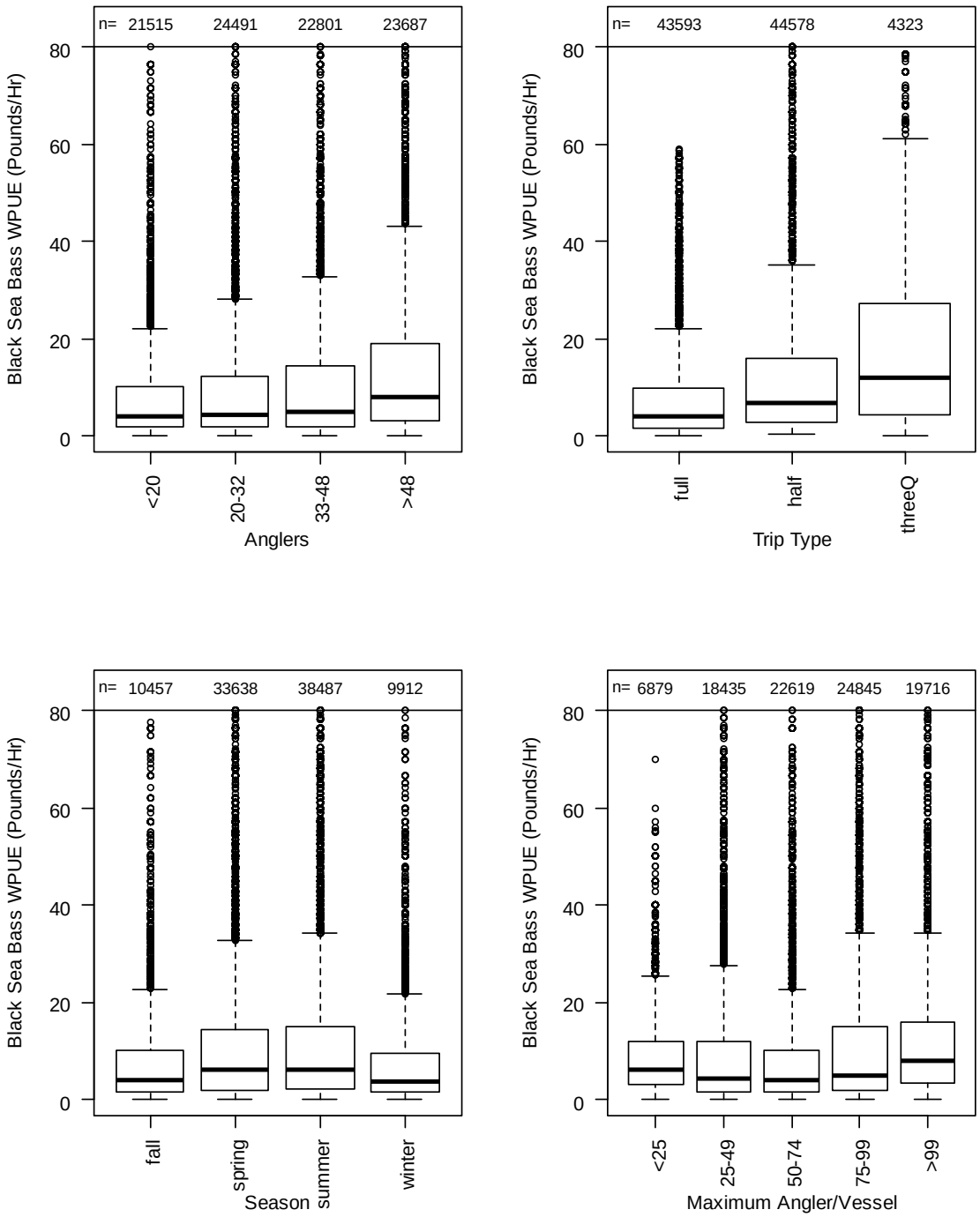


Figure A6. Observed black sea bass WPUE for anglers, trip type, season, and maximum anglers.

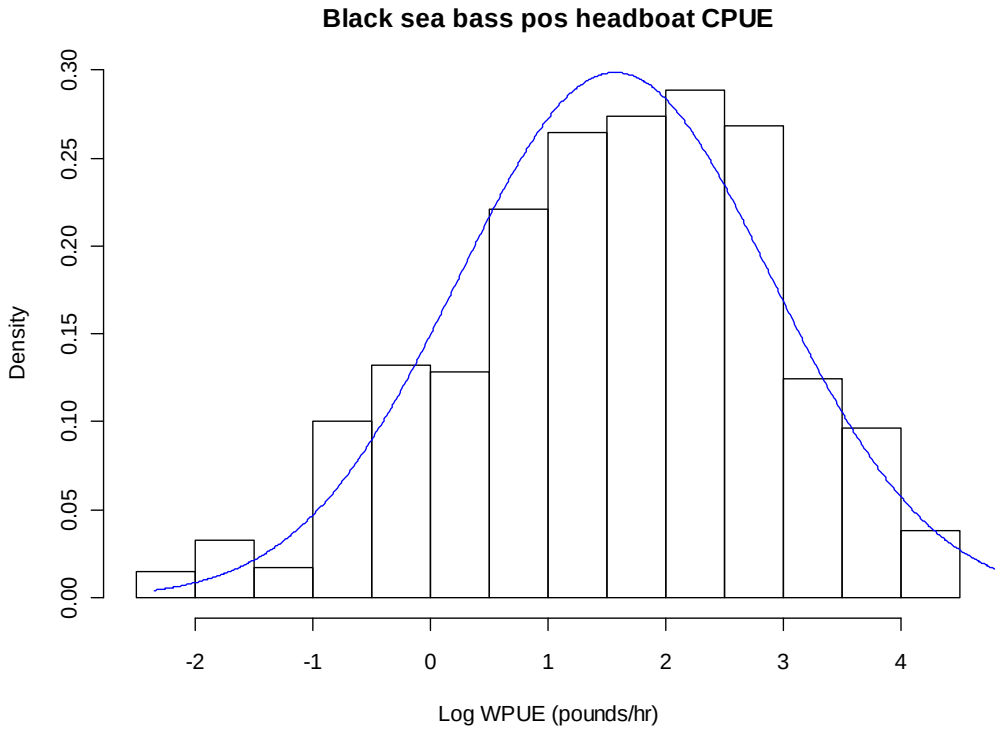
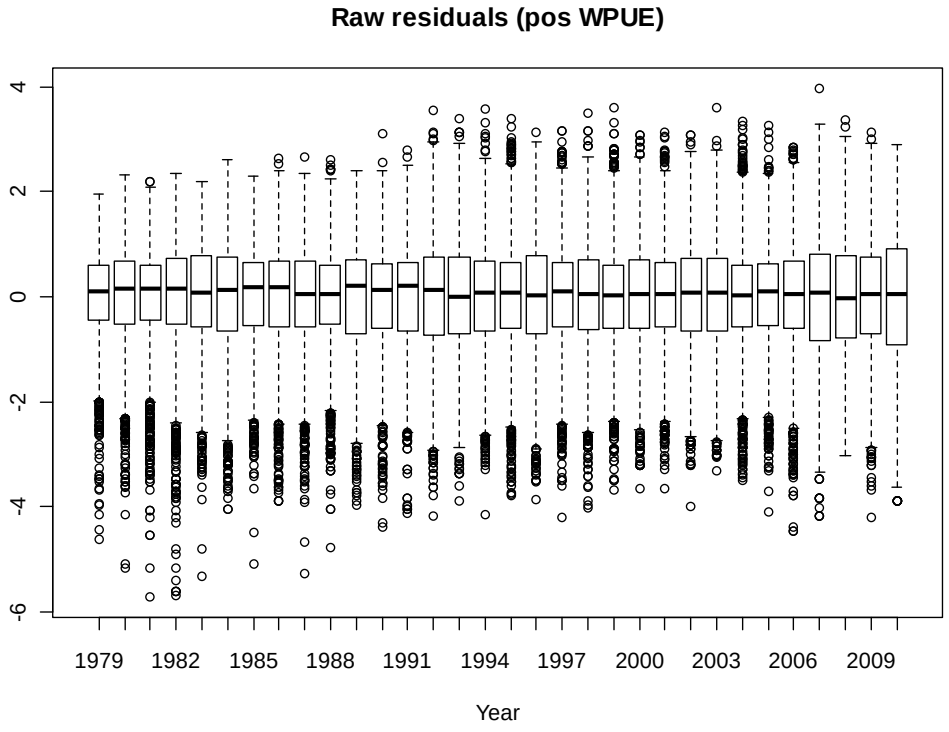


Figure A7. Distribution of log WPUE for black sea bass with the normal distribution (empirical mean and variance) overlaid.

A



B

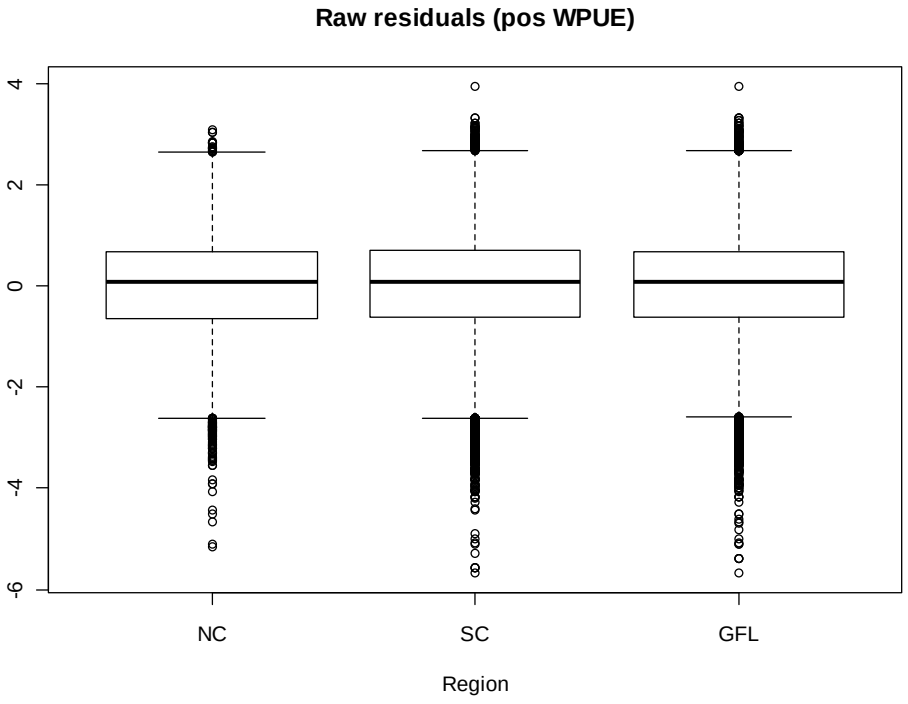
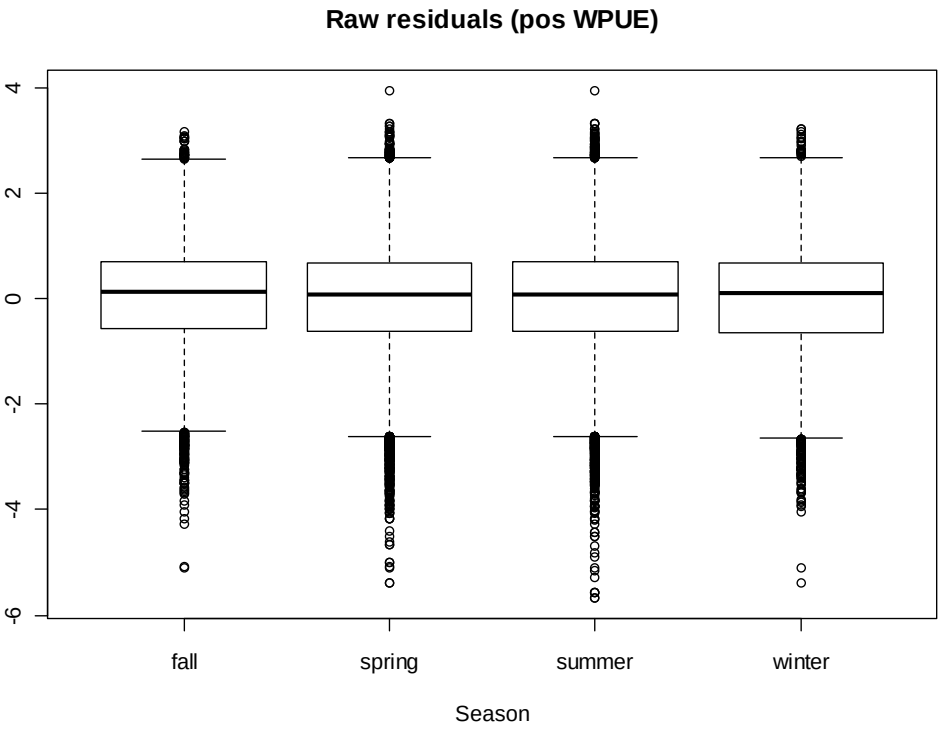


Figure A8. Residuals for year (A), region (zone) (B), season(C), trip type (D), anglers (E), or maximum anglers (F).

C



D

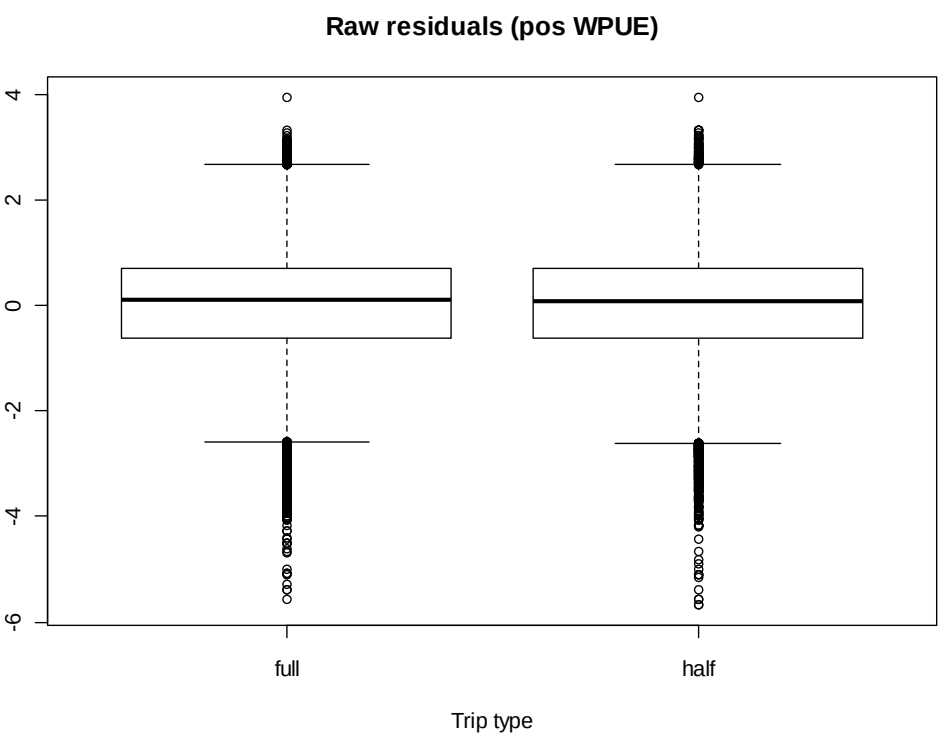
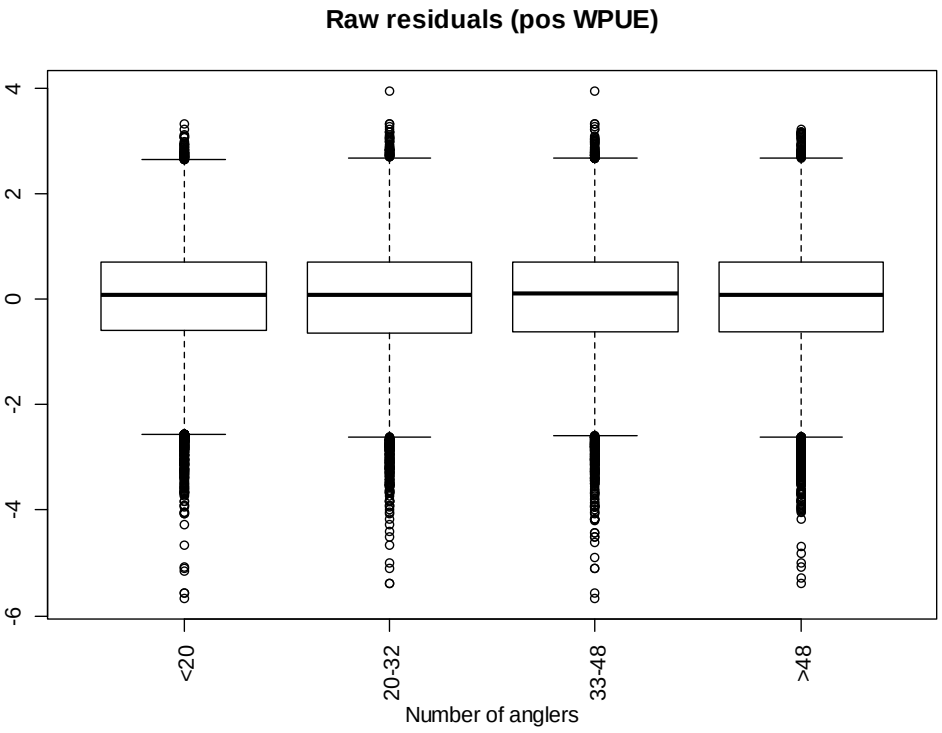


Figure A8 Continued.

E



F

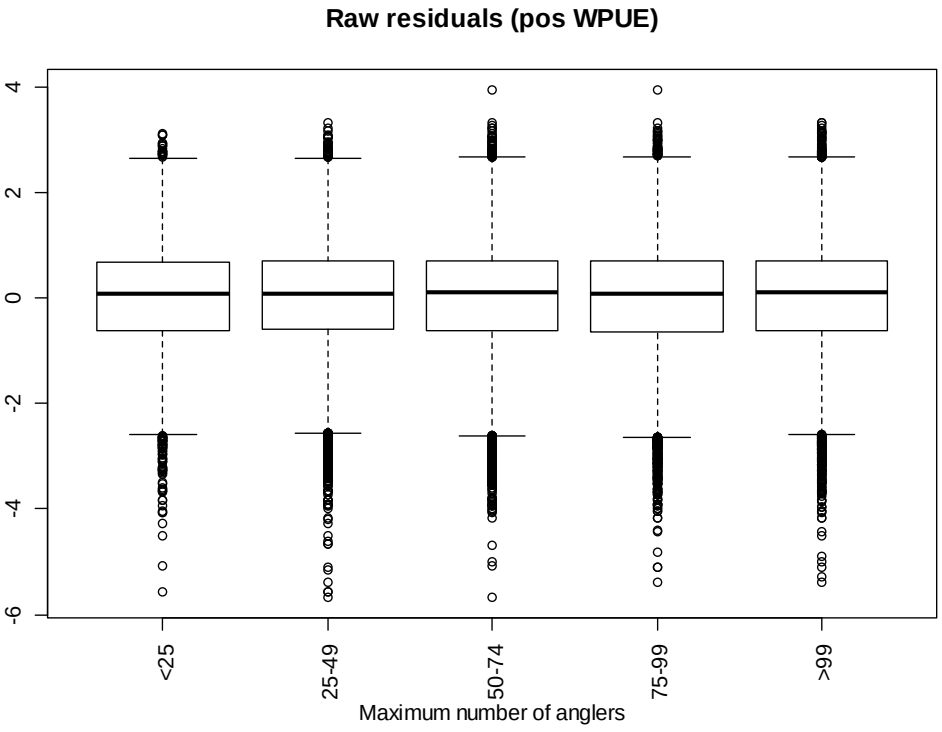
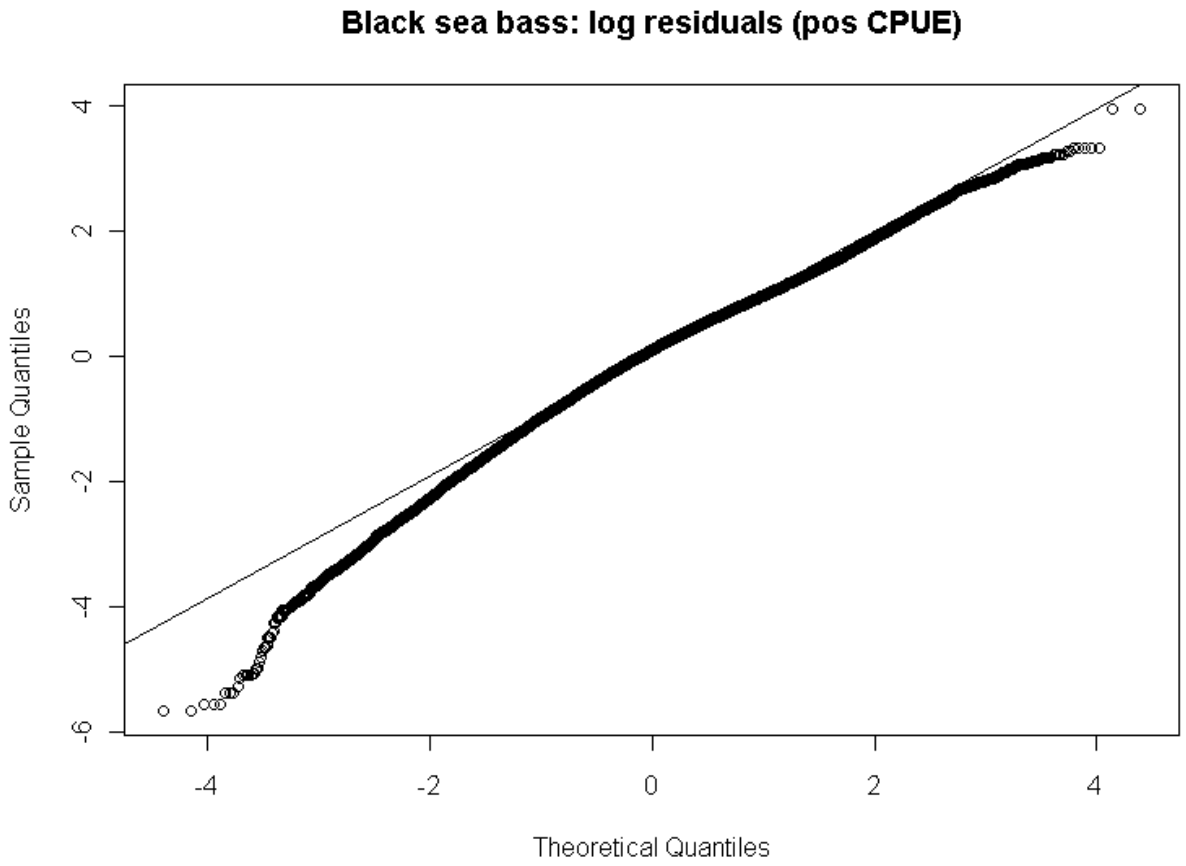


Figure A8 Continued.



FigureA9. QQ plot of log residuals for black sea bass WPUE.

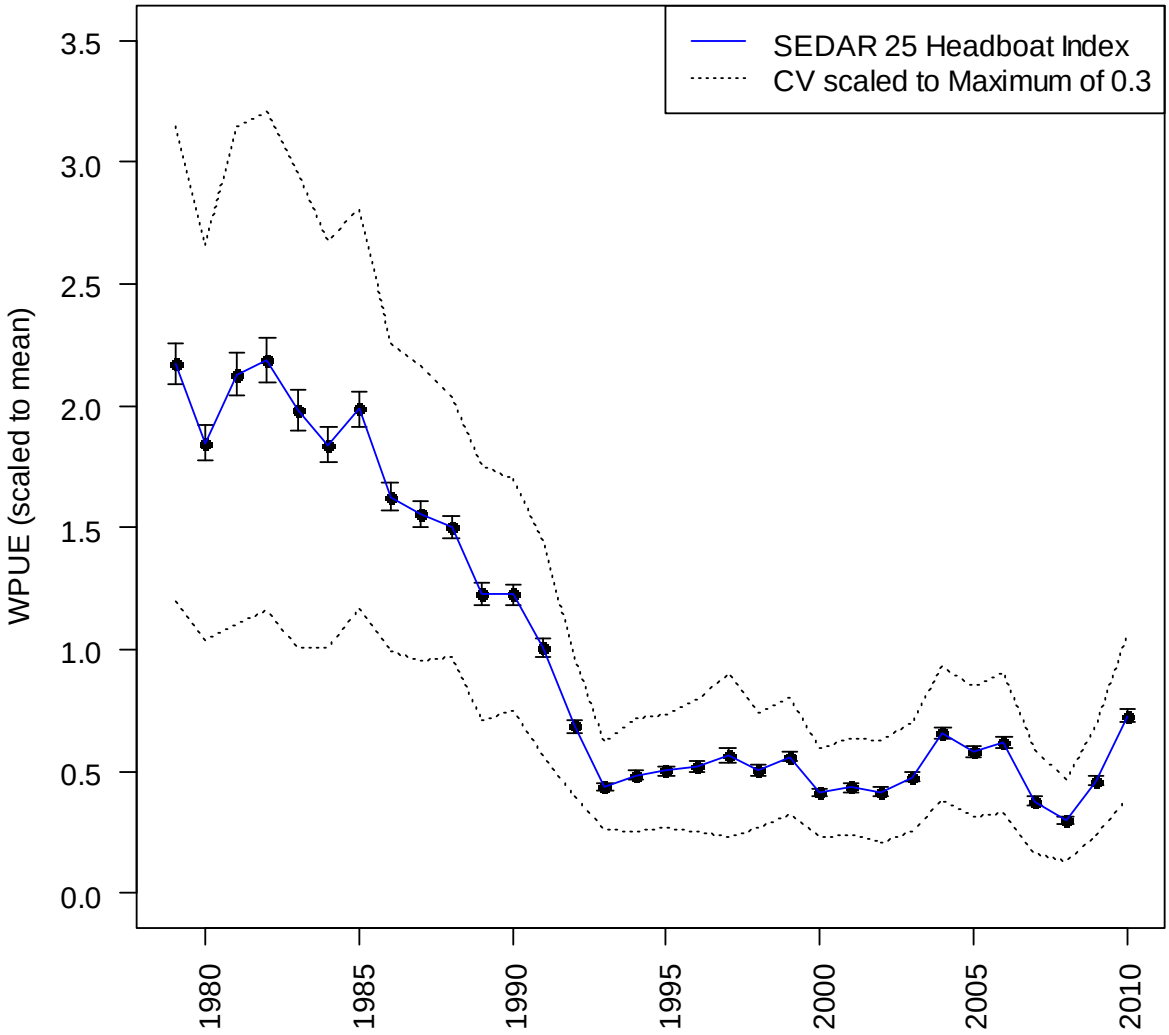


Figure A10. Standardized black sea bass WPUE scaled to the mean with error bars at (+/-) 2 standard deviations. The dotted lines represent one example of methods to scale the error to represent uncertainty in both the fit of the glm and the data.