Standardized Catch Rates of Red Grouper (*Epinephelus morio*) from the U.S. Headboat Fishery in the Gulf of Mexico, 1986-2017

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SEDAR61-WP-05

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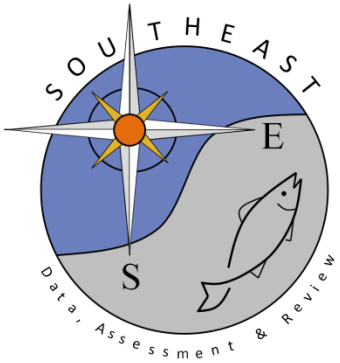

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1. Introduction

The recreational fishery in the Gulf of Mexico is surveyed by the Marine Recreational Fishery Statistics Survey conducted by NOAA Fisheries, the Texas Marine Sport-Harvest Monitoring Program conducted by the Texas Parks and Wildlife Department, and the Headboat Survey (HBS) conducted by NOAA Fisheries. The HBS has monitored catch and effort from party (head) boats in the Gulf of Mexico since 1986. HBS data were used to construct an index of red grouper catch rates in the Gulf of Mexico following the same procedures as SEDAR42. The index was constructed using Generalized Linear Mixed Models, and a delta-lognormal approach.

2. Materials and Methods

Headboat Survey

The Headboat Survey collects data on the catch and effort for individual headboat trips. Reported information includes landing date and location, vessel identification, the number of anglers, fishing location, trip duration and/or type (half/three-quarter/full/multi-day, day/night, morning/afternoon), and catch by species in number and weight.

HBS data were used to characterize abundance trends of red grouper in the Gulf of Mexico. Catch per unit effort (CPUE) was calculated on an individual trip basis. CPUE for each trip was defined as the number of red grouper landed divided by the effort, where effort was the product of the number of anglers and the total hours fished. To estimate effort for each trip type, the following assumptions were necessary:

½ day trip = 5 hours fished
¾ day trip = 7 hours fished
Full day trip = 10 hours fished

Data Filtering Techniques

The following data preparation and filtering techniques from SEDAR 42 were applied to the 1986-2017 HBS dataset:

1. Observations in the Gulf of Mexico were limited to two regions (SW FL, NW FL & AL).
2. Only half-day am, half-day pm, three-quarter day, and full-day trips were retained.
3. Trips with possible errors in effort information or catch amount were excluded.
4. Trips during the closed season for red grouper were excluded.
5. Trips were not separated into periods associated with different size limits.
6. The Stephens MacCall (2004) approach was used to restrict the dataset to those trips that likely encountered red grouper based on the trip's species composition.
7. Trips that reached bag limits for red grouper and aggregate groupers were retained.

Standardization

A delta-lognormal approach (Lo et al., 1992) was used to develop standardized catch rate indices. This method combines separate generalized linear modeling (GLM) analyses of the proportion of trips that observed red grouper and the catch rates on positive trips to construct a single standardized index of abundance. A forward stepwise approach based on AIC was used during the construction of each GLM. In addition to screening using AIC, factors were also screened and not added to the model if the reduction in deviance per degree of freedom was less than one percent. The following factors were examined as possible influences on the proportion of positive trips, and the catch rates on positive trips:

Factor	Levels	Details
Year	32	1986-2017
Area	2	NW FL & AL, SW FL
Season	4	Dec-Feb, Mar-May, Jun-Aug, Sep-Nov
Anglers*	5	1-10, 11-20, 21-30, 41-50, 51-60
Trip Type*	3	Full day, Half day, Three quarter day

*Trip type and number of anglers were only explored as factors for modeling success.

The factors above were examined for the binomial model based on success, where success was defined as whether or not a trip landed red grouper. However, the binomial component of the delta lognormal did not model success. Instead, the binomial component modeled the proportion of positive trips in each unique combination of variables associated with the fixed factors.

Once a set of fixed factors was identified, first level interactions were examined. The significance of these interactions was evaluated between nested models using the likelihood ratio test. Interactions were screened and were only retained if the model improvement was significant according to the likelihood ratio test ($p < 0.0001$). Significant YEAR*FACTOR interaction terms were modeled as random effects. The final delta-lognormal model was fit using the SAS macro GLIMMIX and the SAS procedure PROC MIXED (SAS Institute Inc. 1997) following the procedures by Lo et al. (1992).

The variation in catch rates by vessel was examined using a "repeated measures" approach (Littell et al., 1998). The term 'repeated measures' refers to multiple measurements taken over time on the same experimental unit (i.e. vessel). Specifying the repeated measure "VESSEL" and the subject "VESSEL(YEAR)" allows PROC MIXED to model the covariance structure of the data. This is particularly important because catch rates may vary by vessel and because catch rates by a given vessel that are close in time can be more highly correlated than those far apart in time (Littell et al., 1998)

3. Results and Discussion

Stephens and MacCall

The minimum difference between the predicted and the observed number of trips that reported red grouper occurred at the probability threshold of 0.37 (Figure 1a). Trips with a predicted probability that was greater than the critical threshold probability were identified as trips that targeted red grouper (Figure 2b). This method retained 28.3% of trips, and 51.5% of trips that reported red grouper. Prior to trip selection, there were 165,449 trips and the proportion positive was 0.277, and after selection there were 46,782 trips and the proportion positive was 0.506. Given these diagnostics, sufficient trips were retained to develop a standardized index of abundance.

Annual Abundance Indices

Table 1 summarizes the standardized index and corresponding coefficients of variation, upper confidence limits, lower confidence limits, and nominal CPUE. Final deviance tables are included in Table 2. Tables 3-5, in appendix A, provide the number of observations, the number of positive observations, and the proportion of positive observations by year and factor.

The final models for the binomial and lognormal components were:

Proportion Positive = YEAR + TRIP TYPE + AREA + YEAR*AREA + YEAR*TRIP TYPE
ln(CPUE) = YEAR + AREA + SEASON + YEAR*AREA + YEAR*SEASON

The standardized index, with 95% confidence intervals, is shown in Figure 2. Diagnostics for each component of the GLM are provided in Figures 3 and 4. The over-dispersion parameter for the binomial component was 6.55. Figure 5 provides a comparison of the headboat index that resulted from the current analysis to the headboat index derived during SEDAR42. Note that for SEDAR 61 the YEAR*TRIP TYPE interaction in contrast to SEDAR 42 where this interaction was not significant in the likelihood ratio test when modeling the proportion positive.

Comments on Adequacy for Assessment

The headboat index presented in this working paper reflects the continuity index of the Headboat index that was deemed adequate for use in the SEDAR 42 assessment. This decision was based on the long time series and large spatial coverage associated with the Headboat Survey. This index is associated with high variability and future recommendations should address how to most appropriately model interactions and how to most appropriately calculate the variance associated with the index.

4. References

Littell, R.C., P.R. Henry and C.B. Ammerman. 1998. Statistical analysis of repeated measures data using SAS procedures. J. Anim. Sci. 76:1216-1231.

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

SAS Institute Inc. 1997, SAS/STAT® Software: Changes and Enhancements through Release 6.12. Cary, NC:Sas Institute Inc., 1997. 1167 pp.

Stephens, A. and A. MacCall. 2004. A multispecies approach to subsetting logbook data for purposes of estimating CPUE. Fisheries Research 70:299-310.

5. Tables

Table 1. Number of total trips and positive trips, proportion of positive trips (PPT), relative nominal CPUE, and abundance index statistics for the headboat index.

YEAR	TRIPS	POSITIVE TRIPS	PPT	RELATIVE NOMINAL INDEX	RELATIVE INDEX	LOWER 95% CI	UPPER 95% CI	CV
1986	1254	816	0.651	2.0583	1.1890	0.3496	4.0440	0.6741
1987	1100	811	0.737	3.3007	1.7750	0.5665	5.5614	0.6209
1988	1043	807	0.774	3.8659	1.7354	0.5683	5.2990	0.6046
1989	1318	950	0.721	3.4133	1.7208	0.5394	5.4897	0.6324
1990	2265	1257	0.555	1.2481	0.7480	0.2018	2.7721	0.7319
1991	2311	1211	0.524	0.8278	0.5035	0.1261	2.0105	0.7841
1992	2224	1121	0.504	0.7914	0.4278	0.1040	1.7592	0.8052
1993	2096	960	0.458	0.6033	0.6158	0.1685	2.2503	0.7223
1994	1996	960	0.481	0.6799	0.6583	0.1831	2.3662	0.7111
1995	1552	750	0.483	2.5179	0.9219	0.2736	3.1058	0.6679
1996	1592	466	0.293	0.4675	0.5226	0.1370	1.9938	0.7520
1997	1526	481	0.315	0.7444	0.5275	0.1394	1.9955	0.7461
1998	1346	524	0.389	0.4606	0.5622	0.1490	2.1216	0.7445
1999	1276	468	0.367	0.2424	0.4836	0.1262	1.8527	0.7549
2000	1473	706	0.479	0.5014	0.5728	0.1504	2.1815	0.7508
2001	1017	457	0.449	0.3762	0.9441	0.2812	3.1699	0.6656
2002	939	410	0.437	0.3647	0.8844	0.2642	2.9598	0.6635
2003	1212	694	0.573	0.5005	1.3684	0.4659	4.0195	0.5803
2004	1497	948	0.633	0.8484	2.0884	0.7719	5.6501	0.5301
2005	1540	972	0.631	1.0369	2.5562	1.0033	6.5130	0.4944
2006	886	309	0.349	0.2829	0.9349	0.2827	3.0913	0.6556
2007	945	404	0.428	0.4046	1.0340	0.3200	3.3411	0.6407
2008	1536	703	0.458	0.6205	0.9819	0.3085	3.1251	0.6309
2009	1854	719	0.388	0.4163	0.7605	0.2302	2.5125	0.6550
2010	1607	861	0.536	0.6478	1.1304	0.3777	3.3832	0.5920
2011	928	538	0.58	0.6009	1.2927	0.4661	3.5855	0.5451
2012	1311	817	0.623	0.8428	1.5925	0.5959	4.2560	0.5227
2013	1292	912	0.706	1.1610	1.4145	0.5039	3.9708	0.5524
2014	1258	834	0.663	0.6593	0.7803	0.2494	2.4414	0.6200
2015	1206	677	0.561	0.6938	0.6576	0.1911	2.2624	0.6817
2016	1840	740	0.402	0.6097	0.3787	0.1001	1.4325	0.7461
2017	1582	373	0.236	0.2109	0.2364	0.0573	0.9758	0.8081

Table 2. Final deviance tables for the Gulf of Mexico red grouper regressions from the headboat fishery. The table shows the order of the factors as they were sequentially added to each model. Fit diagnostics listed for each factor were the diagnostics from a model that included that factor and all of the factors listed above it in the tables below.

Binomial								
Factor	**DF**	**Deviance**	**Residual Df**	**Residual Deviance**	**AIC**	**% Deviance Reduced**	**log likelihood**	**Likelihood Ratio Test**
Null	1	64903.9	46821	64903.9	64904.00	-	-32452.0	-
Year	32	61732.5	46790	3171.4	61732.40	4.82%	-30866.2	3171.6
Trip Type	3	59415.6	46788	2316.9	59415.60	3.75%	-29707.8	2316.8
Area	2	58696.0	46787	3036.5	58696.00	1.21%	-29348.0	719.6
Year * Area	32	57103.3	46756	4629.2	57103.40	2.65%	-28551.7	1592.6
Year * Trip Type	63	56018.3	46694	3397.3	56018.40	1.77%	-28009.2	1085.0
Lognormal								
Factor	**DF**	**Deviance**	**Residual Df**	**Residual Deviance**	**AIC**	**% Deviance Reduced**	**log likelihood**	**Likelihood Ratio Test**
Null	1	30639.2	23655	30639.2	73251.80	-	-36625.9	-
Year	32	26667.5	23624	3971.7	69967.40	12.85%	-34983.7	3284.4
Area	2	26024.6	23623	642.9	69390.20	2.41%	-34695.1	577.2
Season	4	25750.3	23620	274.3	69139.60	1.04%	-34569.8	250.6
Year*Area	32	24543.6	23589	1206.7	68004.20	4.56%	-34002.1	1135.4
Year*Season	94	23837.9	23496	705.7	67314.00	2.49%	-33657.0	690.2

6. Figures

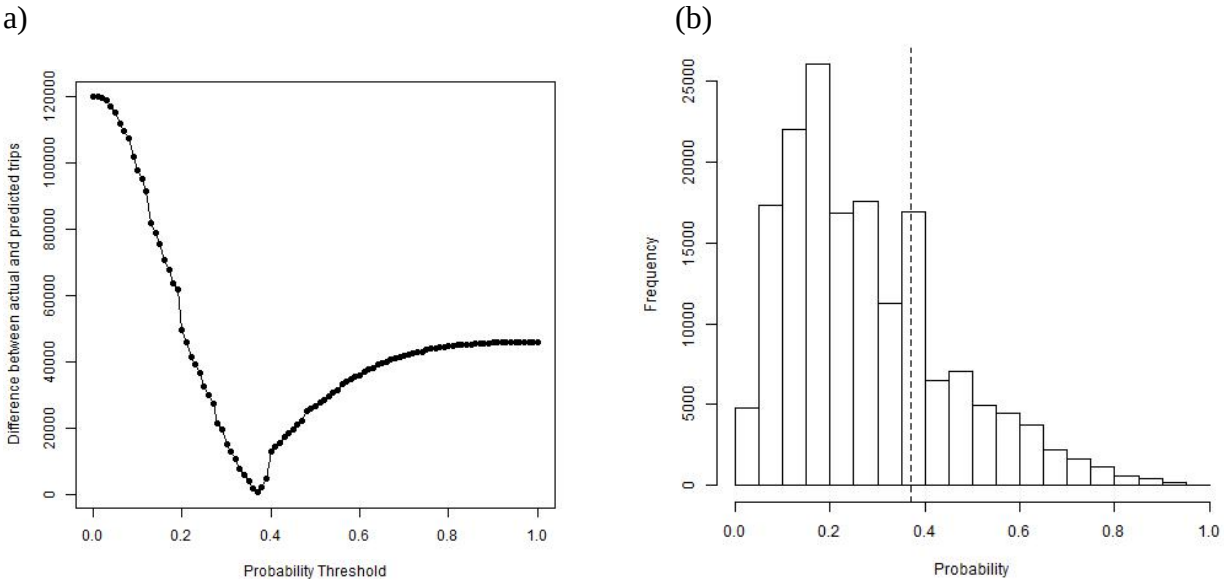

Figure 1: (a) Plot of the difference between the number of records in which red grouper are observed and the number in which they are predicted to occur for each probability threshold. (b) Histogram of probabilities generated for each trip by the species-based regression. The dashed vertical line indicates the critical value where false prediction is minimized.

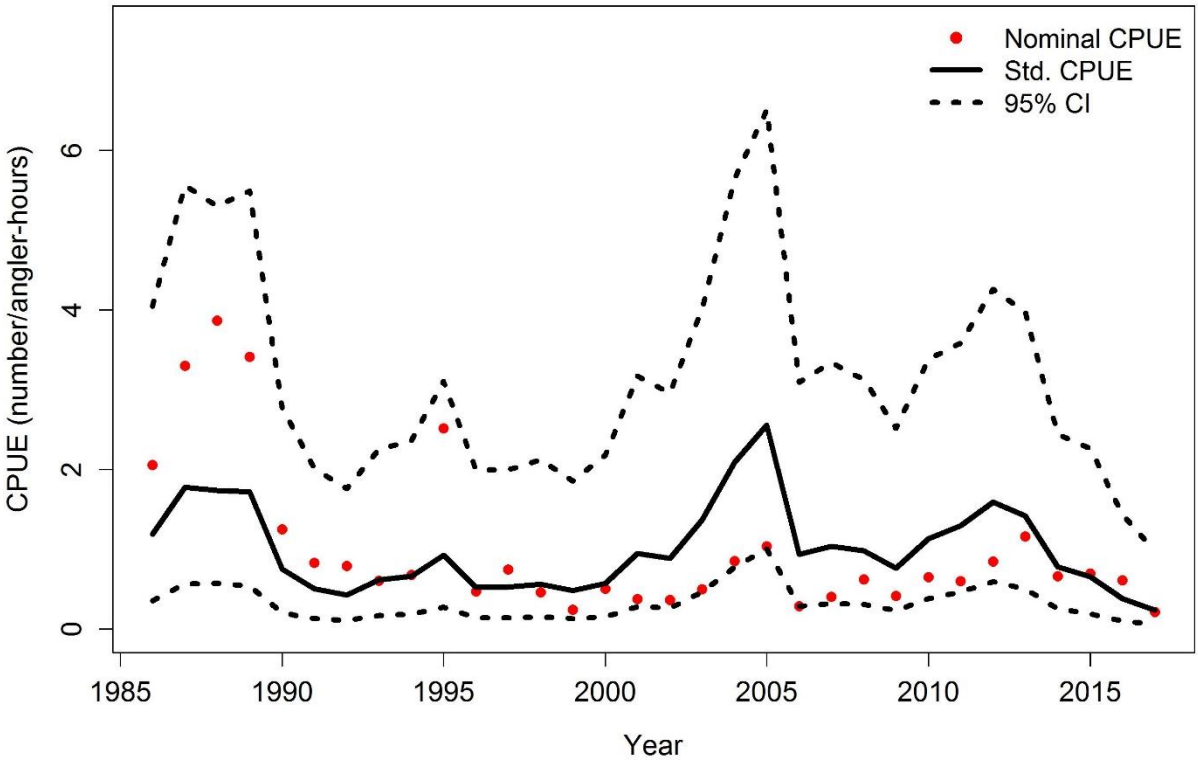

Figure 2: Standardized indices with 95% confidence intervals and nominal CPUE for the Gulf of Mexico red grouper headboat index.

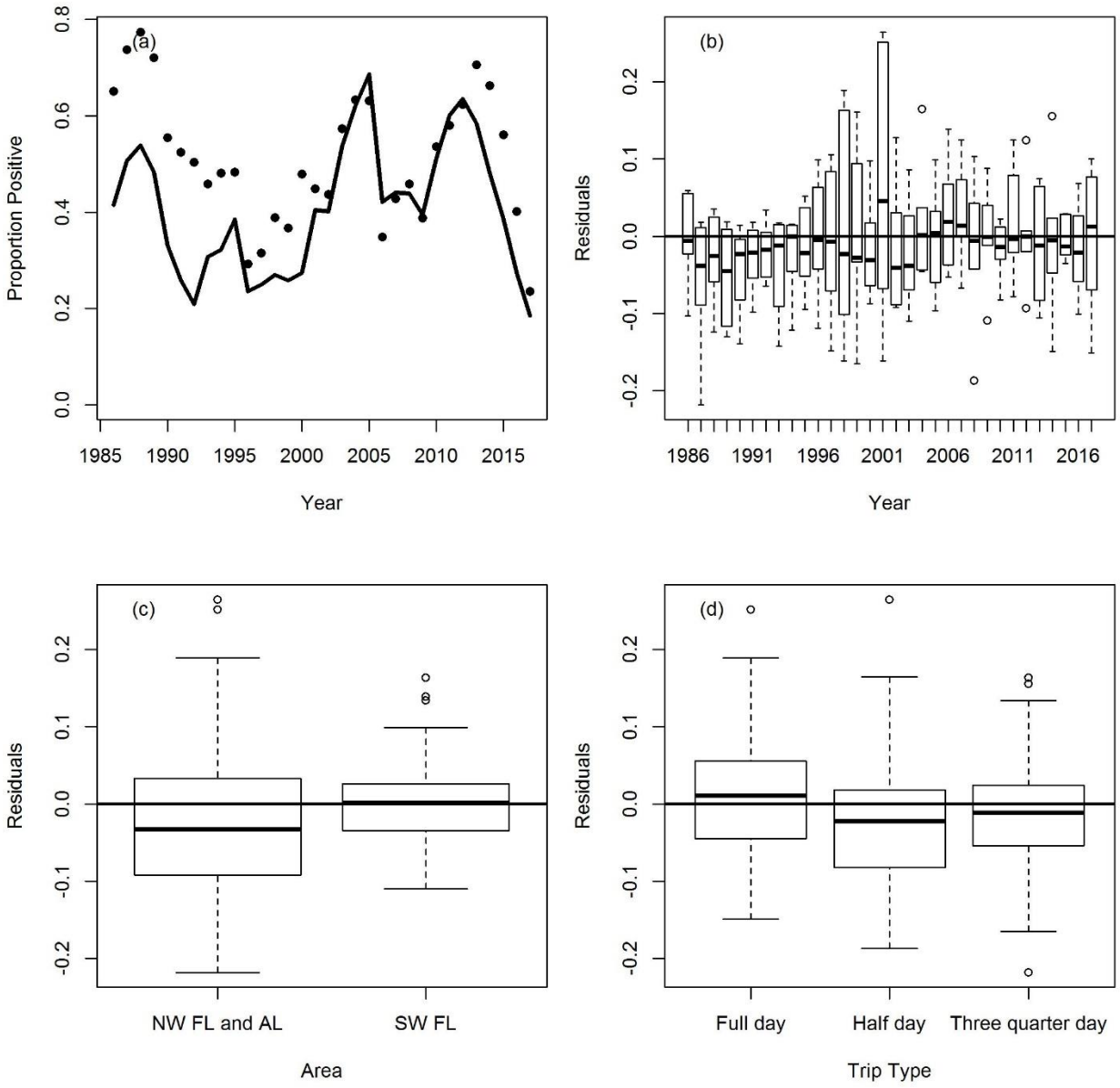

Figure 3. Diagnostic plots for the binomial model. Shown here are the predicted (solid line) and observed proportion of positive trips by year (a), and the residuals from the binomial model by year (b), area (c), and trip type (d).

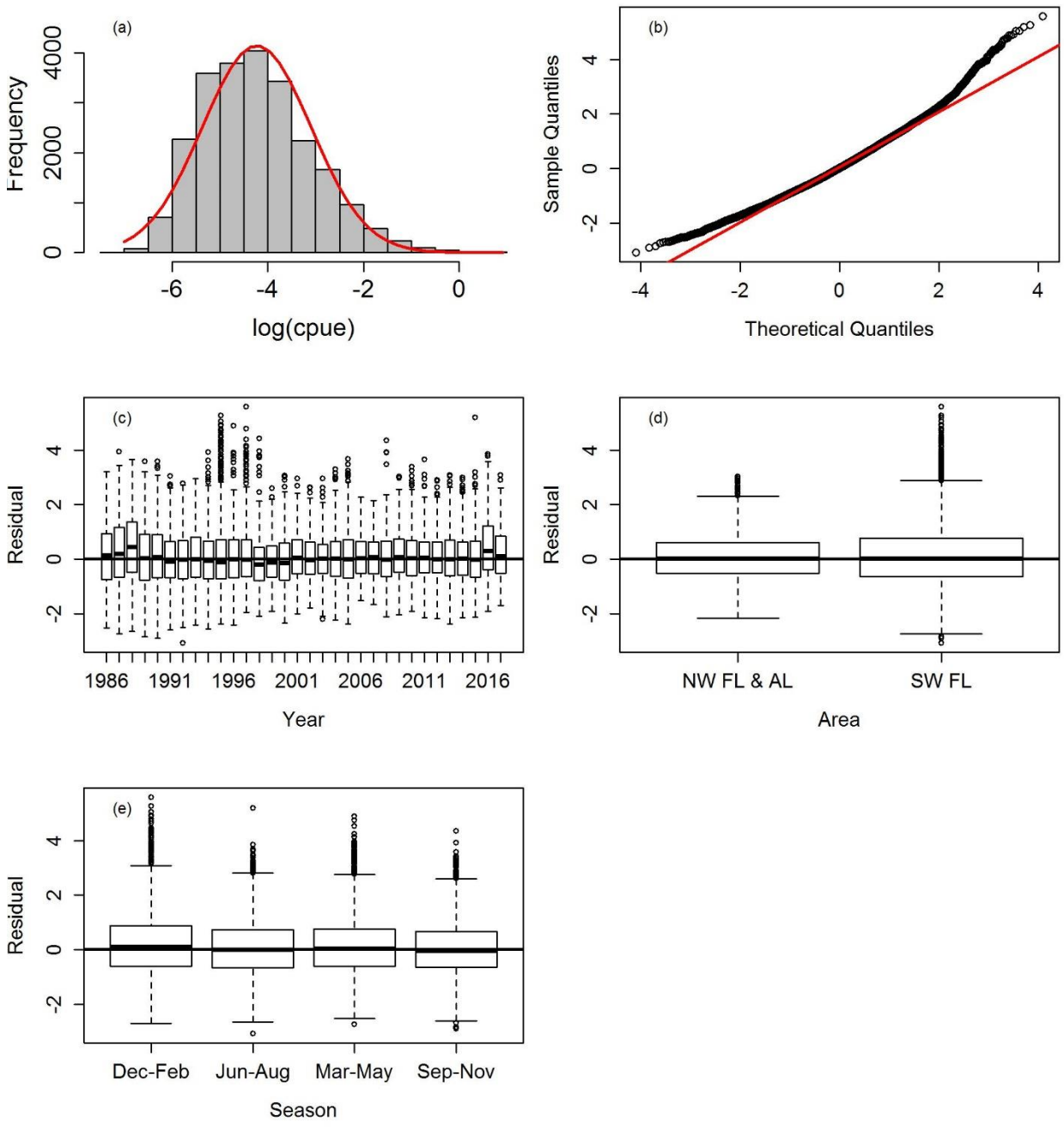

Figure 4. Diagnostic plots for the lognormal model of catch rates on positive trips. Shown here are the frequency distribution of catch rates (a), the cumulative normalized residuals (b), and the distribution of residuals by year (c), area (d), and season (e). The red lines represent the expected normal distribution.

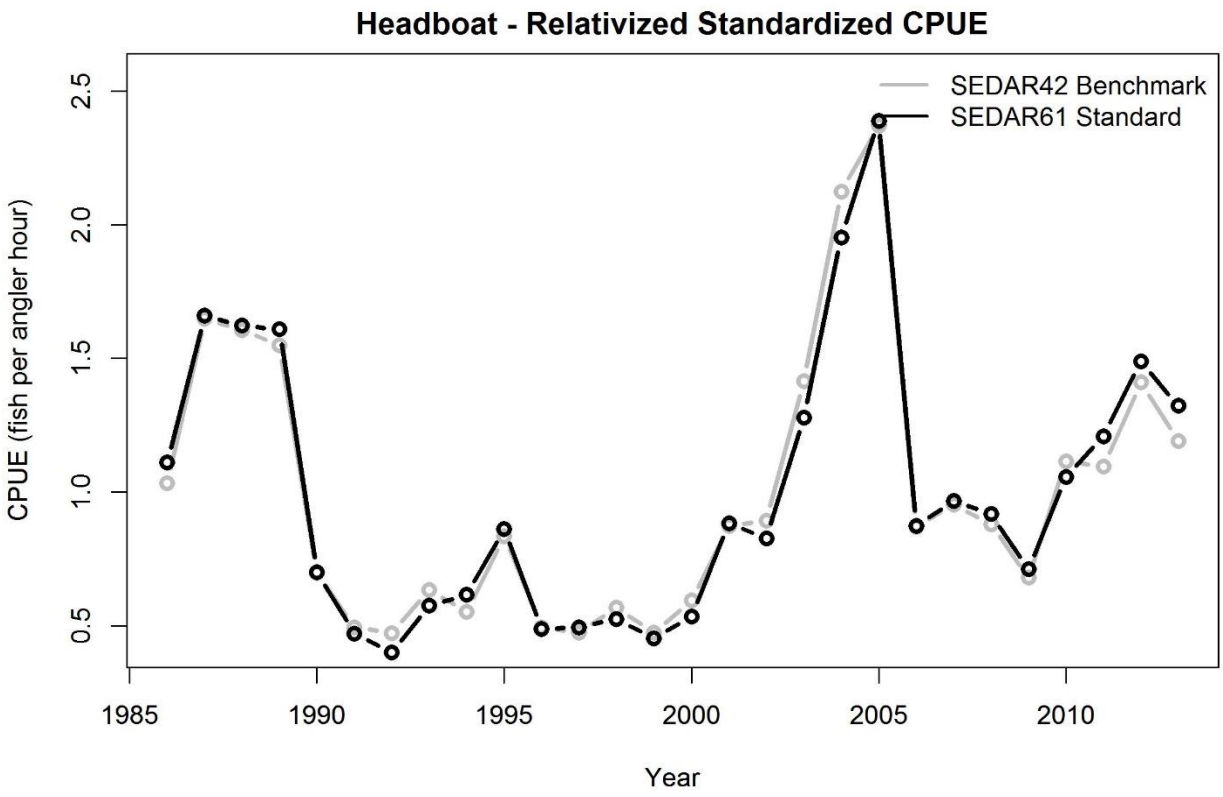

Figure 5: Standardized headboat index for SEDAR 61 compared to the headboat indices provided in for SEDAR 42. For comparison, both indices have been normalized by their respective means.

7. Appendix A

Description of the analysis dataset after exclusions and other treatments

Table 3: Number of Trips by Factor and Year.

	Areas		Trip Types			Seasons			
Year	NW FL and AL	SW Florida	0.5 day	0.75 day	Full day	Dec-Feb	Mar-May	Jun-Aug	Sep-Nov
1986	143	1111	378	146	730	281	324	395	254
1987	115	985	361	70	669	280	343	303	174
1988	82	961	373	127	543	242	306	325	170
1989	114	1204	563	258	497	280	374	363	301
1990	87	2178	741	609	915	612	549	516	588
1991	100	2211	649	768	894	632	537	578	564
1992	155	2069	477	784	963	527	599	526	572
1993	207	1889	474	777	845	449	544	612	491
1994	257	1739	388	502	1106	322	585	646	443
1995	264	1288	478	426	648	301	454	472	325
1996	410	1182	361	372	859	245	363	584	400
1997	461	1065	405	298	823	297	423	491	315
1998	331	1015	297	325	724	220	347	441	338
1999	218	1058	299	338	639	332	492	287	165
2000	218	1255	252	335	886	295	487	395	296
2001	224	793	155	282	580	174	393	272	178
2002	263	676	102	532	305	199	262	225	253
2003	324	888	132	805	275	225	338	353	296
2004	303	1194	157	968	372	299	604	400	194
2005	425	1115	218	810	512	281	567	516	176
2006	253	633	101	629	156	202	265	231	188
2007	204	741	254	486	205	208	260	285	192
2008	355	1181	292	976	268	284	435	466	351
2009	423	1431	311	1305	238	347	531	561	415
2010	278	1329	421	1036	150	208	429	465	505
2011	350	578	179	653	96	91	134	270	433
2012	483	828	298	910	103	126	186	532	467
2013	328	964	238	367	687	122	127	557	486
2014	207	1051	235	319	704	163	332	632	131
2015	160	1046	241	359	606	202	392	457	155
2016	230	1610	525	435	880	398	471	539	432
2017	209	1373	331	404	847	438	386	450	308
All	8181	38641	10686	17411	18725	9282	12839	14145	10556

Table 4: Number of Positive Trips by Factor and Year.

	Areas		Trip Types			Seasons			
Year	NW FL and AL	SW Florida	0.5 day	0.75 day	Full day	Dec-Feb	Mar-May	Jun-Aug	Sep-Nov
1986	28	788	164	104	548	188	170	253	205
1987	35	776	226	42	543	208	251	213	139
1988	19	788	281	81	445	192	228	251	136
1989	25	925	392	174	384	207	268	258	217
1990	20	1236	274	305	677	392	236	314	314
1991	11	1200	180	387	644	308	247	388	268
1992	17	1104	80	368	673	254	255	310	302
1993	77	882	100	316	543	196	187	350	226
1994	76	885	117	224	620	121	267	338	235
1995	84	666	139	263	348	129	248	220	153
1996	117	350	61	85	321	54	99	211	103
1997	124	357	73	74	334	92	116	173	100
1998	82	442	62	86	376	86	94	171	173
1999	58	410	46	113	309	124	169	100	75
2000	56	649	38	75	592	98	207	245	155
2001	131	326	25	115	317	39	179	167	72
2002	144	266	11	222	177	57	101	123	129
2003	213	482	25	476	194	99	173	213	210
2004	216	731	65	617	265	128	348	317	154
2005	350	622	127	481	364	184	344	352	92
2006	162	147	20	166	123	42	86	111	70
2007	106	298	48	206	150	77	87	136	104
2008	133	571	99	398	207	123	201	230	150
2009	142	578	95	467	158	132	185	215	188
2010	127	734	189	576	96	82	184	295	300
2011	192	346	87	376	75	47	63	160	268
2012	216	601	163	568	86	64	106	318	329
2013	132	780	137	204	571	91	90	374	357
2014	67	767	108	184	542	107	220	418	89
2015	41	635	102	203	371	87	233	279	77
2016	33	707	244	196	300	155	219	246	120
2017	32	341	89	122	162	102	118	125	28
All	3266	20390	3867	8274	11515	4265	5979	7874	5538

Table 5: Proportion of Positive Trips by Factor and Year.

	Areas		Trip Types			Seasons			
Year	NW FL and AL	SW Florida	0.5 day	0.75 day	Full day	Dec-Feb	Mar-May	Jun-Aug	Sep-Nov
1986	0.20	0.71	0.43	0.71	0.75	0.67	0.52	0.64	0.81
1987	0.30	0.79	0.63	0.60	0.81	0.74	0.73	0.70	0.80
1988	0.23	0.82	0.75	0.64	0.82	0.79	0.75	0.77	0.80
1989	0.22	0.77	0.70	0.67	0.77	0.74	0.72	0.71	0.72
1990	0.23	0.57	0.37	0.50	0.74	0.64	0.43	0.61	0.53
1991	0.11	0.54	0.28	0.50	0.72	0.49	0.46	0.67	0.48
1992	0.11	0.53	0.17	0.47	0.70	0.48	0.43	0.59	0.53
1993	0.37	0.47	0.21	0.41	0.64	0.44	0.34	0.57	0.46
1994	0.30	0.51	0.30	0.45	0.56	0.38	0.46	0.52	0.53
1995	0.32	0.52	0.29	0.62	0.54	0.43	0.55	0.47	0.47
1996	0.29	0.30	0.17	0.23	0.37	0.22	0.27	0.36	0.26
1997	0.27	0.34	0.18	0.25	0.41	0.31	0.27	0.35	0.32
1998	0.25	0.44	0.21	0.26	0.52	0.39	0.27	0.39	0.51
1999	0.27	0.39	0.15	0.33	0.48	0.37	0.34	0.35	0.45
2000	0.26	0.52	0.15	0.22	0.67	0.33	0.43	0.62	0.52
2001	0.58	0.41	0.16	0.41	0.55	0.22	0.46	0.61	0.40
2002	0.55	0.39	0.11	0.42	0.58	0.29	0.39	0.55	0.51
2003	0.66	0.54	0.19	0.59	0.71	0.44	0.51	0.60	0.71
2004	0.71	0.61	0.41	0.64	0.71	0.43	0.58	0.79	0.79
2005	0.82	0.56	0.58	0.59	0.71	0.65	0.61	0.68	0.52
2006	0.64	0.23	0.20	0.26	0.79	0.21	0.32	0.48	0.37
2007	0.52	0.40	0.19	0.42	0.73	0.37	0.33	0.48	0.54
2008	0.37	0.48	0.34	0.41	0.77	0.43	0.46	0.49	0.43
2009	0.34	0.40	0.31	0.36	0.66	0.38	0.35	0.38	0.45
2010	0.46	0.55	0.45	0.56	0.64	0.39	0.43	0.63	0.59
2011	0.55	0.60	0.49	0.58	0.78	0.52	0.47	0.59	0.62
2012	0.45	0.73	0.55	0.62	0.84	0.51	0.57	0.60	0.70
2013	0.40	0.81	0.58	0.56	0.83	0.75	0.71	0.67	0.73
2014	0.32	0.73	0.46	0.58	0.77	0.66	0.66	0.66	0.68
2015	0.26	0.61	0.42	0.57	0.61	0.43	0.59	0.61	0.50
2016	0.14	0.44	0.46	0.45	0.34	0.39	0.47	0.46	0.28
2017	0.15	0.25	0.27	0.30	0.19	0.23	0.31	0.28	0.09
All	0.40	0.53	0.36	0.48	0.61	0.46	0.47	0.56	0.52