Standardized Catch Rates of Red Grouper (*Epinephelus morio*) from the U.S. Headboat Fishery in the Gulf of Mexico, 1986-2013

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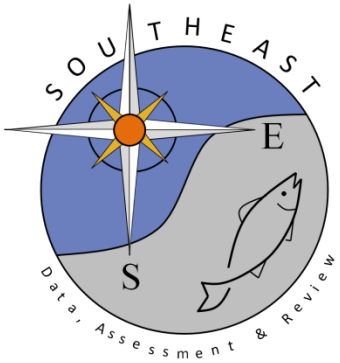

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1. Introduction

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. 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 were applied to the 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 greater amberjack 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 targeted red grouper.
7. Trips that reached bag limits for red grouper and aggregate groupers were retained.

Data were limited to trips in the southwest Florida (Naples to Crystal River) and northwest Florida and Alabama (Carrabelle to Pensacola, including Panama City and Destin). These regions accounted for 98% of trips in the Gulf of Mexico that reported red grouper. Data were also filtered to include only half-day am, half-day pm, three-quarter-day and full-day fishing trips. These 4 trips types accounted for 98 percent of trips in the regions retained that reported red grouper. Furthermore, 262 trips that were flagged due to possible errors in effort information or catch amount were excluded.

Recreational fishing for red grouper is managed using size limits, bag limits, and fishing seasons (see section 2 of the SEDAR 42 Data Workshop Report for a summary of the management history). Landings by the headboat fishery were assumed to be affected by the implementation of closed seasons. For this reason, trips during the closed seasons for red grouper were excluded from the analysis. Removal of closed season data resulted in a 3.6% reduction in the number of trips and in a 0.4% reduction in the number of trips that reported red grouper.

Recreational size limits for red grouper in the Gulf of Mexico have been in place since the beginning of the available headboat time series. From 1986 to 1990, the size limit in Florida was 18 inches total length (TL). In 1990, a federal size limit of 20 inches TL was implemented. After the increase in the size limit, the size frequency of red grouper landed by headboats shifted to larger fish (Cass-Calay, 2006). In previous assessments of Gulf of Mexico red grouper (SEDAR12 and 2009 SEDAR Update), this was addressed by constructing two indices of abundance for the headboat fishery. The first index was associated with the 18 inch size limit and the second was associated with the 20 inch size limit. Since the SEDAR 42 assessment will use a modeling framework that allows the size selectivity of a fishery to vary over time, it was not necessary to develop two separate indices.

Headboat trips can target any number of species on any given trip; therefore, species targeting is generally unknown. The Stephens and MacCall (2004) approach was used to restrict the dataset to trips that targeted red grouper. This approach uses the species composition of each trip in a logistic regression of species presence/absence to infer if effort on a given trip occurred in similar habitat to red grouper. If effort on a trip was determined to occur in similar habitat to red grouper, or if a trip caught only red grouper, then that trip was used in the analysis.

The filtered headboat data were explored to determine the number of trips that reached red grouper bag limits as well as aggregate grouper bag limits. Of the 20,880 trips that landed red

grouper between 1986 and 2013, 46 trips reached or exceeded the red grouper bag limit (0.2%) and 54 trips reached or exceeded the aggregate grouper bag limit (0.3%). Most of those trips occurred in 1995. Of the 717 trips that landed red grouper in 1995, 24 reached or exceeded the red grouper bag limit (3%) and 30 reached or exceeded the aggregate grouper bag limit (4%). Given that so few trips appear to have been influenced by the bag limits, headboat trips that met or exceeded their bag limits were retained in the analysis.

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	28	1986-2013
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 0.38 (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 28.7% of trips, and 52.2% of trips that reported red grouper. Prior to trip selection, there were 139,479 trips and the proportion positive was 0.287, and after selection there were 40,001 trips and the proportion positive was 0.522. 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
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 overdispersion parameter for the binomial component was 8.71. Figure 5 provides a comparison of the headboat index that resulted from the current analysis to the headboat indices that were used in 2009 SEDAR update assessment.

Comments on Adequacy for Assessment

The headboat index presented in this working paper 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. The group noted that the index is associated with high variability and recommended that future investigations should address how to most appropriately model interactions and how to most appropriately calculate the variance associated with the index.

Size and Age Data

It is assumed that the size range of red grouper by headboats is comprised of legal sized fish. Size and age data for red grouper that were sampled from headboat, charterboat, and private boat recreational fisheries from 1991 to 2013 were summarized by Chih (2014).

4. References

Cass-Calay, Shannon. 2006. The Standardized catch rates of red grouper (*Epinephelus morio*) from the U.S. headboat fishery in the Gulf of Mexico, 1986-2005. SEDAR12-AW-02. SEDAR, North Charleston, SC. 9 pp.

Chih, Ching-Ping. 2014. Length and age frequency distributions for red groupers collected in the Gulf ofMexico from 1984 to 2013. SEDAR42-DW-18. SEDAR, North Charleston, SC. 42 pp.

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 CPUE	RELATIVE INDEX	LOWER 95% CI	UPPER 95% CI	CV
1986	1242	809	0.651	1.8953	1.0334	0.2845	3.7544	0.7183
1987	1055	788	0.747	3.1274	1.6494	0.5133	5.3000	0.6371
1988	998	772	0.774	3.5868	1.6056	0.5101	5.0544	0.6239
1989	1272	930	0.731	3.2024	1.5487	0.4727	5.0744	0.6497
1990	2131	1206	0.566	1.1943	0.6990	0.1831	2.6687	0.7525
1991	2209	1160	0.525	0.7867	0.4941	0.1198	2.0386	0.8076
1992	2058	1045	0.508	0.7488	0.4723	0.1147	1.9451	0.8063
1993	1962	916	0.467	0.5862	0.6343	0.1724	2.3336	0.7269
1994	1871	881	0.471	0.6115	0.5523	0.1442	2.1152	0.7546
1995	1455	717	0.493	2.4753	0.8352	0.2364	2.9504	0.6993
1996	1483	461	0.311	0.4419	0.4933	0.1252	1.9436	0.7746
1997	1117	361	0.323	0.8408	0.4750	0.1199	1.8820	0.7786
1998	1187	482	0.406	0.4631	0.5671	0.1467	2.1927	0.7614
1999	1165	446	0.383	0.2368	0.4741	0.1206	1.8641	0.7731
2000	1439	689	0.479	0.4683	0.5944	0.1540	2.2946	0.7603
2001	1036	467	0.451	0.3499	0.8726	0.2511	3.0328	0.6885
2002	923	412	0.446	0.3568	0.8929	0.2644	3.0162	0.6696
2003	1218	717	0.589	0.4879	1.4145	0.4900	4.0837	0.5696
2004	1473	955	0.648	0.8441	2.1247	0.7860	5.7434	0.5296
2005	1536	975	0.635	0.9737	2.3719	0.8876	6.3388	0.5227
2006	780	287	0.368	0.2924	0.8687	0.2482	3.0405	0.6932
2007	927	397	0.428	0.3731	0.9534	0.2870	3.1670	0.6586
2008	1558	692	0.444	0.5589	0.8800	0.2612	2.9648	0.6679
2009	1876	715	0.381	0.3773	0.6800	0.1950	2.3709	0.6906
2010	1646	874	0.531	0.6013	1.1157	0.3638	3.4216	0.6073
2011	1140	632	0.554	0.4965	1.0953	0.3755	3.1950	0.5760
2012	1648	1018	0.618	0.6944	1.4104	0.5122	3.8832	0.5407
2013	1596	1071	0.671	0.9282	1.1915	0.3983	3.5645	0.5917

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. Although the interaction term between Year and Trip Type (highlighted in gray) was significant in the binomial deviance analysis for success, it was not used to model proportion positive because the likelihood ratio test for this interaction was not significant.

Binomial Model for Success (whether or not a trip landed red grouper)								
Factor	**DF**	**Deviance**	**Residual Df**	**Residual Deviance**	**AIC**	**% Deviance Reduced**	**Log likelihood**	**Likelihood Ratio Test**
Null	1	55375.8	40000	55375.8	55375.80	-	-27687.9	-
Year	28	53132.9	39973	2242.9	53132.80	3.99%	-26566.4	2243.0
Trip Type	3	50507.1	39971	2625.8	50507.20	4.94%	-25253.6	2625.6
Area	2	49903.7	39970	3229.2	49903.60	1.19%	-24951.8	3229.2
Year * Area	28	48280.0	39943	4852.9	48280.00	3.19%	-24140.0	4852.8
Year * Trip Type	55	47712.7	39889	2794.4	47712.80	1.04%	-23856.4	2794.4
Lognormal Model for Catch Rates From Positive Trips								
Factor	**DF**	**Deviance**	**Residual Df**	**Residual Deviance**	**AIC**	**% Deviance Reduced**	**Log likelihood**	**Likelihood Ratio Test**
Null	1	27178.9	20879	27178.9	64759.80	-	-32379.9	-
Year	28	23636.5	20852	3542.4	61844.00	12.92%	-30922.0	2915.8
Area	2	23044.9	20851	591.6	61314.80	2.50%	-30657.4	529.2
Season	4	22792.1	20848	252.8	61084.40	1.08%	-30542.2	230.4
Year*Area	28	21628.5	20821	1163.6	59990.20	4.98%	-29995.1	1094.2
Year*Season	82	20916.7	20740	711.8	59291.60	2.91%	-29645.8	698.6

6. Figures

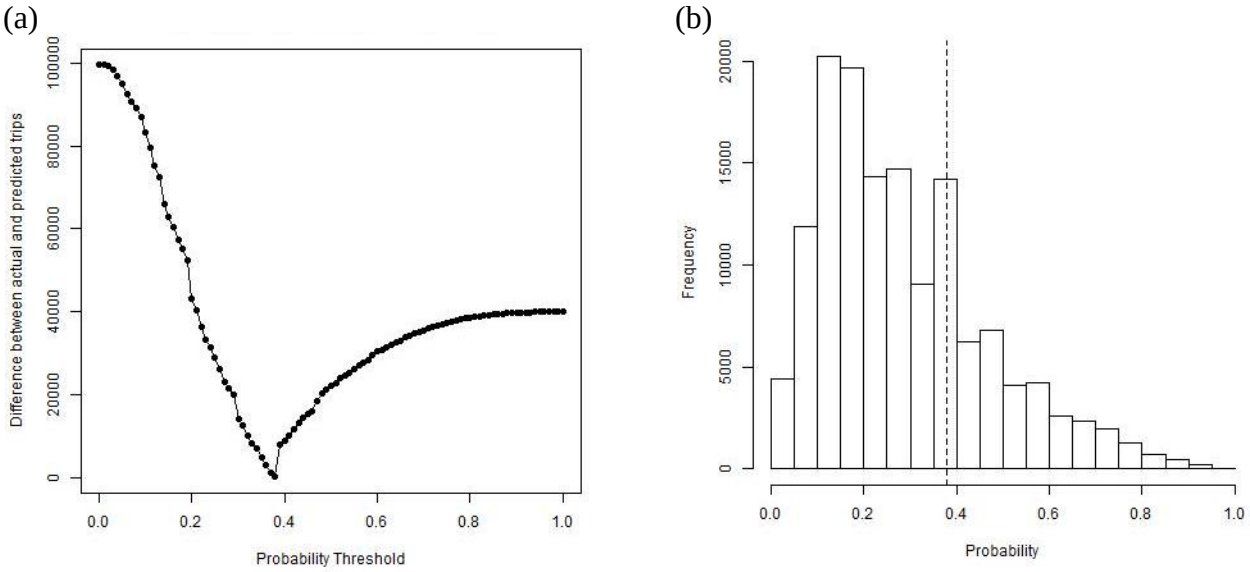

Figure 1: (a) Plot of the difference between the number of records in which red grouper are observed and the number in which they are predicted to occur for each probability threshold. (b) Histogram of probabilities generated for each trip by the species-based regression. The dashed vertical line indicates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

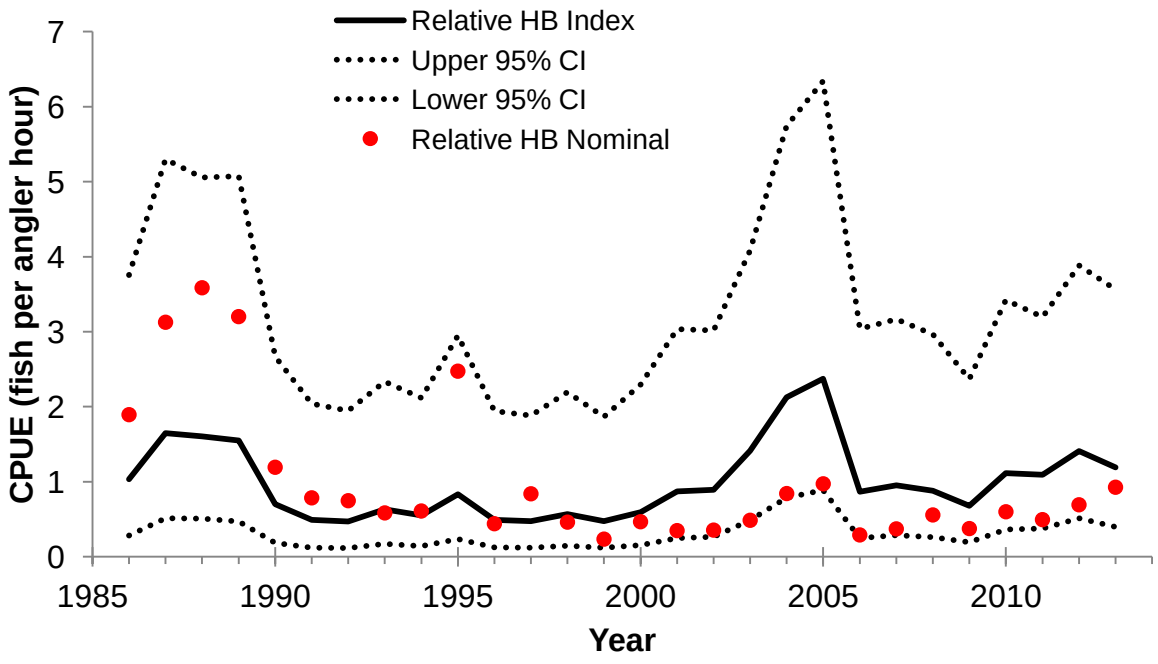

Figure 2: Standardized indices with 95% confidence intervals and nominal CPUE for the Gulf of Mexico red grouper headboat index.

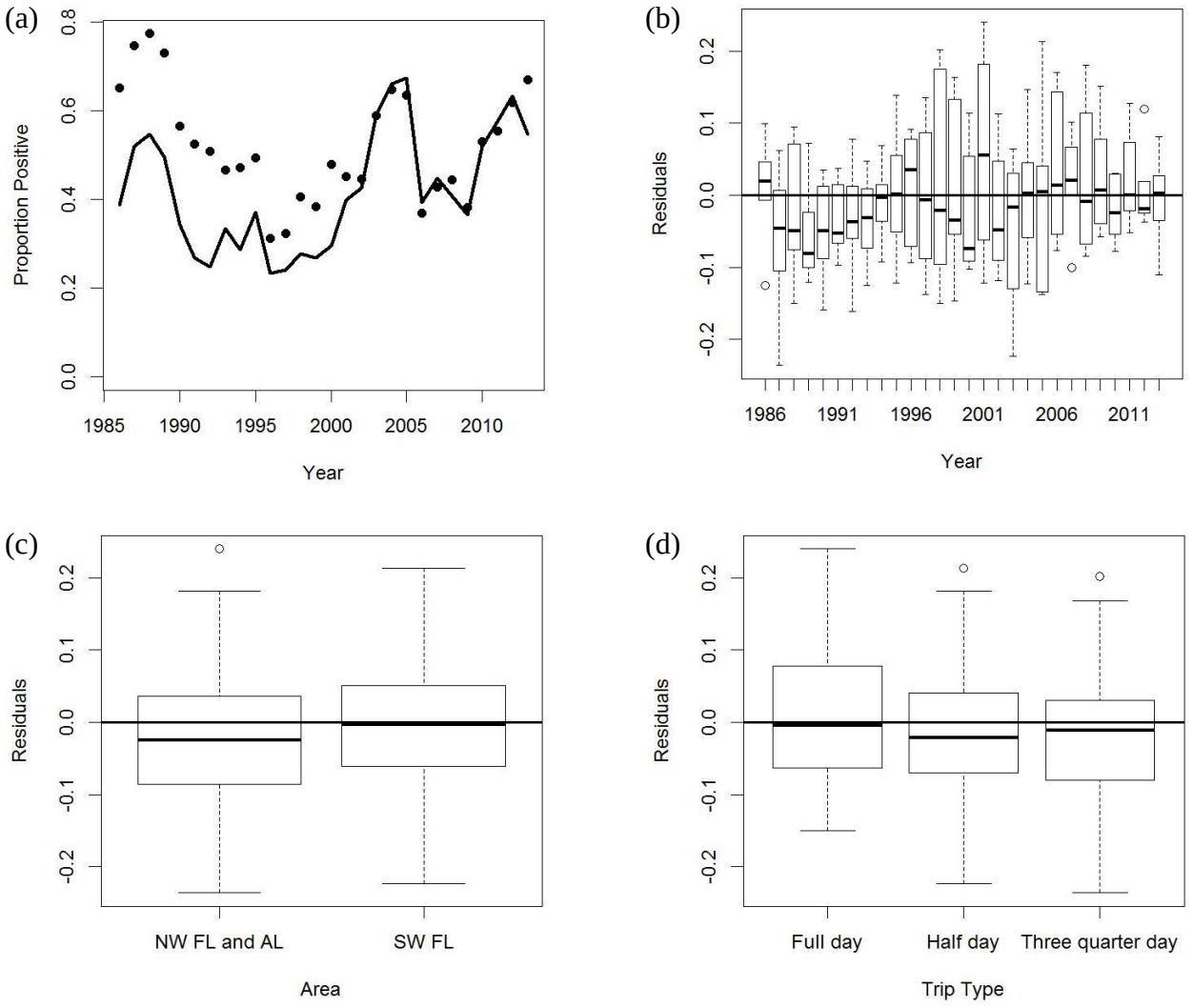

Figure 3. Diagnostic plots for the binomial model. Shown here are the predicted (solid line) and observed proportion of positive trips by year (a), and the residuals from the binomial model by year (b), area (c), and trip type (d).

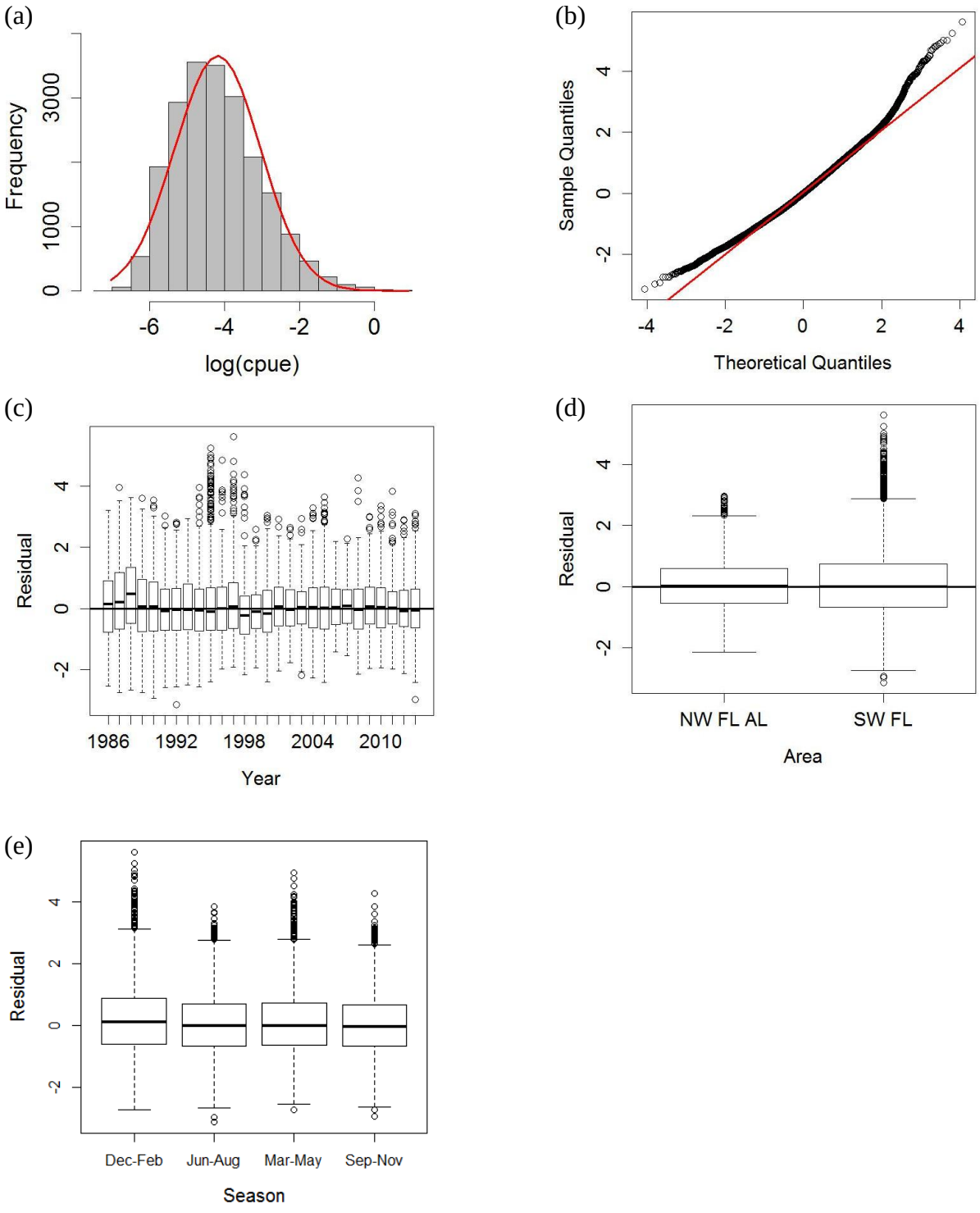

Figure 4. Diagnostic plots for the lognormal model of catch rates on positive trips. Shown here are the frequency distribution of catch rates (a), the cumulative normalized residuals (b), and the distribution of residuals by year (c), area (d), and season (e). The red lines represent the expected normal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

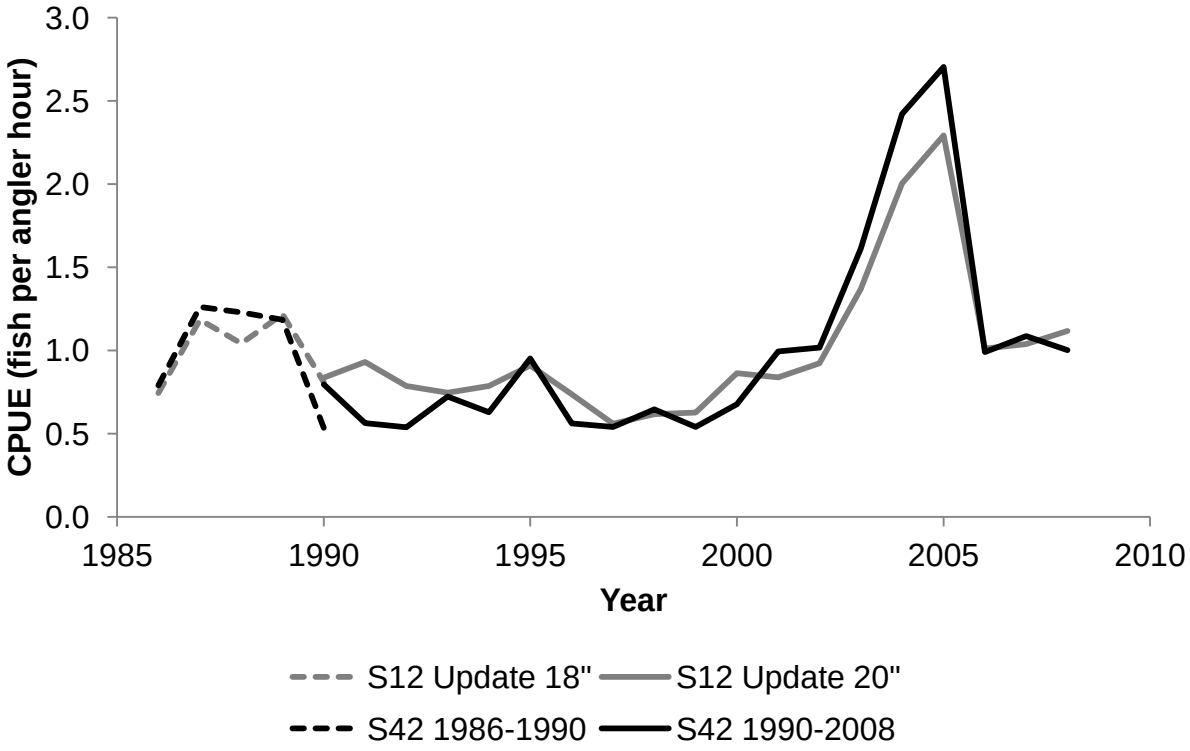

Figure 5: Standardized headboat index for SEDAR 42 compared to the headboat indices provided in the 2009 SEDAR Update Assessment Report. For comparison, the SEDAR 42 index was split into two periods (1986-1990 and 1990-2008) and normalized by their respective means.

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 FL	0.5 day	0.75 day	Full day	Dec-Feb	Mar-May	Jun-Aug	Sep-Nov
1986	134	1108	366	150	726	285	324	383	250
1987	114	941	327	68	660	261	330	294	170
1988	88	910	345	130	523	234	293	316	155
1989	117	1155	516	259	497	274	370	349	279
1990	85	2046	626	619	886	575	524	480	552
1991	107	2102	591	759	859	610	518	550	531
1992	145	1913	405	724	929	504	551	498	505
1993	212	1750	392	748	822	433	520	573	436
1994	263	1608	313	480	1078	299	554	605	413
1995	277	1178	441	406	608	274	416	454	311
1996	418	1065	324	348	811	225	349	556	353
1997	414	703	291	215	611	223	384	439	71
1998	350	837	228	312	647	194	293	405	295
1999	226	939	262	328	575	301	440	268	156
2000	226	1213	248	328	863	293	469	383	294
2001	264	772	158	302	576	180	407	278	171
2002	279	644	97	533	293	189	255	226	253
2003	371	847	138	797	283	221	339	355	303
2004	328	1145	162	939	372	289	592	393	199
2005	447	1089	218	812	506	278	570	511	177
2006	264	516	93	543	144	143	214	242	181
2007	236	691	238	484	205	201	255	285	186
2008	420	1138	289	1000	269	277	435	488	358
2009	480	1396	308	1316	252	342	548	558	428
2010	314	1332	424	1062	160	208	449	473	516
2011	402	738	196	841	103	119	173	382	466
2012	658	990	329	1195	124	180	267	662	539
2013	493	1103	277	425	894	161	220	676	539
All	8132	31869	8602	16123	15276	7773	11059	12082	9087

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

	Areas		Trip Types			Seasons			
Year	NW FL and AL	SW FL	0.5 day	0.75 day	Full day	Dec-Feb	Mar-May	Jun-Aug	Sep-Nov
1986	24	785	160	106	543	183	172	250	204
1987	35	753	209	41	538	197	248	205	138
1988	22	750	263	84	425	191	216	244	121
1989	25	905	374	175	381	203	271	250	206
1990	20	1187	242	298	667	374	234	301	298
1991	11	1149	170	375	615	298	244	363	255
1992	19	1027	59	335	652	242	239	296	269
1993	84	833	77	308	532	191	181	333	212
1994	76	805	79	206	596	113	242	312	214
1995	90	627	133	249	335	123	236	211	147
1996	130	331	58	83	320	51	101	211	98
1997	119	242	62	41	258	71	113	160	17
1998	87	395	52	83	347	82	83	157	160
1999	61	385	44	107	295	121	159	94	72
2000	55	634	37	76	576	98	207	229	155
2001	148	319	27	122	318	42	183	170	72
2002	153	259	12	221	179	55	100	125	132
2003	245	473	28	487	203	101	175	224	218
2004	240	715	70	618	267	126	351	316	162
2005	370	606	124	489	363	186	348	347	95
2006	160	127	19	153	115	30	76	110	71
2007	122	275	44	204	149	78	91	132	96
2008	151	541	91	395	206	120	191	232	149
2009	160	555	87	458	170	129	188	211	187
2010	146	728	188	583	103	85	189	298	302
2011	218	414	86	465	81	54	83	221	274
2012	297	721	169	748	101	95	164	392	367
2013	174	897	135	208	728	113	159	426	373
All	3442	17438	3099	7718	10063	3752	5244	6820	5064

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

	Areas		Trip Types			Seasons			
Year	NW FL and AL	SW FL	0.5 day	0.75 day	Full day	Dec-Feb	Mar-May	Jun-Aug	Sep-Nov
1986	0.18	0.71	0.44	0.71	0.75	0.64	0.53	0.65	0.82
1987	0.31	0.80	0.64	0.60	0.82	0.75	0.75	0.70	0.81
1988	0.25	0.82	0.76	0.65	0.81	0.82	0.74	0.77	0.78
1989	0.21	0.78	0.72	0.68	0.77	0.74	0.73	0.72	0.74
1990	0.24	0.58	0.39	0.48	0.75	0.65	0.45	0.63	0.54
1991	0.10	0.55	0.29	0.49	0.72	0.49	0.47	0.66	0.48
1992	0.13	0.54	0.15	0.46	0.70	0.48	0.43	0.59	0.53
1993	0.40	0.48	0.20	0.41	0.65	0.44	0.35	0.58	0.49
1994	0.29	0.50	0.25	0.43	0.55	0.38	0.44	0.52	0.52
1995	0.32	0.53	0.30	0.61	0.55	0.45	0.57	0.46	0.47
1996	0.31	0.31	0.18	0.24	0.39	0.23	0.29	0.38	0.28
1997	0.29	0.34	0.21	0.19	0.42	0.32	0.29	0.36	0.24
1998	0.25	0.47	0.23	0.27	0.54	0.42	0.28	0.39	0.54
1999	0.27	0.41	0.17	0.33	0.51	0.40	0.36	0.35	0.46
2000	0.24	0.52	0.15	0.23	0.67	0.33	0.44	0.60	0.53
2001	0.56	0.41	0.17	0.40	0.55	0.23	0.45	0.61	0.42
2002	0.55	0.40	0.12	0.41	0.61	0.29	0.39	0.55	0.52
2003	0.66	0.56	0.20	0.61	0.72	0.46	0.52	0.63	0.72
2004	0.73	0.62	0.43	0.66	0.72	0.44	0.59	0.80	0.81
2005	0.83	0.56	0.57	0.60	0.72	0.67	0.61	0.68	0.54
2006	0.61	0.25	0.20	0.28	0.80	0.21	0.36	0.45	0.39
2007	0.52	0.40	0.18	0.42	0.73	0.39	0.36	0.46	0.52
2008	0.36	0.48	0.31	0.40	0.77	0.43	0.44	0.48	0.42
2009	0.33	0.40	0.28	0.35	0.67	0.38	0.34	0.38	0.44
2010	0.46	0.55	0.44	0.55	0.64	0.41	0.42	0.63	0.59
2011	0.54	0.56	0.44	0.55	0.79	0.45	0.48	0.58	0.59
2012	0.45	0.73	0.51	0.63	0.81	0.53	0.61	0.59	0.68
2013	0.35	0.81	0.49	0.49	0.81	0.70	0.72	0.63	0.69
All	0.42	0.55	0.36	0.48	0.66	0.48	0.47	0.56	0.56