Indices of relative abundance for young-of-the-year and subadult red drum in Florida.

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Florida's Fishery-Independent Monitoring Program

The FWC's Fishery Independent Monitoring (FIM) program uses a stratified, random design to collect information on animal populations. Strata are primarily defined by depth, shore type (overhanging or not), and bottom vegetation (sea grass or not). This program also supplies length, weight, sex and material for the determination of age while monitoring abundance of young-of-the-year (age-0) and larger fishes. Annual Atlantic coast young-of-the-year (red drum smaller than or equal to 40 mm standard length) indices were estimated from collections of red drum made using 21.3-m (3.1mm bar mesh) center-bag seines. Sets used to develop these indices were made from September through March during 1993-2007 in the northern Indian River Lagoon and during 2001-2007 in the St. Johns River/Nassua Sound region. Though data were available since 1990 few or no red drum were captured during these "start-up" years and these were not considered indicative of red drum abundance. Indices for subadult red drum (300 mm SL and larger) were based on year-round collections made using the 183-m (51 mm stretched mesh) seines deployed following the fishery-independent survey design (Fisheries-Independent Monitoring Program Staff 2008). All sets made during 1997-2007 in the northern and southern Indian River Lagoon, and 2001-2007 in the St Johns River/Nassua Sound region were used.

Up to 20 red drum-per-size-class captured during 21.3-m bag seine sampling were measured for standard length (SL) and all were counted within each size class. When more than 20 red drum were encountered then length frequencies of the 20 fish were expanded to the total number caught to estimate the sample catch length frequency. All red drum used in the analysis from the young-of-the-year survey, 12.3-m bag seines, were less than or equal to 40 mm SL and were assumed to be age 0. In the haul seine sets, all captured red drum were measured and if five or fewer red drum were captured all were retained and brought back to the lab where weights and lengths were measured, sex determined and samples taken for age determination. The numbers of red drum sampled for ages comprise a portion of the red drum samples used in the year-specific age-length keys.

During the annual recruitment windows defined above at least one-hundred 21.3-m bag seine sets were made since 1997 on the Atlantic coast (Table 1). Sampling increased in 2001 with expansion to include northeast Florida estuaries. Use of 183-m haul seines began in 1997 and included additional sites in the southern Indian River Lagoon. Changes in sampling intensity with this gear also reflects the expansion of the monitoring program over time to northeast Florida.

Estimated annual length frequencies for red drum caught in the 183-m haul seine showed a wide size range was captured by the gear (Table 2). Most captured red drum were between 14 and 24 inches TL, also with a secondary mode at 5 or 6 inches. During 2004 there was an abundant group of red drum between 4 and 12 inches long. The ages of red drum captured in haul-seine sets was mostly 1 and 2 year-olds on both coasts, with occasional high numbers of age-0 or age-3 fish (Table 3).

Catch rate analyses

The fishery independent datasets used for developing estimates of red drum relative abundance were the complete monitoring program dataset described for 21-m seines (young-of-the-year index) or 183-m seines (subadult indices). For both of these sets, the complete dataset and a subset of these data based on a Stephens and MacCall (2004) subsetting process, were used to develop the relative abundance estimates. Standardized annual catch rates for red drum were estimated using a delta lognormal model (dual Generalized Linear Models, Lo et al. 1992). All factors used in the analyses were simplified categorical effects: bayzone (region within sampled estuary), bottom sediment type (sand, mud), month, shore type (overhanging vegetation, structure, other), bottom vegetation (seagrass, none), salinity (low,<8ppt; medium,8-33ppt; high,>33ppt), and temperature (low,<15degreesC; medium,16-25degreesC; high,>25 degreesC). Only main effects were used in the model. The distribution of back-transformed least-square means estimates for each year was generated through Monte Carlo simulation using the annual least squares means and the estimated asymptotic standard errors. An index of annual abundance was developed for red drum 300 mm SL or larger using the same techniques as used for the recruits. It is possible, using the proportions for age groups in the random subsamples, to partition the subadult index to represent age-1, age-2, or age-3 relative abundance.

The indices generated for young-of-the-year red drum indicate strong year-classes occurred periodically but the strongest of these occurred during the fall/winter of 1998. A string of three consecutive, above average yearclasses occurred during the period 2002-2004 (Table 4, Fig. 1). Weak year-classes have occurred recently; young-of-the-year were at low levels of abundance in 1996 and possibly again in 2005. In general, similar trends were seen for the standardized indices (both full dataset and Stephens and MacCall subsetted) and the observed data. However, the observed data indicated lower relative abundance during 1993-1996 than did the standardized indices. The log-tranformed positive catch data did not fit the expected lognormal distribution very well though it looked like the residuals were reasonable (Appendix A). The final distributions generated for the standardized indices for the full dataset showed low precision, especially prior to 1998 (Table 5, Fig. 2).

Indices generated for subadult red drum show a peak in 1998 and a general increase after 2003. According to the sampled age structure (Table 3) most of the peak in 1998 should be attributed to an abundance of age-1 red drum which should indicate a strong 1996 year class, not seen in the young-of-the-year index. However, the general increase in abundance of subadults after 2003 does seem to correlate well with the elevated young-of-the-year indices during 2002-2004. For subadults, the standardized indices using the Stephens and MacCall subset more closely matched the observed abundance trends than did the standardized full dataset estimates (Fig. 1). Data fitting issues were similar to those for young-of-the-year (Appendix A).

References

Fisheries-Independent Monitoring Program Staff. 2008. Fisheries-independent monitoring program 2007 annual data summary report. Florida Fish and Wildlife Conservation Commission Fish and Wildlife Research Institute, In-House Report 2008-006.

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.

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

Table 1. Number of hauls, number of red drum captured, many were measured for length, and number sampled for sex and age determination each year by the FWC's Fishery-Independent monitoring programs stratified random surveys operating on the Atlantic coast and using 12.3-m bag seines and 183-m haul seines. The 12.3-m bag seine sets and numbers of fish represent those sets made during the recruitment window (September-March; the September year is shown) and counts of only red drum that were 40 mm standard length or shorter (assumed all young-of-the-year). All 183-m haul seine sets made each year were used and all fish captured were measured for lengths and a random subsample was collected for sex and age determination.

Atlantic coast

	12.3-m bag seine			183-m haul seine			
	hauls	No. fish	No./haul	hauls	No. fish	No./haul	Sex,Age
1993	25	1	0.04				
1994	51	8	0.16				
1995	89	25	0.28				
1996	98	4	0.04				
1997	140	48	0.34	364	217	0.60	91
1998	204	668	3.27	434	315	0.73	62
1999	252	244	0.97	420	207	0.49	68
2000	238	357	1.50	420	233	0.55	84
2001	458	356	0.78	531	247	0.47	64
2002	464	731	1.58	589	307	0.52	107
2003	465	1,051	2.26	613	287	0.47	57
2004	518	1,124	2.17	614	315	0.51	72
2005	632	446	0.71	610	356	0.58	145
2006	588	668	1.14	611	417	0.68	123
2007	304	409	1.35	613	348	0.57	153

Table 2. Total lengths (inches) of red drum captured using the 183-m haul seine or purse seine deployed during the Fishery-Independent monitoring program's 1996-2007 stratified random sampling surveys conducted along the Atlantic coast of Florida.

	Year										
TL	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	0	0	0	0	0	0	6	3	0	0	0
2	2	0	1	1	2	0	5	2	3	0	2
3	0	1	0	1	2	0	2	5	4	0	3
4	1	2	0	0	8	2	9	19	15	6	14
5	5	10	9	3	24	5	16	44	37	11	13
6	6	10	6	2	10	2	10	31	11	2	7
7	7	8	1	2	8	2	11	25	13	3	10
8	2	1	3	0	7	1	11	27	8	7	6
9	2	3	4	2	8	6	11	40	16	5	9
10	2	4	7	8	7	8	4	24	17	10	9
11	6	6	7	4	7	14	18	22	33	13	15
12	6	11	13	6	13	11	24	31	30	16	16
13	6	14	13	5	18	41	15	46	46	27	13
14	3	22	22	16	9	31	14	27	39	40	25
15	10	30	16	10	14	46	14	33	40	50	27
16	8	32	18	16	6	28	14	26	37	24	23
17	14	12	17	15	9	25	10	22	28	30	37
18	8	9	5	17	6	10	16	14	28	20	26
19	11	6	13	7	4	5	10	17	27	32	37
20	18	20	12	20	11	12	11	11	32	24	31
21	26	22	13	13	11	14	19	10	24	23	27
22	16	23	15	24	23	8	29	16	15	30	27
23	19	31	12	18	19	17	24	12	15	25	33
24	25	23	10	20	28	22	17	22	12	19	8
25	18	13	11	8	15	14	24	22	4	11	8
26	11	16	5	5	23	10	22	6	1	11	5
27	9	17	8	9	16	16	7	9	9	5	9
28	6	2	6	9	13	15	15	7	2	5	3
29	7	2	5	5	7	7	8	6	4	3	4
30	3	1	2	1	6	3	5	4	3	4	0
31	2	5	1	5	6	3	3	3	1	2	1
32	1	1	2	3	3	5	3	5	1	3	1
33	1	0	1	1	1	2	2	4	2	1	0
34	1	2	0	3	2	3	2	3	3	1	0
35	0	2	0	1	3	1	2	0	0	3	0
36	0	0	0	0	0	0	3	0	2	2	1
37	1	0	1	0	0	0	3	1	3	2	2
38	0	2	1	0	0	3	0	1	0	1	0
39	0	0	0	1	0	0	1	6	1	1	2
40+	0	15	6	4	3	1	4	6	4	4	3
Totals	263	378	266	265	352	393	424	612	570	476	457

Table 3. Randomly sampled age structure from the fishery-independent monitoring's 183-m haul seine catches of red drum made along Florida's Atlantic coasts during 1996-2007. Numbers under each age are the proportions of each year's total sample size, by number, in that age group. Ages used coincided with the calendar year.

	Atlantic								Total
	0	1	2	3	4	5	6	7^+	sample
1997	0.0659	0.2857	0.3626	0.1978	0.0440	0.0330	0.0000	0.0110	91
1998	0.1452	0.6129	0.1613	0.0323	0.0161	0.0000	0.0161	0.0161	62
1999	0.2647	0.4412	0.2059	0.0147	0.0294	0.0294	0.0000	0.0147	68
2000	0.1310	0.6786	0.1310	0.0476	0.0000	0.0000	0.0000	0.0119	84
2001	0.2031	0.4375	0.3125	0.0469	0.0000	0.0000	0.0000	0.0000	64
2002	0.1028	0.6168	0.1869	0.0467	0.0467	0.0000	0.0000	0.0000	107
2003	0.1053	0.3509	0.4035	0.1228	0.0175	0.0000	0.0000	0.0000	57
2004	0.0278	0.5278	0.1806	0.2500	0.0139	0.0000	0.0000	0.0000	72
2005	0.1862	0.6552	0.1379	0.0207	0.0000	0.0000	0.0000	0.0000	145
2006	0.1301	0.5041	0.2764	0.0650	0.0163	0.0081	0.0000	0.0000	123
2007	0.1111	0.4902	0.3007	0.0719	0.0261	0.0000	0.0000	0.0000	153

Table 4. Estimated catch rates for young-of-the-year red drum (less than or equal to 40-mm standard length and captured during September-March, Jan 1 for year) and subadult red drum captured by 12.3-m seines or 183-m seines, respectively, during the FWC fishery Independent Monitoring on the Atlantic coast. The sample sizes (N) are given with the mean of the empirical catch data (Observations) and a delta lognormal standardization of all the data (Delta All) or of a Stephens-and-MacCall-based subset of the data (Delta SM Subset). All annual means are presented as relative to the mean of the annual means to facilitate comparison.

YOY

	Observations		Delta All		Delta SM Subset	
	N	RelMean	N	RelMean	N	RelMean
1993	25	0.036	25	0.218		
1994	51	0.142	51	1.055		
1995	89	0.254	89	0.831		
1996	98	0.037	98	0.203		
1997	140	0.310	140	0.366	7	0.326
1998	204	2.964	204	1.227	18	3.268
1999	252	0.876	252	0.346	28	0.152
2000	238	1.358	238	0.633	37	0.375
2001	458	0.703	458	0.844	35	0.593
2002	464	1.426	464	1.586	30	0.601
2003	465	2.046	465	1.551	75	0.898
2004	518	1.964	518	2.677	99	1.964
2005	632	0.639	632	0.588	73	0.669
2006	588	1.028	588	1.274	86	0.890
2007	304	1.218	304	1.603	38	1.264

Subadults

	Observations		Delta All		Delta SM Subset	
	N	RelMean	N	RelMean	N	RelMean
1997	364	0.916	364	0.916	65	1.063
1998	434	1.029	434	1.029	79	1.294
1999	420	0.912	420	0.912	88	0.879
2000	420	1.088	420	1.088	90	0.989
2001	531	0.824	531	0.824	99	0.829
2002	589	1.022	589	1.022	122	0.929
2003	613	0.887	613	0.887	144	0.835
2004	614	1.032	614	1.032	144	0.914
2005	610	1.116	610	1.116	113	1.040
2006	611	1.009	611	1.009	115	1.217
2007	613	1.165	613	1.165	151	1.012

Table 5. Number of net sets (full dataset) made on the Atlantic coast of Florida using 21-m seines (YOY) during the recruitment-window months or using 183-m seines (Subadult) during the years 1993-2007. Also given is the distribution (median, 2.5-, 25-, 75-, and 97.5- percentiles) of the standardized, full-dataset, catch rate of red drum.

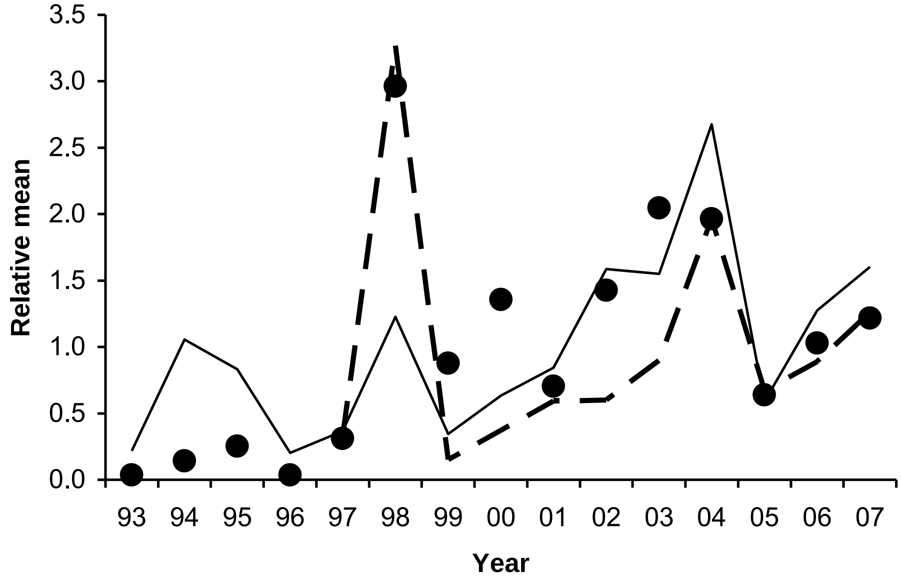
		Total Catch Rate Distribution				
YOY	Sets	2.5th	25th	Median	75th	97.5th
1993	25	0.002	0.009	0.020	0.040	0.161
1994	51	0.007	0.044	0.097	0.218	1.412
1995	89	0.012	0.048	0.076	0.131	0.456
1996	98	0.003	0.010	0.019	0.038	0.144
1997	140	0.008	0.021	0.034	0.054	0.149
1998	204	0.055	0.089	0.113	0.142	0.224
1999	252	0.014	0.025	0.032	0.041	0.067
2000	238	0.030	0.046	0.058	0.072	0.108
2001	458	0.043	0.064	0.078	0.092	0.130
2002	464	0.091	0.124	0.146	0.171	0.230
2003	465	0.086	0.120	0.143	0.170	0.244
2004	518	0.162	0.214	0.246	0.286	0.383
2005	632	0.032	0.046	0.054	0.064	0.092
2006	588	0.072	0.100	0.117	0.138	0.187
2007	304	0.080	0.121	0.147	0.177	0.256

Subadult	Sets	2.5th	25th	Median	75th	97.5th
1997	364	0.178	0.218	0.245	0.274	0.351
1998	434	0.205	0.249	0.276	0.308	0.386
1999	420	0.179	0.220	0.244	0.274	0.329
2000	420	0.211	0.261	0.292	0.323	0.387
2001	531	0.164	0.198	0.221	0.243	0.296
2002	589	0.209	0.249	0.274	0.299	0.348
2003	613	0.183	0.217	0.238	0.263	0.311
2004	614	0.217	0.255	0.276	0.301	0.360
2005	610	0.232	0.271	0.299	0.325	0.384
2006	611	0.209	0.248	0.270	0.298	0.350
2007	613	0.245	0.290	0.312	0.338	0.406

Table 6. Number of net sets (Stephens and MacCall subset) made on the Atlantic coast of Florida using 21-m seines (YOY) during the recruitment-window months or using 183-m seines (Subadult) during the years 1993-2007. Also given is the distribution (median, 2.5-, 25-, 75-, and 97.5- percentiles) of the standardized, full-dataset, catch rate of red drum.

		Total Catch Rate Distribution				
YOY	Sets	2.5th	25th	Median	75th	97.5th
1997	7	0.000	0.009	0.029	0.091	1.503
1998	18	0.053	0.172	0.294	0.506	1.500
1999	28	0.003	0.008	0.014	0.024	0.068
2000	37	0.009	0.022	0.034	0.052	0.117
2001	35	0.015	0.034	0.053	0.083	0.184
2002	30	0.016	0.036	0.054	0.082	0.214
2003	75	0.033	0.060	0.081	0.113	0.212
2004	99	0.082	0.134	0.177	0.235	0.432
2005	73	0.025	0.044	0.060	0.082	0.150
2006	86	0.034	0.060	0.080	0.104	0.186
2007	38	0.036	0.076	0.114	0.165	0.354
Subadult	Sets	2.5th	25th	Median	75th	97.5th
1997	65	0.353	0.546	0.674	0.866	1.387
1998	79	0.549	0.842	1.009	1.252	1.849
1999	88	0.357	0.517	0.624	0.762	1.148
2000	90	0.410	0.581	0.700	0.862	1.236
2001	99	0.337	0.505	0.617	0.738	1.052
2002	122	0.391	0.533	0.627	0.740	1.024
2003	144	0.366	0.501	0.586	0.679	0.906
2004	144	0.428	0.592	0.694	0.819	1.097
2005	113	0.521	0.744	0.886	1.057	1.522
2006	115	0.517	0.732	0.861	1.022	1.427
2007	151	0.519	0.692	0.805	0.932	1.285

Young-of-the-year



Subadults

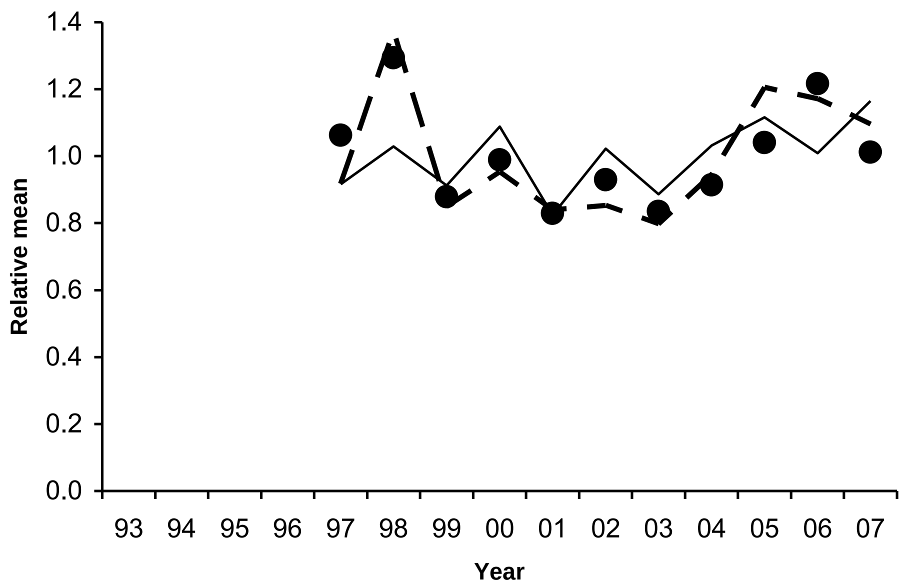
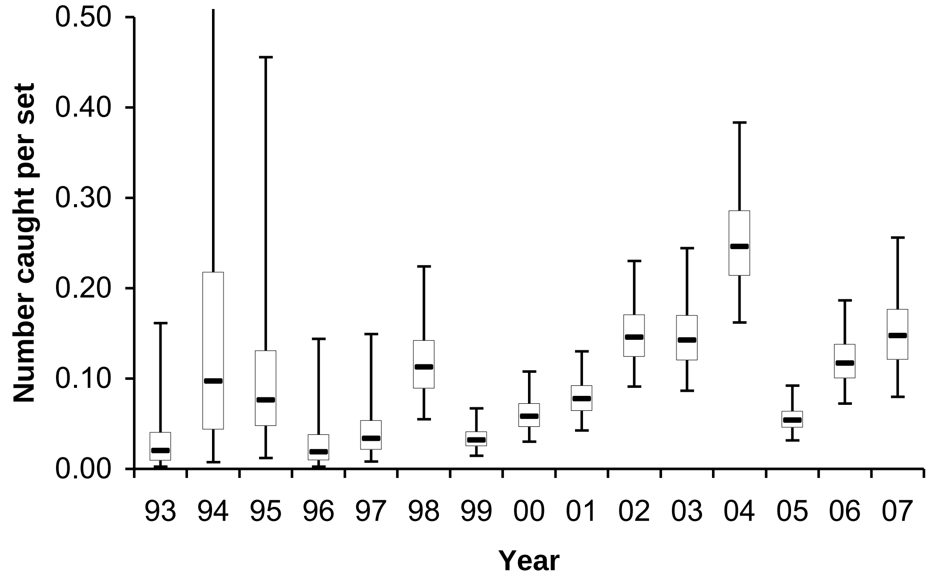


Figure 1. Indices of abundance for young-of-the-year red drum or subadults on the Atlantic coast of Florida. All points are relative to the mean of the annual estimates for the empirical catch data (points), a delta lognormal standardization of all the data (solid line) or of a Stephens-and-MacCall-based subset of the data (dashed line).

Young-of-the-year



Subadults

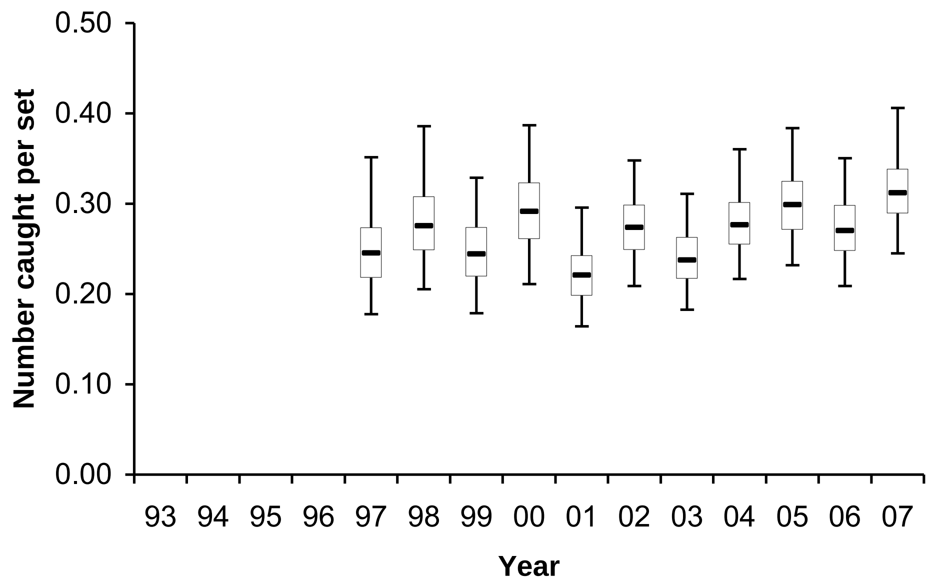


Figure 2. Distribution of a delta lognormal standardization of all the data on the abundance for young-of-the-year red drum or subadults on the Atlantic coast of Florida. The dash shows the median, the box the interquartile range and the whiskers the 95% confidence interval. The young-of-the-year 97.5th point was 1.41 and is not shown to enhance the visible contrast.

Appendix A1. Delta lognormal model selection. Final deviance tables showing sequential selection of explanatory variables to include in the lognormal or binomial model portions of the delta lognormal standardization for the full young-of-the-year dataset.

Positives, young-of-the-year: final model – log(total catch)=B_0+B_1(year)+B_2(bayzone)+B_3(month)

expl_var	Deviance	DF	Dev_ perDF	Pct_dev_ redDF	ChiSq	Prob ChiSq
year (Null)	961.11	550	1.74748	.	19.7	0.14
year bayzone	849.13	555	1.52996	12.45	89.7	<.0001
year sal	948.88	562	1.6884	3.38	26.9	<.0001
year month	951.24	558	1.70473	2.45	25.5	0.0003
year bveg	960.83	563	1.70662	2.34	19.9	<.0001
year shore	971.44	562	1.72854	1.08	13.7	0.0011
year bottom	981.15	563	1.74272	0.27	8.0	0.0046
year temp	990.57	562	1.76258	-0.86	2.6	0.2671
	.	.	.	.	.	.
year bayzone	819.70	541	1.51516	.	19.9	0.1324
year bayzone month	807.54	549	1.47093	2.53	92.5	<.0001
year bayzone bottom	841.12	554	1.51827	-0.18	87.0	<.0001
year bayzone sal	842.60	553	1.52369	-0.49	67.1	<.0001
year bayzone shore	845.60	553	1.52912	-0.80	78.4	<.0001
year bayzone bveg	848.35	554	1.53131	-0.92	70.4	<.0001
year bayzone temp	847.45	553	1.53245	-0.99	88.2	<.0001
	.	.	.	.	.	.
year bayzone month	779.41	535	1.45683	.	20.0	0.129
year bayzone month bottom	799.16	548	1.45831	-0.08	91.5	<.0001
year bayzone month sal	802.41	547	1.46692	-0.58	70.3	<.0001
year bayzone month temp	803.88	547	1.46961	-0.73	88.8	<.0001
year bayzone month bveg	805.56	548	1.47	-0.75	71.8	<.0001
year bayzone month shore	804.20	547	1.47021	-0.77	82.5	<.0001

Zeroes, young-of-the-year: final model – log(total catch)=B_0+B_1(year)+B_2(bayzone)+B_3(month)

expl_var	Deviance	DF	Dev_ perDF	Pct_dev_ redDF	ChiSq	Prob ChiSq
year (Null)	3,329.76	4,511	0.73814	.	77.8	<.0001
year bayzone	2,894.08	4,516	0.64085	13.18	513.5	<.0001
year month	3,242.12	4,519	0.71744	2.80	165.5	<.0001
year shore	3,351.90	4,522	0.74124	-0.42	55.4	<.0001
year temp	3,360.36	4,523	0.74295	-0.65	47.2	<.0001
year sal	3,380.21	4,523	0.74734	-1.25	27.4	<.0001
year bveg	3,381.71	4,523	0.74767	-1.29	25.6	<.0001
year bottom	3,404.20	4,523	0.75264	-1.96	3.1	0.0765
	.	.	.	.	.	.
year bayzone	2,817.97	4,502	0.62594	.	76.1	<.0001
year bayzone month	2,699.60	4,510	0.59858	3.71	542.5	<.0001
year bayzone temp	2,858.16	4,514	0.63318	-0.98	502.2	<.0001
year bayzone sal	2,879.94	4,514	0.638	-1.63	500.3	<.0001
year bayzone shore	2,889.95	4,513	0.64036	-1.95	462.0	<.0001
year bayzone bveg	2,892.88	4,514	0.64087	-2.02	488.8	<.0001
year bayzone bottom	2,893.88	4,514	0.64109	-2.05	510.3	<.0001
	.	.	.	.	.	.
year bayzone month	2,626.01	4,496	0.58408	.	73.6	<.0001
year bayzone month temp	2,690.03	4,508	0.59672	-1.71	514.7	<.0001
year bayzone month sal	2,692.72	4,508	0.59732	-1.79	525.0	<.0001
year bayzone month bveg	2,695.80	4,508	0.598	-1.89	515.5	<.0001
year bayzone month shore	2,697.01	4,507	0.5984	-1.94	484.6	<.0001
year bayzone month bottom	2,699.58	4,508	0.59884	-2.00	539.2	<.0001

Appendix A2. Delta lognormal model selection. Final deviance tables showing sequential selection of explanatory variables to include in the lognormal or binomial model portions of the delta lognormal standardization for the full subadult dataset.

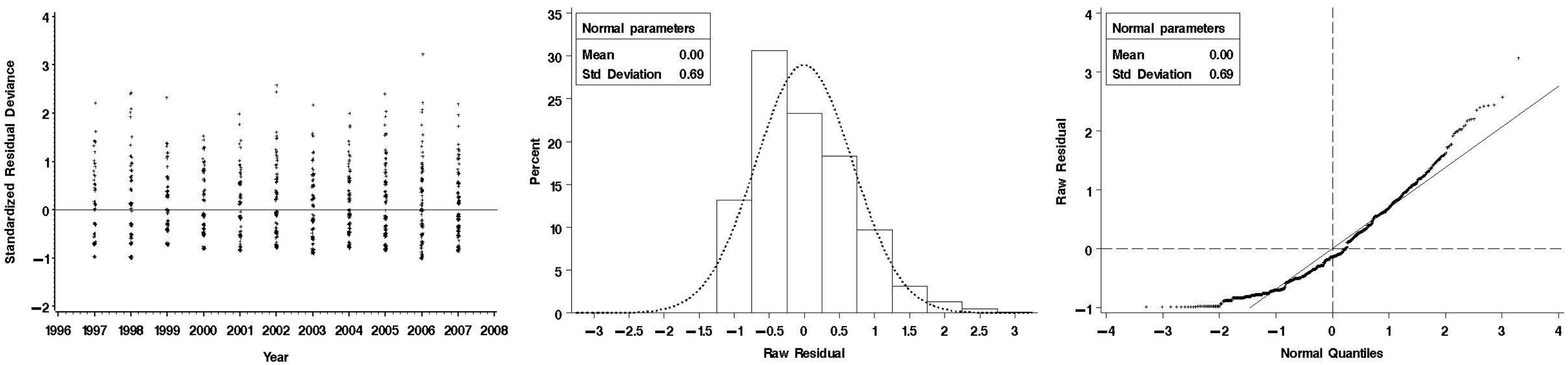
Positives, subadults: final model – log(total catch) = $B_0 + B_1(\text{year}) + B_2(\text{bayzone})$

expl_var	Deviance	DF	Dev_ perDF	Pct_dev_ redDF	ChiSq	Prob ChiSq
year (Null)	648.09	1,231	0.52648	.	20.1	0.028
year bayzone	599.94	1,231	0.48736	7.43	116.0	<.0001
year sal	644.73	1,238	0.52078	1.08	25.8	<.0001
year month	643.71	1,230	0.52334	0.60	28.6	0.0027
year temp	651.52	1,239	0.52584	0.12	13.6	0.0011
year bveg	653.14	1,240	0.52672	-0.05	10.5	0.0012
year shore	656.36	1,239	0.52975	-0.62	4.4	0.111
year bottom	658.00	1,240	0.53064	-0.79	1.3	0.255
	.	.	.	.	.	.
year bayzone	590.33	1,221	0.48348	.	20.1	0.0287
year bayzone month	584.98	1,220	0.47949	0.76	118.8	<.0001
year bayzone temp	595.30	1,229	0.48438	-0.17	112.1	<.0001
year bayzone shore	595.51	1,229	0.48455	-0.20	120.8	<.0001
year bayzone bottom	598.79	1,230	0.48682	-0.63	117.1	<.0001
year bayzone bveg	599.81	1,230	0.48765	-0.79	105.8	<.0001
year bayzone sal	599.17	1,228	0.48792	-0.84	91.0	<.0001

Zeroes, subadults: model – logit(presence/absence) = $B_0 + B_1(\text{year}) + B_2(\text{bayzone})$

expl_var	Deviance	DF	Dev_ perDF	Pct_dev_ redDF	ChiSq	Prob ChiSq
year (Null)	6,015.70	5,808	1.03576	.	18.3	0.0495
year bayzone	4,997.52	5,808	0.86045	16.93	1,036.5	<.0001
year bveg	5,633.98	5,813	0.9692	6.43	398.1	<.0001
year sal	5,945.54	5,799	1.02527	1.01	77.7	<.0001
year month	6,014.26	5,807	1.03569	0.01	19.8	0.0485
year shore	6,025.24	5,812	1.03669	-0.09	6.9	0.0321
year bottom	6,031.94	5,813	1.03766	-0.18	0.2	0.6755
year temp	6,025.89	5,804	1.03823	-0.24	2.4	0.3048
	.	.	.	.	.	.
year bayzone	4,976.17	5,798	0.85826	.	21.4	0.0188
year bayzone bveg	4,962.10	5,803	0.85509	0.31	671.9	<.0001
year bayzone month	4,972.23	5,797	0.85773	0.05	1,042.0	<.0001
year bayzone bottom	4,986.40	5,803	0.85928	-0.10	1,045.5	<.0001
year bayzone shore	4,988.86	5,802	0.85985	-0.15	1,036.4	<.0001
year bayzone sal	4,981.51	5,789	0.86051	-0.22	964.0	<.0001
year bayzone temp	4,992.25	5,794	0.86162	-0.33	1,033.7	<.0001

Positives, subadults



Positives, young-of-the-year

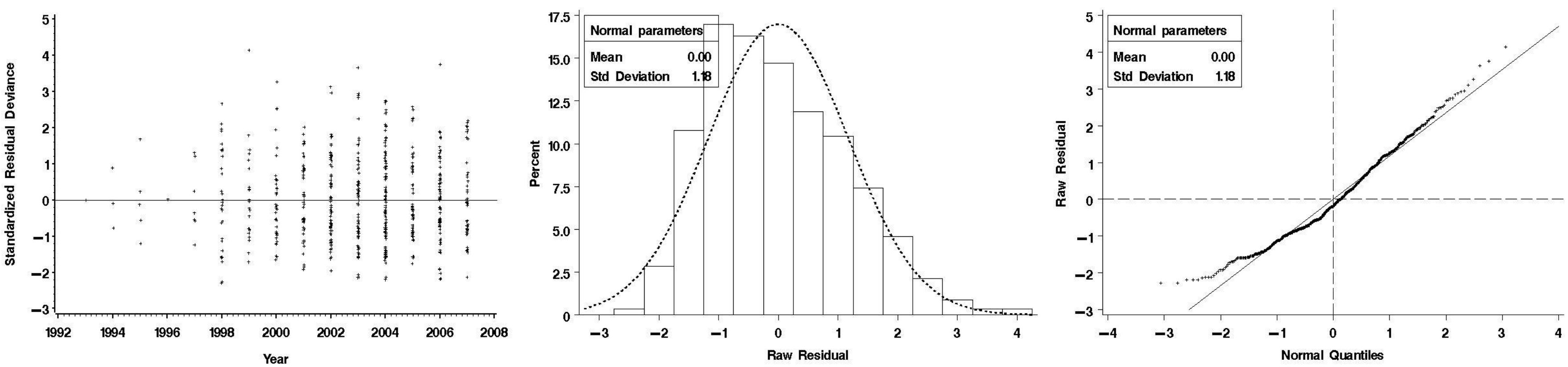
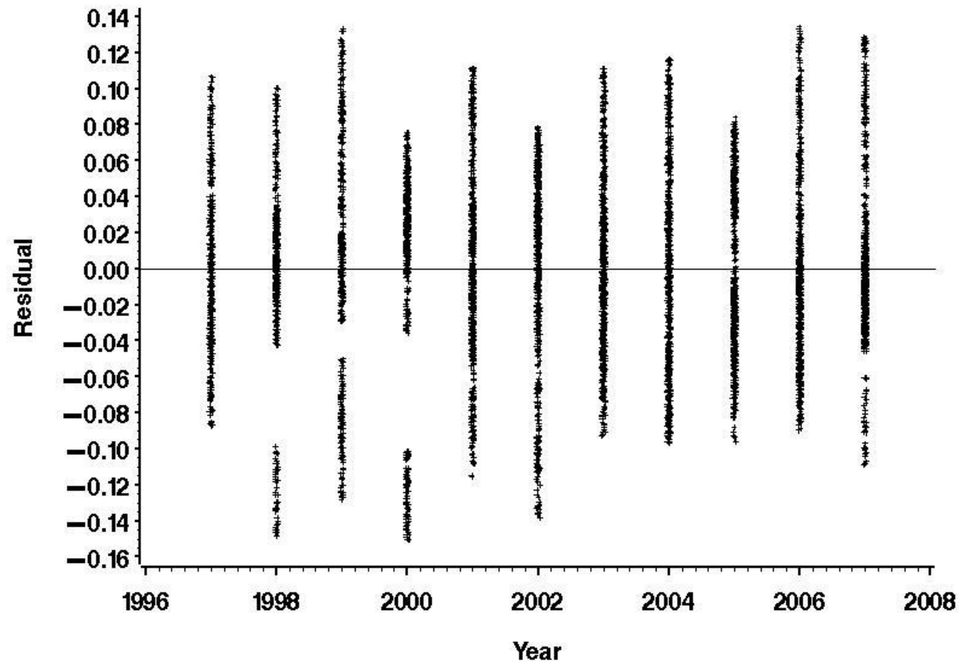


Fig. A1. Diagnostics for fit to final lognormal standardization models for positive catch observations for subadult or young-of-the-year red drum from full fisheries-independent dataset.

Zeroes, subadults



Zeroes, young-of-the-year

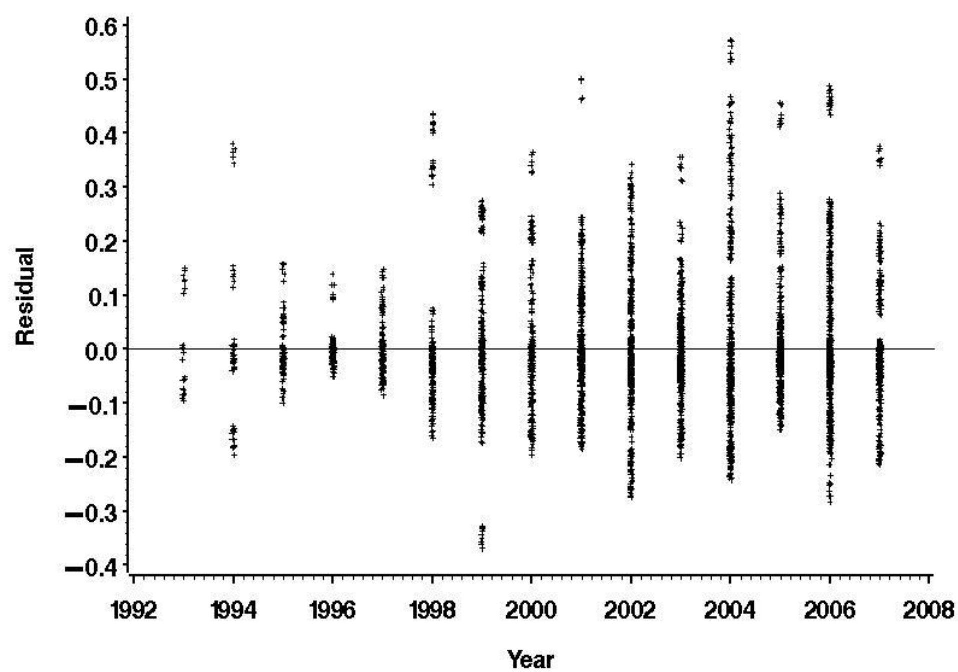


Figure A2. Diagnostics for fit to final binomial standardization models for presence/absence catch observations for subadult or young-of-the-year red drum from full fisheries-independent dataset.

Appendix A3. Delta lognormal model selection. Final deviance tables showing sequential selection of explanatory variables to include in the lognormal or binomial model portions of the delta lognormal standardization for the Stephens and MacCall subset data for of young-of-the-year.

Positives, young-of-the-year:

final model – log(total catch)=B_0+B_1(year)+B_2(bayzone)+B_3(month)+B_4(bottom)+B_5(shore)

expl_var	Deviance	DF	Dev_ perDF	Pct_dev_ redDF	ChiSq	Prob ChiSq
year (Null)	485.66	240	2.02357	.	10.3	0.4131
year bayzone	451.90	242	1.86737	7.72	28.4	0.0004
year month	467.00	244	1.91395	5.42	20.2	0.0026
year bottom	485.77	249	1.95088	3.59	10.3	0.0014
year sal	488.19	248	1.9685	2.72	9.0	0.011
year bveg	496.78	249	1.99509	1.41	4.6	0.0313
year shore	500.45	248	2.01793	0.28	2.8	0.2481
year temp	502.35	248	2.02558	-0.10	1.8	0.3989
year bayzone	435.32	232	1.87636	.	9.4	0.4958
year bayzone month	414.92	236	1.75815	5.84	29.7	0.0002
year bayzone bottom	428.32	241	1.77727	4.90	31.6	0.0001
year bayzone shore	433.91	240	1.80795	3.38	35.8	<.0001
year bayzone sal	446.79	240	1.8616	0.73	22.2	0.0045
year bayzone temp	447.25	240	1.86354	0.63	29.2	0.0003
year bayzone bveg	451.13	241	1.87189	0.22	24.2	0.0021
year bayzone month	398.55	226	1.76347	.	10.1	0.431
year bayzone month bottom	392.40	235	1.66976	4.63	32.0	<.0001
year bayzone month shore	398.83	234	1.70441	2.92	35.8	<.0001
year bayzone month bveg	410.82	235	1.74818	0.76	23.4	0.0029
year bayzone month sal	412.28	234	1.76187	0.08	23.0	0.0034
year bayzone month temp	413.12	234	1.76548	-0.10	30.1	0.0002
year bayzone month bottom	378.55	225	1.68244	.	9.0	0.5306
year bayzone month bottom shore	380.19	233	1.6317	2.51	36.9	<.0001
year bayzone month bottom bveg	387.73	234	1.65697	1.26	28.1	0.0005
year bayzone month bottom sal	390.40	233	1.67553	0.34	24.6	0.0018
year bayzone month bottom temp	391.69	233	1.68107	0.07	31.5	0.0001
year bayzone month bottom shore	364.37	223	1.63394	.	10.7	0.3842
year bayzone month bottom shore bveg	376.18	232	1.62146	0.62	33.0	<.0001
year bayzone month bottom shore sal	378.75	231	1.6396	-0.28	29.5	0.0003
year bayzone month bottom shore temp	379.56	231	1.64313	-0.45	36.5	<.0001

Appendix A3 (con't.). Delta lognormal model selection. Final deviance tables showing sequential selection of explanatory variables to include in the lognormal or binomial model portions of the delta lognormal standardization for the Stephens and MacCall subset data for of young-of-the-year.

Zeroes, young-of-the-year: final model – log(total catch)=B_0+B_1(year)+B_2(bayzone)+B_3(month)

expl_var	Deviance	DF	Dev_ perDF	Pct_dev_ redDF	ChiSq	Prob ChiSq
year (Null)	706.46	515	1.37177	.	21.6	0.0171
year bayzone	658.05	516	1.2753	7.03	70.0	<.0001
year month	696.81	519	1.3426	2.13	31.3	<.0001
year bveg	710.10	524	1.35516	1.21	18.0	<.0001
year sal	712.77	523	1.36286	0.65	15.3	0.0005
year shore	715.53	523	1.36812	0.27	12.6	0.0019
year bottom	722.01	524	1.37789	-0.45	6.1	0.0137
year temp	722.20	523	1.38088	-0.66	5.9	0.0525
year bayzone	631.82	506	1.24865	.	26.2	0.0034
year bayzone month	615.32	510	1.2065	3.07	81.5	<.0001
year bayzone temp	649.18	514	1.263	-1.05	73.0	<.0001
year bayzone sal	652.53	514	1.26952	-1.52	60.2	<.0001
year bayzone bottom	654.64	515	1.27115	-1.64	67.4	<.0001
year bayzone bveg	658.03	515	1.27773	-2.12	52.1	<.0001
year bayzone shore	657.51	514	1.2792	-2.23	58.0	<.0001
year bayzone month	580.66	500	1.16132	.	34.7	0.0001
year bayzone month bottom	611.62	509	1.20161	-2.94	78.4	<.0001
year bayzone month sal	611.86	508	1.20445	-3.14	70.8	<.0001
year bayzone month temp	613.71	508	1.20809	-3.41	79.8	<.0001
year bayzone month shore	613.92	508	1.2085	-3.44	68.4	<.0001
year bayzone month bveg	615.13	509	1.2085	-3.44	60.8	<.0001

Appendix A4. Delta lognormal model selection. Final deviance tables showing sequential selection of explanatory variables to include in the lognormal or binomial model portions of the delta lognormal standardization for Stephen and MacCall subset for subadults.

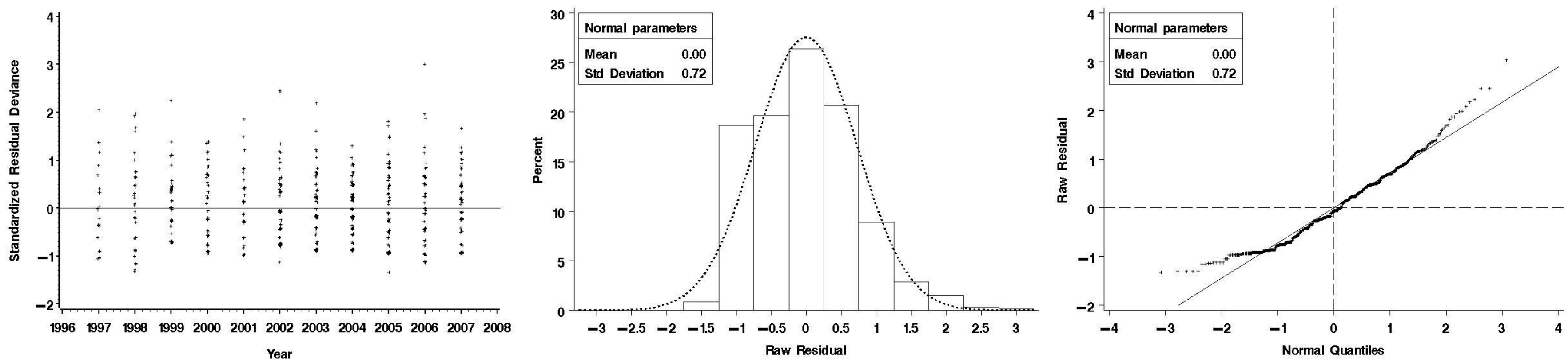
Positives, subadults: final model – log(total catch) = B_0 + B_1(year)+B_2(bayzone)

expl_var	Deviance	DF	Dev_ perDF	Pct_dev_ redDF	ChiSq	Prob ChiSq
year (Null)	335.01	584	0.57364	.	24.8	0.0058
year bayzone	324.74	584	0.55605	3.07	43.3	<.0001
year temp	339.51	592	0.57349	0.03	16.8	0.0002
year month	338.26	583	0.58021	-1.15	19.0	0.0609
year sal	343.71	592	0.58058	-1.21	9.5	0.0086
year shore	347.26	592	0.58658	-2.26	3.4	0.1831
year bottom	348.83	593	0.58824	-2.55	0.7	0.3997
year bveg	348.96	593	0.58846	-2.58	0.5	0.4842
year bayzone	311.88	574	0.54335	.	24.0	0.0075
year bayzone temp	316.08	582	0.54309	0.05	42.6	<.0001
year bayzone month	313.33	573	0.54682	-0.60	45.6	<.0001
year bayzone shore	322.14	582	0.55351	-1.77	44.7	<.0001
year bayzone bottom	324.37	583	0.55638	-2.27	43.3	<.0001
year bayzone sal	324.04	582	0.55677	-2.34	35.1	0.0001
year bayzone bveg	324.69	583	0.55692	-2.37	42.9	<.0001

Zeroes, subadults: model – logit(presence/absence) = B_0 + B_1(year)+B_2(bayzone)

expl_var	Deviance	DF	Dev_ perDF	Pct_dev_ redDF	ChiSq	Prob ChiSq
year (Null)	1,669.25	1,199	1.39221	.	7.8	0.6453
year bayzone	1,514.86	1,199	1.26343	9.25	162.2	<.0001
year bveg	1,635.58	1,206	1.3562	2.59	38.8	<.0001
year sal	1,663.07	1,206	1.37899	0.95	12.7	0.0018
year shore	1,667.75	1,205	1.38402	0.59	6.6	0.0364
year month	1,663.06	1,198	1.3882	0.29	14.0	0.2317
year bottom	1,674.35	1,206	1.38835	0.28	0.0	0.876
year temp	1,676.50	1,207	1.38898	0.23	0.6	0.7449
year bayzone	1,505.84	1,189	1.26648	.	9.0	0.5307
year bayzone bveg	1,503.78	1,196	1.25734	0.66	131.8	<.0001
year bayzone shore	1,505.95	1,195	1.26021	0.45	161.8	<.0001
year bayzone month	1,499.20	1,188	1.26195	0.33	163.9	<.0001
year bayzone bottom	1,509.95	1,196	1.2625	0.29	164.4	<.0001
year bayzone sal	1,510.74	1,196	1.26316	0.24	152.3	<.0001
year bayzone temp	1,514.41	1,197	1.26517	0.09	162.1	<.0001

Positives, subadults



Positives, young-of-the-year

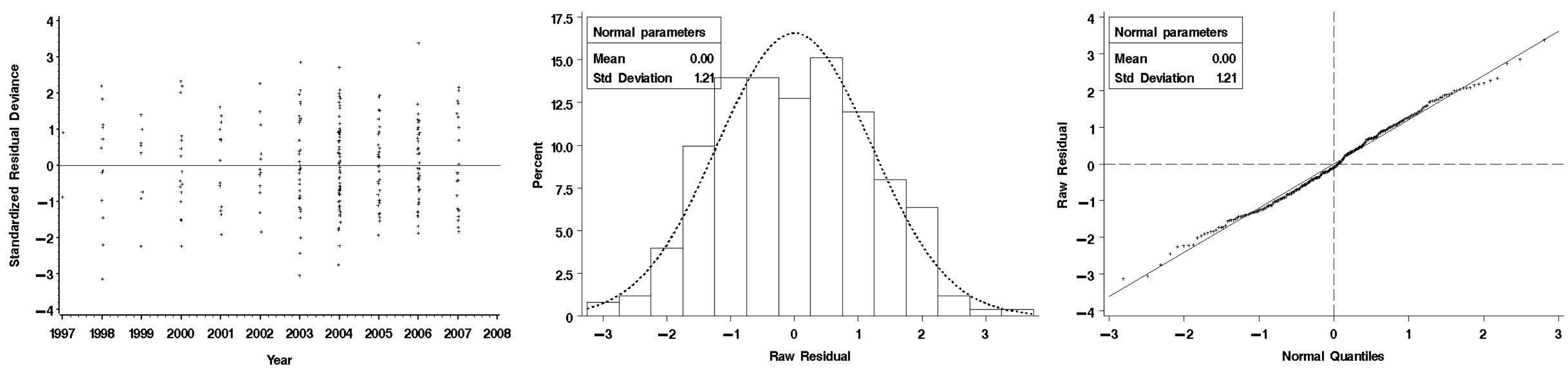
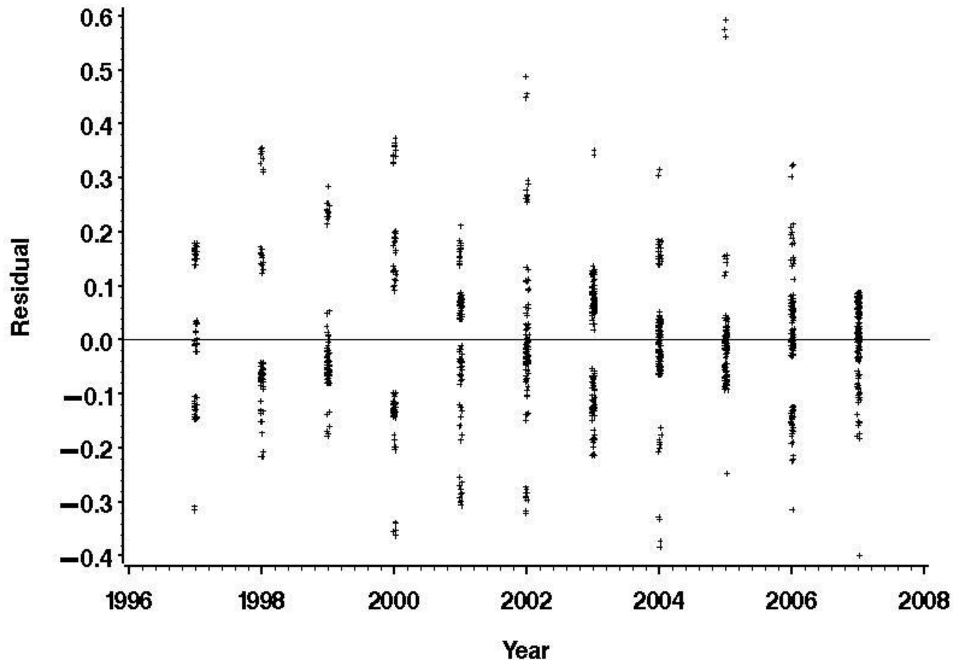


Fig. A3. Diagnostics for fit to final lognormal standardization models for positive catch observations for subadult or young-of-the-year red drum from the Stephens-and-MacCall-subset, fisheries-independent dataset.

Zeroes, subadults



Zeroes, young-of-the-year

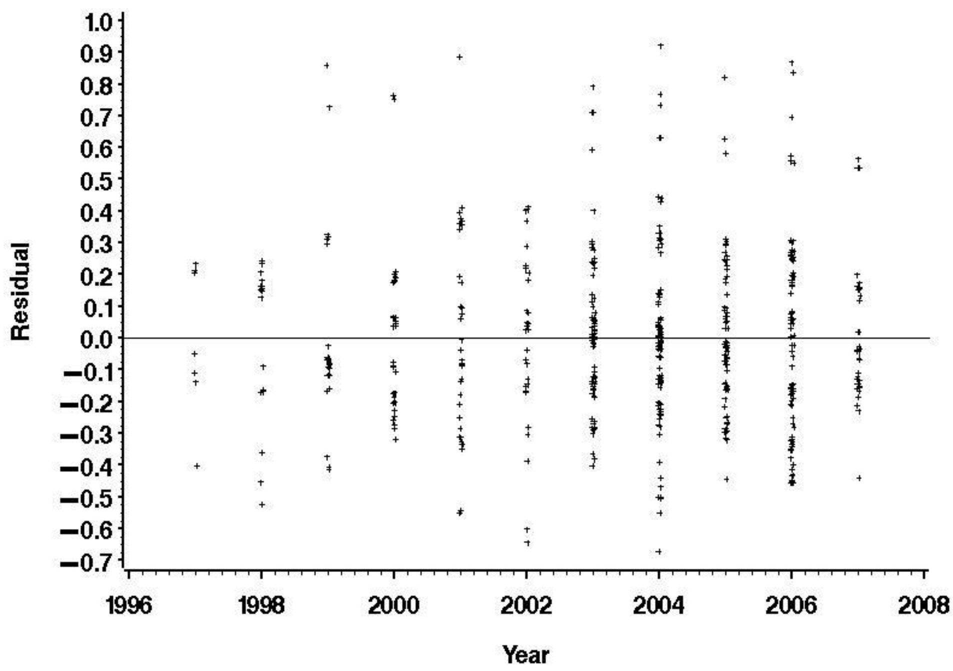


Figure A4. Diagnostics for fit to final binomial standardization models for presence/absence catch observations for subadult or young-of-the-year red drum from the Stephens-and-MacCall-subset, fisheries-independent dataset.