Fishery-independent surveys of juvenile gag grouper in the Gulf of Mexico (1994-2019)

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NOAA Fisheries Service, Southeast Fisheries Science Center, Mississippi Laboratories, Pascagoula, Mississippi

In order to develop abundance indices of age-0 gag grouper in the Gulf of Mexico, three available data bases were combined and subsequently analyzed. In the following sections, each database is briefly outlined along with the survey methodology. Next is presented the statistical approach by which the indices are developed from the combined data. The analyses herein follow those detailed in SEDAR33-AW-06.

1. FSU estuarine gag survey

Gear: 5-m otter trawl towed for 5 minutes at ~2 km/h covering approximately a 150 m transect. Numbers of gag caught are standardized by tow time and estimates of area covered.

Areas covered: St. Andrew Bay, St. Joe Bay, Turkey Point, Big Bend (Keaton Beach, Cedar Key), Crystal River, Anclote Key, Sarasota Bay, Sanibel, primarily in seagrass habitat. The 35 sampling locations in this survey were lumped into 9 sampling regions (Table 1.1 and Figure 1.1) similar to those of Brown et al. (2000).

Index years: 1991-1999, 2003-2009, 2011

Index value based upon: Number of gag per 100-m tow

Noteworthy: Gag is the target species, primarily captured during summer months in the post-settlement juvenile stage. In early years 1991 and 1993, survey efforts were limited to the Turkey Point area, and no sampling was conducted in years 2000, 2001 and 2003. While this is currently one of the longer-term age-0 surveys, the hiatus in sampling during those years resulted in this survey not being recommended during the data workshop for use in the SEDAR 10 assessment (where data was included up to 2005).

Principal contacts: Chris Koenig (koenig@bio.fsu.edu), FSU Marine Lab

Pertinent references: Koenig and Coleman 1998 a & b, Brown et al. 2000.

2. NMFS PC Lab St. Andrew Bay survey

Gear: Weekly sampling, May-November, 16 (50 m) tows taken using 1 m beam trawl ("crab scrape") at 5 fixed locations pre-determined to be settlement areas. Area covered is precisely measured.

Areas covered: St. Andrew Bay, Florida, principally 1-2 meters depth in conjunction with seagrass habitat

Index years: 1998-2014.

Index value based upon: Catch per meter^2

Noteworthy: Gag, grey snapper, and lane snapper are the target species; fish are primarily sampled soon after settlement into seagrass habitats. This survey has not been used previously as an assessment index for gag.

Principal contacts: Stacey Harter, (Stacey.Harter@noaa.gov) NMFS Panama City

Pertinent references: Harter 2008, 2009, NOAA-FWC 2009

3. State of Florida FWC estuarine (FIM) survey

Gear: 183-m haul seine, a component of the Fishery Independent Monitoring Program (FIM); and 183-m haul seine and 6.1 m otter trawl, components of a polyhaline seagrass survey.

Areas covered: Apalachicola Bay, Cedar Key, Tampa Bay, Charlotte Harbor, in estuarine near-shore habitats (~0.5 m depth).

Index years: 1996-2019

Index value based upon: Catch per haul

Noteworthy: While the FIM survey includes several gear types, the 183-m haul seine catches the most gag juveniles, typically later in the year (about ¾ of a year old) and closer to period of movement to deeper water. Similar sized fish are collected in the 183-m haul seine and 6.1 m otter trawl gears of the recently initiated polyhaline seagrass survey. There was a 2008 expansion to St. Andrew Bay, Big Bend and Apalachicola Bay resulting in increased coverage of seagrass habitats likely to hold juvenile gag. There was a programmatic change in 2019, where the haul seine was discontinued, and that effort was converted into additional trawl effort for the polyhaline seagrass survey. The reason for this was to gain more statistical power; and major size differences between gears for gag and other reef fishes were not observed.

Principal contacts: Ted Switzer (Ted.Switzer@MyFWC.com), FWC St. Petersburg

Pertinent references: Casey et al. 2005, Ingram et al. 2005, NOAA-FWC 2009

4. Combined index of abundance

4.1 Methodology

In order to develop standardized indices of annual abundance of juvenile gag from Florida estuaries and coastal waters in the Gulf of Mexico, data from the above described surveys were combined. This was accomplished by first calculating the overall mean catch rate for each data set and scaling the data in each dataset to a mean of one. Due to the presence of two gear-types in the FWRI data, each gear type was considered a separate dataset, resulting in four datasets (FWRI trawl, FWRI seine, PCNMFS trawl and FSU trawl); and a database code was assigned to each dataset in order to model for differences between datasets. Next, sampling locations in each dataset were lumped into the 9 sampling regions as described in Section 1 (Table 1.1 and Figure 1.1). Therefore, while the FSU dataset (Section 1) had nine regions sampled, the NMFS PC Lab St. Andrew Bay survey (Section 2) sampled only that region (i.e. St. Andrew Bay, SAR) and the FWC estuarine (FIM) survey (Section 3) had four regions sampled (i.e. Charlotte Harbor, CHR; Cedar Key, CKR; Mid Big Bend, MBB; and Tampa Bay, TBR).

Two indices were developed using data from 1994 through 2019. This was due to sampling limited only to the Turkey Point Region in 1991 and 1993. While employing each of the two different time series, an index was developed that was weighted by the aerial coverage of seagrass in each sampling region (Figure 1.1), and an index was developed that was not weighted.

The weight for each region was based on the seagrass coverage area in each region, between 0 and 6 feet of water depth. This depth range was said to be that in which the majority of juvenile gag are captured (Chris Koenig, personal communication). The area between 0 and 6 feet water depth was estimated in each region using a NOAA bathy model of medium scale (http://www.ngdc.noaa.gov/mgg/coastal/model.html for more details). The seagrass aerial coverage for each region was estimated using a GIS data set based on a compilation of statewide seagrass data from various source agencies and scales. The GIS seagrass data were mapped from sources ranging in date from 1987 to 2007. Not all data in this compilation are mapped from photography; some are the results of field measurements. Some used the Florida Land Use Cover and Forms Classification System (FLUCCS) codes 9113 for discontinuous seagrass and 9116 for continuous seagrass; some defined only presence and absence of seagrass, and some defined varying degrees of seagrass percent cover. In order to merge all of these data sources into one compilation data set, FWRI reclassified the various source data attribute schemes into two categories: "continuous" and "discontinuous" seagrass. In areas where studies overlap, the most recent study where a given area has been interpreted is represented in this data set. The seagrass data was cross-referenced with the bathymetry data to estimate the seagrass coverage area in each region, between 0 and 6 feet of water depth (Figure 1.1).

A delta-lognormal model, as described by Lo et al. (1992) was employed for each index. The GLMMIX and MIXED procedures in SAS were employed to provide yearly index values for both the binomial and lognormal sub-models, respectively. A backward stepwise selection procedure was employed to develop both sub-models. Type 3 analyses were used to test each parameter for inclusion or exclusion into the sub-model. Both variable inclusion and exclusion significance level was set at an $\alpha = 0.05$. The parameters tested for inclusion in each sub-model were categorical variables of year, database code, region code, and season (spring: months 4-5; early summer: months 6-7; late summer: month 8-9; and fall: months 10-11). The fit of each model was evaluated using the fit statistics provided by the GLMMIX macro.

During the SEDAR 33 data workshop and subsequent webinars, much of the discussion centered on which version of the index should be utilized, weighted or unweighted. It was the recommendation of the Indices Working Group that the unweighted index spanning 1994-2012 would be the most appropriate. This was a deviation from an initial recommendation of using an index weighted by seagrass area. The final decision to use the unweighted index centered on the apparent better model fit when compared to the weighted index from the same time span. Also, when region-specific abundance patterns were examined (Figure 4.1), data from the Marco Island Region had a short time series, limited sampling area, and the location of the region was in the southern end of the juvenile gag range. Therefore, these data were not included in the analyses, following previous recommendations.

For this analysis, both the unweighted and weighted indices for years 1994-2019 were developed, excluding the data from the Marco Island region.

4.2 Unweighted, 1994-2019

Table 4.2.1 summarizes the results of Type 3 analyses for those variables retained in the binomial sub-model. Table 4.2.2 summarizes the results of Type 3 analyses for those variables retained in the lognormal sub-model. Figure 4.2.1 shows the approximate normality of the residual for the lognormal sub-model. Table 4.2.3 and Figure 4.2.2 summarize the unweighted index values for gag in Gulf estuaries of Florida based on all data sets combined from 1994-2019, excluding the data from the Marco Island region.

4.3 Weighted, 1994-2019

Table 4.3.1 summarizes the results of Type 3 analyses for those variables retained in the binomial sub-model. Table 4.3.2 summarizes the results of Type 3 analyses for those variables retained in the lognormal sub-model. Figure 4.3.1 shows the approximate normality of the residual for the lognormal sub-model. Table 4.3.3 and Figure 4.3.2 summarize the weighted index values for gag in Gulf estuaries of Florida based on all data sets combined from 1994-2019, excluding the data from the Marco Island region.

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Brown, C.A., S.L. Cass-Calay, and C.C. Koenig. 2000. Standardized catch rates of young-of-the-year gag, *Mycteroperca microlepis*, from an otter trawl survey of seagrass habitat off the west Florida coast during 1991-1999. Sustainable Fisheries Division Contribution SFD-00/01-130.

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Table 1.1. Sampling location and corresponding region codes for data used in these analyses.

Location	Site_code	Region	Region_code
Cedar Key	CED	Cedar Key region	CKR
Crystal River	CRY	Cedar Key region	CKR
Homasassa	HOM	Cedar Key region	CKR
Suwanee Sound	SUS	Cedar Key region	CKR
Waccasassa	WAC	Cedar Key region	CKR
Captiva Pass	CAP	Charlotte Harbor region	CHR
Fisherman Key	FIK	Charlotte Harbor region	CHR
Jug Creek Shoal	JUG	Charlotte Harbor region	CHR
Punta Rassa	PUN	Charlotte Harbor region	CHR
Redfish Pass	RED	Charlotte Harbor region	CHR
Sanibel	SAN	Charlotte Harbor region	CHR
Smokehouse Bay	SHB	Charlotte Harbor region	CHR
Ussepa Island	USI	Charlotte Harbor region	CHR
Wulford Pass	WUP	Charlotte Harbor region	CHR
Cape Romano	CPR	Marco Island region	MIR
Horseshoe Beach	HSB	Mid Big Bend region	MBB
Keaton Beach	KEB	Mid Big Bend region	MBB
St Marks	SMK	Mid Big Bend region	MBB
Steinhatchee	STE	Mid Big Bend region	MBB
Longboat Pass	LBP	Sarasota Bay region	SBR
New Pass	NWP	Sarasota Bay region	SBR
Sarasota Bay	SAR	Sarasota Bay region	SBR
Crooked Is Sound	CIS	St. Andrew Bay region	SAR
St Andrew Bay	SAB	St. Andrew Bay region	SAR
St Joe Bay	SJB	St. Joe Bay region	SJR
Anclote	ANC	Tampa Bay region	TBR
Aripeka	ARI	Tampa Bay region	TBR
Bunces Pass	BPN	Tampa Bay region	TBR
Egmont Key	EGM	Tampa Bay region	TBR
Mullet Key	MUL	Tampa Bay region	TBR
NE Anna Maria	NAM	Tampa Bay region	TBR
Tampa Bay	TPB	Tampa Bay region	TBR
Dog Is Shoal	DIS	Turkey Pt region	TPR
Lanark	LAN	Turkey Pt region	TPR
Turkey Point	TUP	Turkey Pt region	TPR

Figure 1.1. Nine sampling regions used in this study. The green areas indicate seagrass coverage between 0 and 6 feet of water depth. Seagrass coverage in acres for each region is listed.

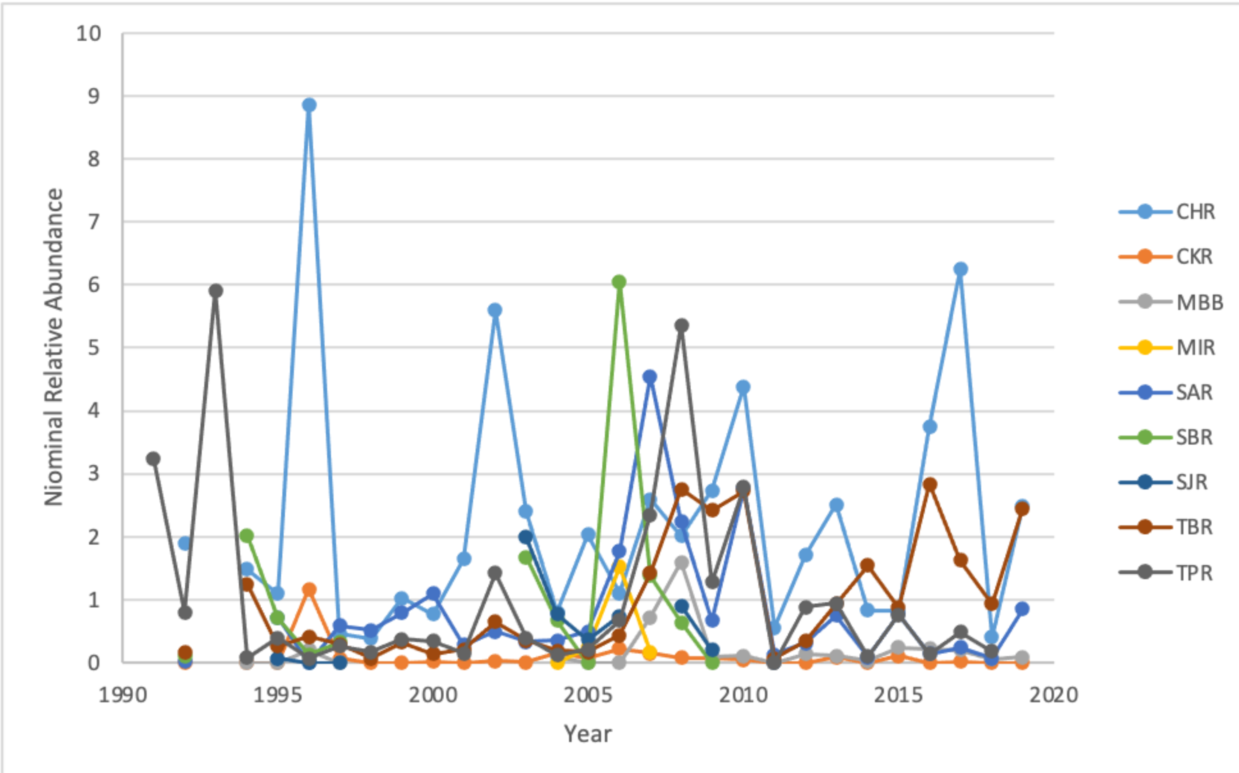

Figure 4.1. Nominal relative abundance per region. Region codes described in Table 1.1.

Table 4.2.1. Type 3 tests of fixed effects for binomial sub-model for the unweighted index from 1994-2019.

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
year	25	33E3	997.88	39.92	<.0001	<.0001
season	3	33E3	442.88	147.63	<.0001	<.0001
region_code	7	33E3	1515.41	216.49	<.0001	<.0001
database_code	3	33E3	686.84	228.95	<.0001	<.0001

Type 3 Tests of Fixed Effects

Table 4.2.2. Type 3 tests of fixed effects for lognormal sub-model for the unweighted index from 1994-2019.

Effect	*Num DF*	*Den DF*	*F Value*	*Pr > F*
year	25	3403	16.80	<.0001
season	3	3403	16.84	<.0001
region_code	7	3403	20.00	<.0001
database_code	3	3403	660.55	<.0001

Type 3 Tests of Fixed Effects

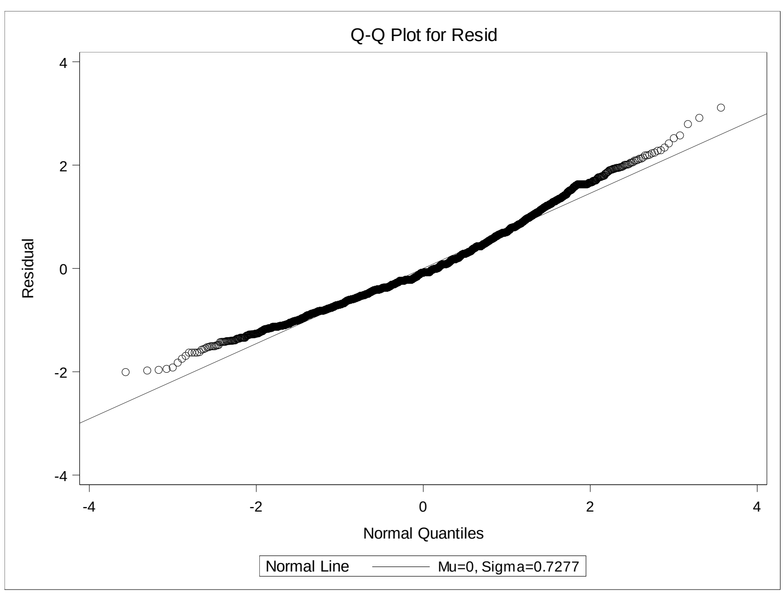

Figure 4.2.1. QQplot of residuals from the lognormal sub-model for the unweighted index based on all data sets combined from 1994-2015.

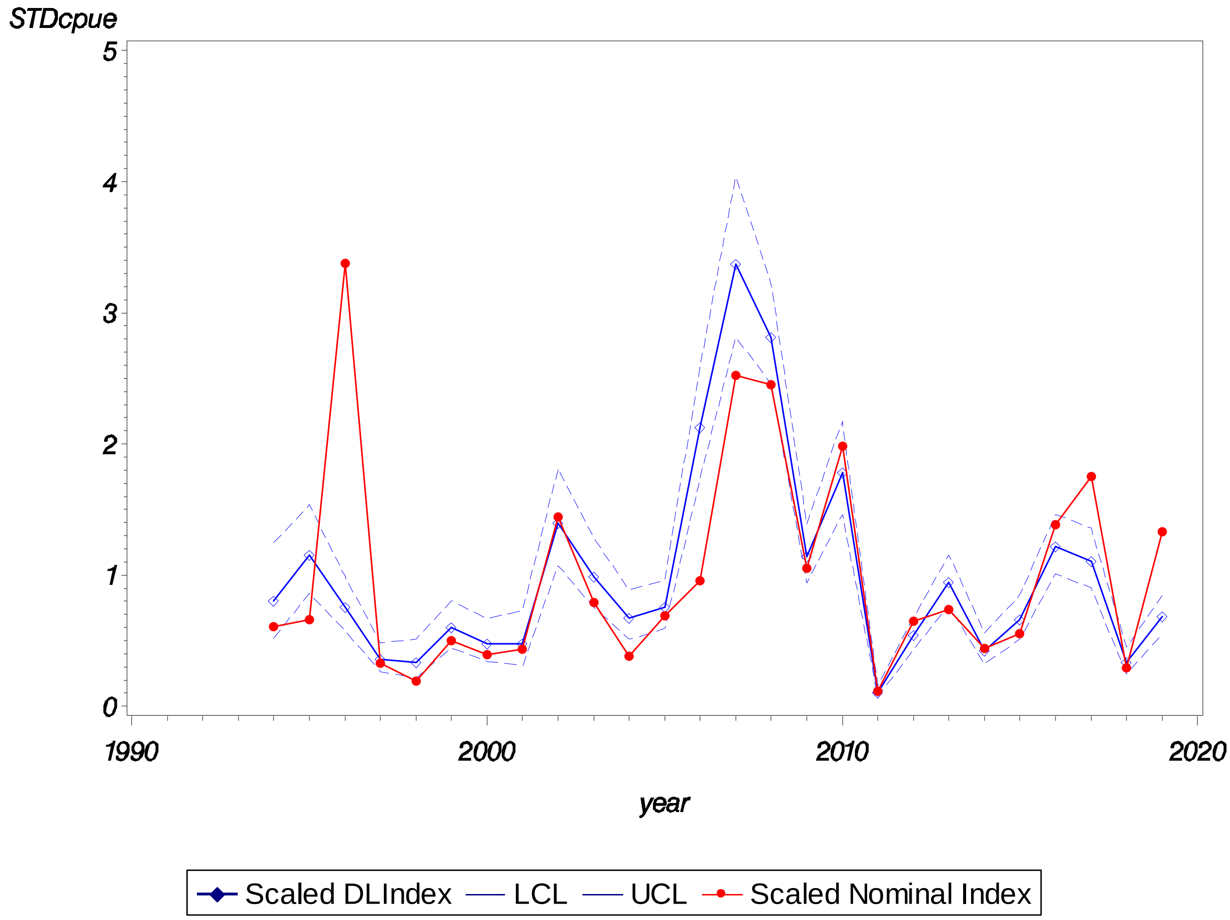

Figure 4.2.2. Unweighted abundance indices developed from all data sets combined from 1994-2015.

Table 4.2.3. Unweighted abundance indices developed from all data sets combined from 1994-2015.

Survey Year	*Nominal Frequency*	*N*	*DL Index*	*Scaled DL Index*	*CV*	*LCL*	*UCL*
1994	0.34921	126	0.48919	0.80458	0.22218	0.51869	1.24804
1995	0.50742	337	0.69913	1.14987	0.14553	0.86080	1.53601
1996	0.18557	679	0.45883	0.75464	0.13615	0.57547	0.98960
1997	0.13803	681	0.21762	0.35793	0.15098	0.26509	0.48327
1998	0.06098	574	0.20181	0.33191	0.21804	0.21569	0.51076
1999	0.11111	729	0.36405	0.59875	0.14842	0.44570	0.80438
2000	0.08067	657	0.29083	0.47832	0.16808	0.34257	0.66788
2001	0.04372	709	0.28953	0.47620	0.21596	0.31070	0.72985
2002	0.09821	896	0.84732	1.39360	0.13169	1.07213	1.81146
2003	0.11982	868	0.59929	0.98565	0.13290	0.75647	1.28428
2004	0.10867	865	0.40836	0.67163	0.13901	0.50929	0.88572
2005	0.12883	977	0.45885	0.75467	0.12176	0.59208	0.96190
2006	0.19565	966	1.29350	2.12742	0.10023	1.74184	2.59835
2007	0.23799	895	2.04810	3.36852	0.09048	2.81199	4.03520
2008	0.20494	2225	1.71040	2.81310	0.06729	2.45925	3.21786
2009	0.08210	2229	0.69495	1.14299	0.09816	0.93968	1.39027
2010	0.10991	1574	1.08457	1.78381	0.09926	1.46334	2.17445
2011	0.01860	2043	0.06390	0.10510	0.19886	0.07089	0.15584
2012	0.08362	1734	0.32790	0.53930	0.11158	0.43173	0.67367
2013	0.07759	2088	0.57299	0.94239	0.10203	0.76885	1.15511
2014	0.04574	1771	0.25761	0.42370	0.13989	0.32073	0.55973
2015	0.05746	1775	0.40026	0.65831	0.12684	0.51133	0.84754
2016	0.12240	1830	0.73975	1.21668	0.09262	1.01134	1.46371
2017	0.08862	2065	0.67231	1.10575	0.10268	0.90095	1.35711
2018	0.03629	1929	0.20282	0.33358	0.15060	0.24724	0.45006
2019	0.09832	1790	0.41443	0.68161	0.10778	0.54978	0.84505

Table 4.3.1. Type 3 based on all data sets combined from 1994-2019.

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
year	25	33E3	1128.32	45.13	<.0001	<.0001
season	3	33E3	207.72	69.24	<.0001	<.0001
region_code	7	33E3	2002.83	286.12	<.0001	<.0001
database_code	3	33E3	823.81	274.60	<.0001	<.0001

Table 4.3.2. Type 3 tests of fixed effects for lognormal sub-model for the weighted index from 1994-2019.

Type 3 Tests of Fixed Effects

Effect	*Num DF*	*Den DF*	*F Value*	*Pr > F*
year	25	3403	14.14	<.0001
season	3	3403	21.74	<.0001
region_code	7	3403	32.52	<.0001
database_code	3	3403	722.48	<.0001

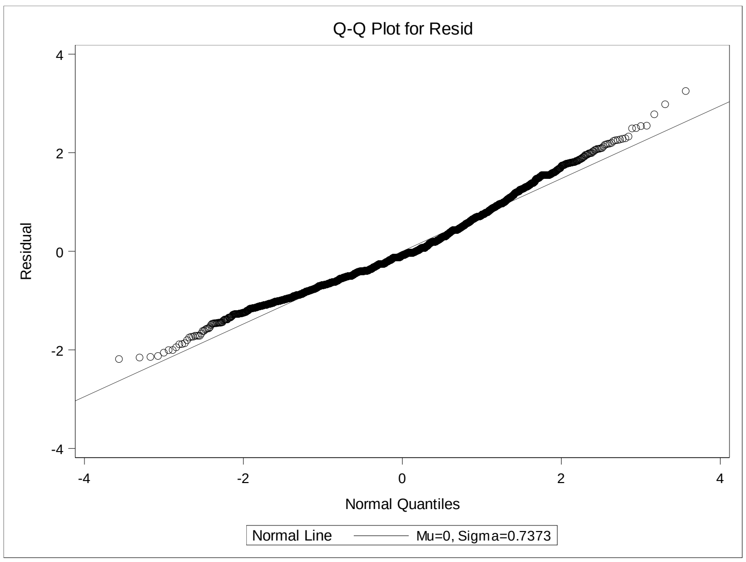

Figure 4.3.1. QQplot of residuals from the lognormal sub-model for the weighted index from 1994-2019.

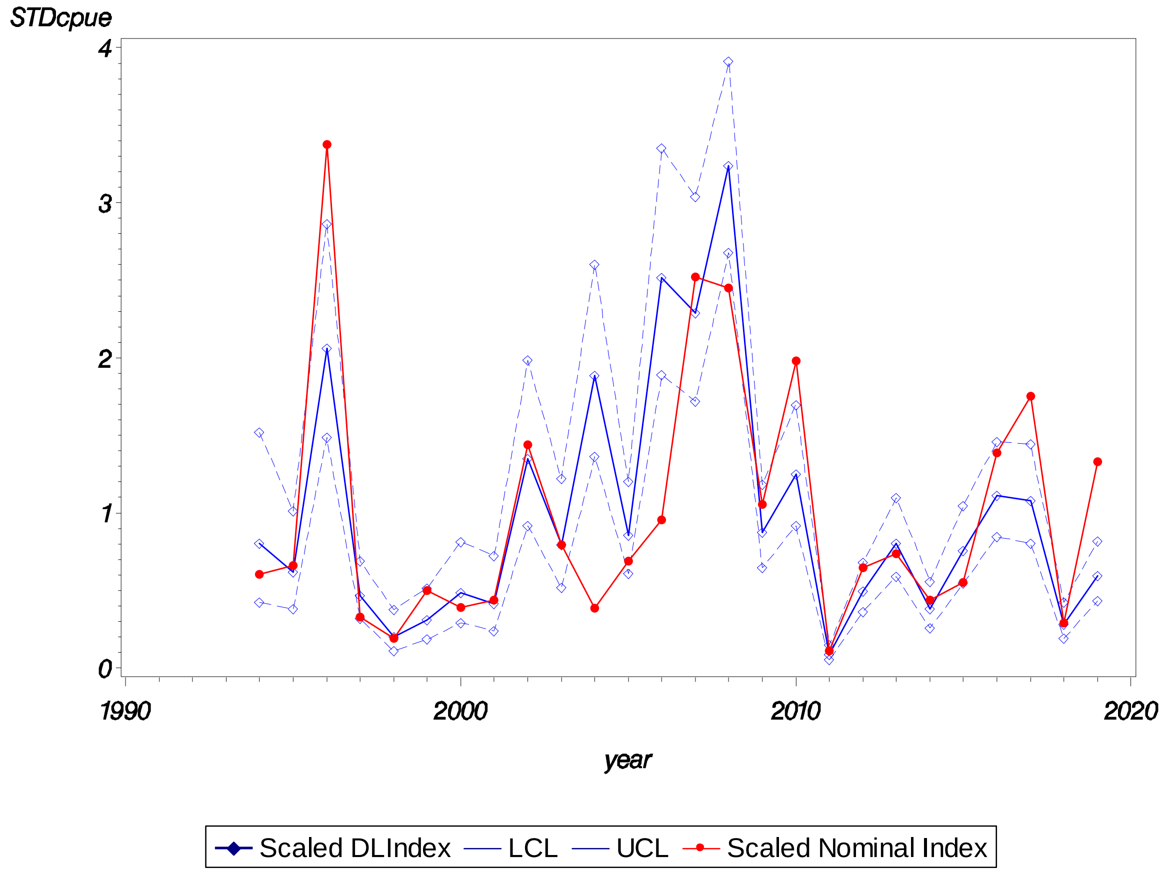

Figure 4.3.2. Weighted abundance indices developed from all data sets combined from 1994-2015.

Table 4.3.3. Weighted abundance indices developed from all data sets combined from 1994-2019.

Survey Year	*Nominal Frequency*	*N*	*DL Index*	*Scaled DL Index*	*CV*	*LCL*	*UCL*
1994	0.34921	126	0.37926	0.80404	0.32683	0.42517	1.52051
1995	0.50742	337	0.29207	0.61919	0.24871	0.37934	1.01068
1996	0.18557	679	0.97294	2.06263	0.16526	1.48541	2.86415
1997	0.13803	681	0.22098	0.46848	0.19473	0.31851	0.68907
1998	0.06098	574	0.09527	0.20196	0.31879	0.10840	0.37627
1999	0.11111	729	0.14557	0.30861	0.26043	0.18488	0.51513
2000	0.08067	657	0.22994	0.48746	0.26079	0.29183	0.81423
2001	0.04372	709	0.19638	0.41632	0.28266	0.23912	0.72484
2002	0.09821	896	0.63678	1.34998	0.19431	0.91856	1.98401
2003	0.11982	868	0.37498	0.79495	0.21664	0.51799	1.22001
2004	0.10867	865	0.88826	1.88311	0.16294	1.36231	2.60301
2005	0.12883	977	0.40272	0.85376	0.17173	0.60709	1.20065
2006	0.19565	966	1.18661	2.51562	0.14408	1.88859	3.35083
2007	0.23799	895	1.07869	2.28683	0.14300	1.72049	3.03959
2008	0.20494	2225	1.52652	3.23623	0.09478	2.67855	3.91001
2009	0.08210	2229	0.41166	0.87272	0.15215	0.64487	1.18106
2010	0.10991	1574	0.58863	1.24790	0.15477	0.91737	1.69752
2011	0.01860	2043	0.04163	0.08825	0.25601	0.05332	0.14607
2012	0.08362	1734	0.23369	0.49543	0.15935	0.36094	0.68002
2013	0.07759	2088	0.37975	0.80506	0.15609	0.59030	1.09797
2014	0.04574	1771	0.17874	0.37893	0.19497	0.25750	0.55761
2015	0.05746	1775	0.35638	0.75552	0.16321	0.54629	1.04490
2016	0.12240	1830	0.52412	1.11113	0.13728	0.84544	1.46032
2017	0.08862	2065	0.50830	1.07760	0.14739	0.80374	1.44475
2018	0.03629	1929	0.13343	0.28286	0.20298	0.18925	0.42277
2019	0.09832	1790	0.28087	0.59544	0.15935	0.43380	0.81729