Standardized Catch Rate Indices for Gulf of Mexico Vermilion Snapper (*Rhomboplites aurorubens*) Commercial Handline Fishery, 1993-2014

Mathew W. Smith and Daniel R. Goethel

SEDAR45-WP-04

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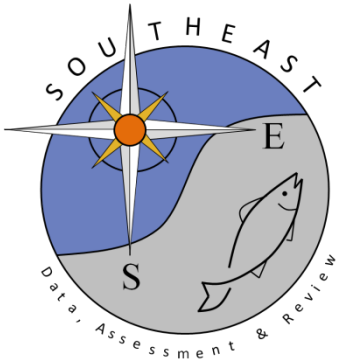

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Mathew W. Smith and Daniel R. Goethel, NMFS, SEFSC, Miami Laboratory

Data:

- National Marine Fisheries Service (NMFS) Gulf of Mexico (GoM) reef fish logbook data set (1993 – 2014)
- Data subsetting (trips excluded):
    - Used any gear other than handline or electric reel
    - Multiple areas fished
    - Appearance of misreporting (e.g., zero hours fished)
    - Duplicate entry of a single trip
    - Incomplete in any way
    - Contained missing values for any of the independent variables
    - Trip occurred in an area where vermilion snapper are unlikely to be found (i.e., trip flagged using Stephens and MacCall, 2004 methodology).
- Prior to index standardization factors (other than year) were grouped into deterministic variables with a pre-determined number of discrete levels (Table 1).
- Effort was calculated as the number of hours a line soaked multiplied by the number of lines set per trip (line-hours).
- CPUE was calculated as the pounds of fish caught divided by effort expended.

Analysis:

- Separate indices of abundance were estimated from data collected in the eastern GoM (Statistical areas 1 – 12) and western GoM (Statistical areas 13 – 21)
- Indices for the eastern and western GoM were estimated with and without the presence of the variable *Red Snapper IFQ*, which recorded the amount of remaining red snapper individual fishing quota (IFQ) available to a given vessel during a given trip.
- Variable *Year* was forced to be in all models regardless of deviance reduction
- For models where *Red Snapper IFQ* was investigated, it was also included regardless of deviance reduction.
- Variables other than *Year* and *Red Snapper IFQ* were included in the model based on the results of a forward stepwise regression analysis (i.e., deviance reduction analysis). During each step, a separate GLM was fit using the model from the previous step [e.g., log(CPUE) ~ *Year*] and one of the remaining candidate variables (e.g., *Crew Number*, *Area Fished, Days Away*). The model that resulted in the greatest reduction in deviance was then used as the base model for the next step [e.g., log(CPUE) ~ *Year* + *Days Away*]. This process was repeated until none of the updated models resulted in a reduction of residual deviance greater than or equal to 1%.
- Two-way interaction terms were then investigated among each of the significant factors using the same stepwise approach.
- Variable selection was conducted separately for the proportion of positive trips and the log(CPUE) models.
- A two-step delta-lognormal generalized linear model (GLM; Lo et al., 1992) was used to standardize the indices.
- All variables and interactions were modeled as fixed effects in the final mixed effects models except for interactions involving year, which were modeled as random effects.

Results: Species Associates

- **Western GoM**
  - 12,608 of 36,052 possible trips (35%) were retained by the Stephens and MacCall (SM; Figure 1) procedure.
  - The probability threshold for inclusion of a trip was equal to 0.38 (Figure 1A).
  - Prior to SM the proportion of trips catching vermilion snapper equaled 35% and after it increased to 62%.
  - Species used in trip selection and their respective correlations are shown in Table 2 Panel A.

- **Eastern GoM**
  - 30,845 of 126,454 possible trips (24%) were retained by the Stephens and MacCall (SM; Figure 2) procedure.
  - The probability threshold for inclusion of a trip was equal to 0.31 (Figure 1B).
  - Prior to SM the proportion of trips catching vermilion snapper equaled 24% and after it increased to 72%.
  - Species used in trip selection and their respective correlations are shown in Table 2 Panel B.

Results: Standardized Indices (No red snapper IFQ variable)

- **Western GoM**
  - The binomial model significant variables were: *year, area, days away, crew size*, and *line hours*.
  - The binomial model significant interactions were: *year*area* and *year*line hours*.
  - The log(CPUE) model significant variables were : *year, red snapper season*, and *area*.
  - The log(CPUE) model significant interactions were: None.
  - The standardized index indicates a major increase in abundance beginning in 2007 followed by a period of moderate declines from 2008 to 2013 and another large increase in 2014 (Figure 2A).
  - The 2007 increase in commercial handline west CPUE coincides with implementation of the red snapper IFQ.
  - Index trends are similar to the western GoM index produced for the 2011 update assessment (Figure 4A).

- **Eastern GoM**
  - The binomial model significant variables were: *year, area*, and *line hours*.
  - The binomial model significant interactions were: *year*area* and *area*line hours*.
  - The log(CPUE) model significant variables were: *year, days away, crew size, red snapper season, red snapper permit*, and *season*.
  - The log(CPUE) model significant interactions were: None.
  - The standardized index indicates a major increase in abundance beginning in 2007, but, unlike the western GoM index, the eastern GoM index indicates that vermilion snapper abundance has declined in the most recent years of the time series (Figure 2B).
  - The 2007 increase in commercial handline East CPUE coincides with implementation of the red snapper IFQ.
  - Index trends are similar to the eastern GoM index produced for the 2011 update assessment (Figure 4B).

Results: Standardized Indices (red snapper IFQ variable included)

- **Western GoM**
  - The binomial model significant variables were: *year, area, days away, crew size*, and *line hours*.
  - The binomial model significant interactions were: *year*area* and *year*line hours*.
  - The log(CPUE) model significant variables were: *year* and *days away*
  - Red snapper IFQ variable, while not significant, was forced to be in the model.
  - The log(CPUE) model significant interactions were: None.
  - The standardized index doubles from 2006 to 2007, but remains relatively constant at the elevated level from 2009 to 2014, and the trend does not match that of the model where the red snapper IFQ variable is excluded (Figure 3A).
  - Index trends differ substantially from the western GoM index produced for the 2011 update assessment (Figure 4A). Abundance is estimated to have been higher prior to 2007 and lower after 2007.

- **Eastern GoM**
  - The binomial model significant variables were: *year, area*, and *line hours*.
  - The binomial model significant interactions were: *year*area* and *area*line hours*.
  - The log(CPUE) model significant variables were: *year, days away, crew size, season*, and *red snapper IFQ*.
  - The log(CPUE) model significant interactions were: None.
  - The standardized index including the IFQ variable indicated a similar increasing trend in abundance in 2007 to the index that did not include the red snapper IFQ variable, but with a slightly lower magnitude (Figure 3B).
  - Index trends differ subtly from the eastern GoM index produced for the 2011 update assessment (Figure 4B). Abundance is estimated to have been higher prior to 2007 and lower after 2007.

DISCUSSION:

A substantial increase in nominal CPUE occurred in 2007 for both the eastern and western Gulf of Mexico commercial handline index. The timing of the increase in the nominal index coincided with the implementation of the Gulf of Mexico red snapper IFQ program, which is thought to have influenced the way in which vermilion snapper were harvested by the commercial fishery. It is believed that a trip will primarily target red snapper when the vessel retains large amounts of red snapper IFQ. However, when little or no remaining red snapper IFQ is available to a vessel the trip will target other substitution species (e.g., vermilion snapper) in order to maximize landings for the trip. We hypothesized that the levels of red snapper IFQ would be negatively correlated with vermillion snapper CPUE (i.e., as red snapper IFQ increased the CPUE of vermilion snapper would decrease and vice-versa). Estimated parameter values for the red snapper IFQ parameter in the eastern GoM were generally negatively correlated with CPUE as expected (Table 5). The pattern in the western GoM was less well defined, but the CPUE of vermilion snapper was lower when quota was high (>5000 lbs.) and higher when quota was low (< 5000 lbs.).

Because commercial handline CPUE data begins in 1993, the red snapper IFQ system was not implemented for a majority of the available timeseries. Consequently, all trips prior to 2007 were recorded as having 0 lbs. of available red snapper quota. This likely resulted in an underestimation of the 0 level parameter for the red snapper IFQ variable. The magnitude of this bias is unknown.

Despite the changes to the standardized indices (particularly in the western GoM), the inclusion of the red snapper IFQ variable did not greatly improve model fit (measured in reduction in residual deviance). Using the deviance based selection criteria described above the red snapper IFQ variable was selected in the east and not in the west, but was forced to be included in the western

model. Development of a split index (before and after 2007) would help eliminate some of the issues related to standardizing the commercial CPUE index for red snapper IFQ and may warrant further exploration. However, implementation of the IFQ variable in the CPUE standardization process is a research topic still being investigated at the SEFSC. Given that no standard practices have been agreed upon for its use (i.e., whether its inclusion should be forced or only included if the deviance criterion deems it significant) and that potential biases created by including it before the IFQ system was implemented (i.e., before 2007) have not been explored, it may not be appropriate to use the IFQ variable for index standardizations at this time. Furthermore, since inclusion of the IFQ variable reduced the estimates of abundance in the later part of the timeseries (Figure 4), using the index incorporating IFQ will reduce model estimates of spawning stock biomass after 2007. The magnitude of this effect and the resulting implications for stock status and management are unknown. One alternative would be to split the survey in 2007, but to only use the historical timeseries (i.e., 1993-2006) for assessment purposes until methodology for addressing the red snapper IFQ variable have been thoroughly tested.

LITERATURE CITED

Lo, N.C., Jacobson, L.D., and 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.

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

TABLES

Table 1: Levels and values for the variables investigated for inclusion in the index standardization model.

Eastern Gulf of Mexico

Factor	Levels	Values
Year	22	1993 - 2014
Season	4	Jan-Mar, Apr-Jun, Jul-Sep, Oct-Dec
Area	6	6, 7, 8, 9, 10, 11
Red Snapper Season	2	Closed, Open
Red Snapper Permit	2	Yes, No
Days away from port	6	1, 2, 3, 4, 5, 6+
Crew Size	4	1, 2, 3, 4+
Line Hours	5	<100, 100-350, 350-1000, 1000-3000, 3000+
Red Snapper IFQ	6	0; 1 – 500; 501 – 1,000; 1,001 – 5,000; 5,001 – 50,000; > 50,000

Western Gulf of Mexico

Factor	Levels	Values
Year	22	1993 - 2014
Season	4	Jan-Mar, Apr-Jun, Jul-Sep, Oct-Dec
Area	3	16, 17, 21
Red Snapper Season	2	Closed, Open
Red Snapper Permit	2	Yes, No
Days away from port	6	1, 2, 3, 4, 5, 6+
Crew Size	4	2, 3, 4, 5+
Line Hours	5	<500, 500-1000, 1000-2000, 2000-4000, 4000+
Red Snapper IFQ	6	0; 1 – 500; 501 – 1,000; 1,001 – 5,000; 5,001 – 50,000; > 50,000

Table 2: Coefficients of correlation used by the Stephens and MacCall (2004) species associates subsetting routine. Species with positive correlation coefficients tended to associate with vermilion snapper, while those with negative correlation coefficients did not. Panel A displays the results for the western Gulf of Mexico and Panel B displays the results from the eastern Gulf of Mexico.

A:

Species	Correlation Coefficient
Snapper, Lane	1.37
Grouper, Black	0.84
Scamp	0.78
Porgy, Red	0.73
Grouper, Warsaw	0.64
Cobia	0.62
Snapper, Red	0.56
Blue Runner	0.51
Jack, Almaco	0.49
Grouper, Gag	0.46
Amberjack, Greater	0.30
Snapper, Mangrove	-0.02
Sea Trout, White	-0.23
Grouper, Yellowedge	-0.48
Mackerel, King	-0.75

B:

Species	Correlation Coefficient
Porgy, Red	2.67
Porgy, Whitebone	2.37
Jack, Almaco	1.95
Scamp	1.32
Snapper, Red	1.02
Snapper, Lane	0.98
Amberjack, Greater	0.87
Cobia	0.12
Mackerel, King	-0.04
Snapper, Mangrove	-0.04
Grouper, Black	-0.05
Grunts	-0.17
Grouper, Gag	-0.25
Grouper, Red	-0.71
Snapper, Mutton	-1.49
Snapper, Yellowtail	-2.16

Table 3: Nominal CPUE and standardized index values (scaled to the timeseries mean) for the commercial handline fishery in the western Gulf of Mexico. The No IFQ and IFQ columns identify the standardized indices and CV's generated by excluding (No IFQ) or including (IFQ) the red snapper IFQ variable.

Western Gulf of Mexico

		Index		CV	
Year	**Nominal**	**No IFQ**	**IFQ**	**No IFQ**	**IFQ**
1993	0.90	0.73	1.06	0.12	0.23
1994	1.70	1.01	1.51	0.11	0.21
1995	0.64	0.64	0.82	0.11	0.21
1996	0.92	0.71	1.03	0.09	0.20
1997	1.11	0.91	1.33	0.06	0.19
1998	1.04	0.73	1.11	0.07	0.19
1999	0.80	0.73	0.99	0.06	0.19
2000	0.67	0.50	0.65	0.07	0.19
2001	0.70	0.53	0.66	0.07	0.20
2002	1.00	0.68	0.83	0.06	0.19
2003	0.91	0.87	1.09	0.06	0.19
2004	0.92	0.86	0.97	0.06	0.19
2005	0.67	0.53	0.61	0.07	0.19
2006	0.63	0.27	0.46	0.08	0.20
2007	1.27	1.35	1.02	0.11	0.16
2008	1.44	2.20	1.48	0.11	0.16
2009	1.33	1.46	0.95	0.13	0.17
2010	1.23	1.43	1.14	0.13	0.18
2011	1.01	1.03	1.07	0.14	0.19
2012	1.06	1.19	1.11	0.12	0.16
2013	0.81	1.18	0.80	0.11	0.15
2014	1.26	2.45	1.30	0.10	0.13

Table 4: Nominal CPUE and standardized index values (scaled to the timeseries mean) for the commercial handline fishery in the eastern Gulf of Mexico. The No IFQ and IFQ columns identify the standardized indices and CV's generated by excluding (No IFQ) or including (IFQ) the red snapper IFQ variable.

Eastern Gulf of Mexico

		Index		CV	
Year	Nominal	No IFQ	IFQ	No IFQ	IFQ
1993	0.83	0.77	0.97	0.07	0.08
1994	1.60	0.94	1.23	0.06	0.07
1995	0.77	0.66	0.87	0.07	0.08
1996	0.81	0.70	0.89	0.06	0.07
1997	0.70	0.64	0.79	0.07	0.08
1998	0.75	0.63	0.76	0.07	0.08
1999	1.41	0.68	0.81	0.06	0.07
2000	0.59	0.58	0.64	0.07	0.08
2001	0.73	0.64	0.70	0.07	0.08
2002	0.79	0.69	0.77	0.06	0.08
2003	0.90	0.74	0.81	0.06	0.07
2004	0.81	0.72	0.75	0.07	0.08
2005	0.96	0.93	0.90	0.06	0.07
2006	1.05	0.94	0.98	0.07	0.08
2007	1.64	1.30	1.13	0.08	0.08
2008	1.23	1.70	1.40	0.07	0.07
2009	1.60	2.05	1.70	0.06	0.06
2010	1.08	1.44	1.28	0.07	0.07
2011	1.47	2.00	1.72	0.06	0.06
2012	0.78	1.18	1.03	0.06	0.06
2013	0.73	0.99	0.92	0.07	0.07
2014	0.77	1.07	0.96	0.07	0.06

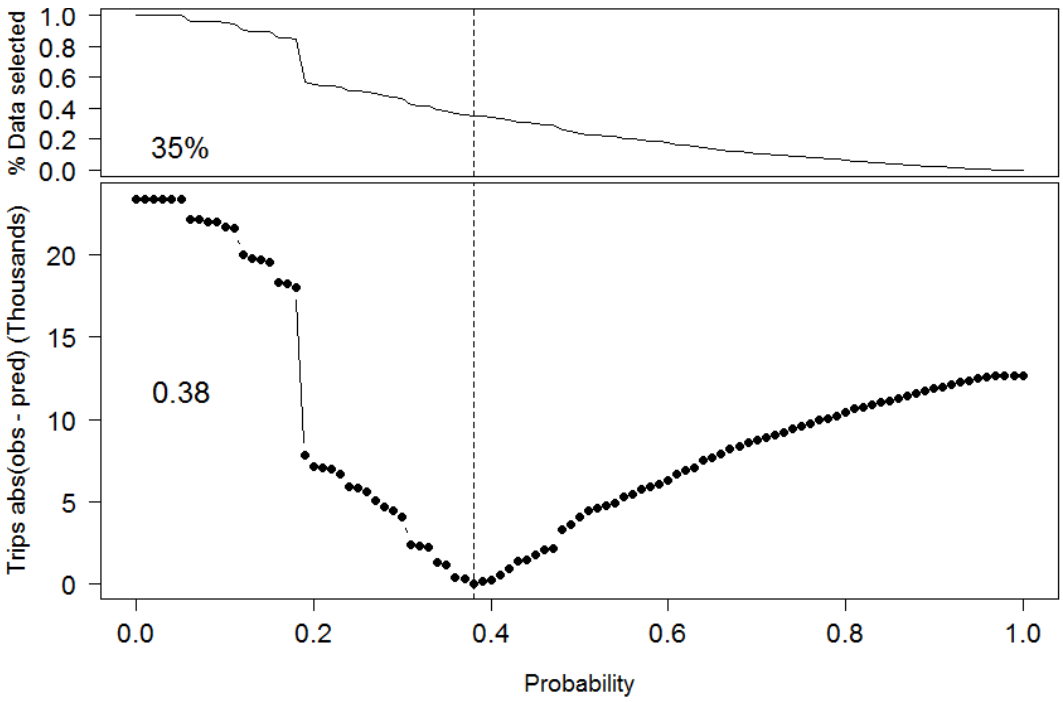
Table 5. Estimated parameter values for the red snapper IFQ variable included in the log(CPUE) model component of the vermilion snapper commercial handline index. Variable level 500,000 is the reference level and has no associated standard error. Variable levels are in pounds of outstanding red snapper IFQ available at the time the commercial fishing trip was undertaken.

	East GoM		West GoM	
Level	**Est.**	**SE**	**Est.**	**SE**
0	0.8335	0.134	-0.08177	0.2059
500	0.7664	0.1344	0.04871	0.2962
1000	1.0101	0.137	0.5359	0.2837
5000	0.6215	0.134	-0.2038	0.1341
50000	0.2495	0.1358	-0.4287	0.102
500000	0	.	0	.

FIGURES

Figure 1: In each panel, the bottom figure shows the difference between the number of records in which the target species were observed and those in which they were predicted to occur for each probability threshold using the Stephens and MacCall (2004) approach. The top figure in each panel shows the % of available data selected for each probability threshold. Panel A, Western GoM, Panel B Eastern GoM.

A.



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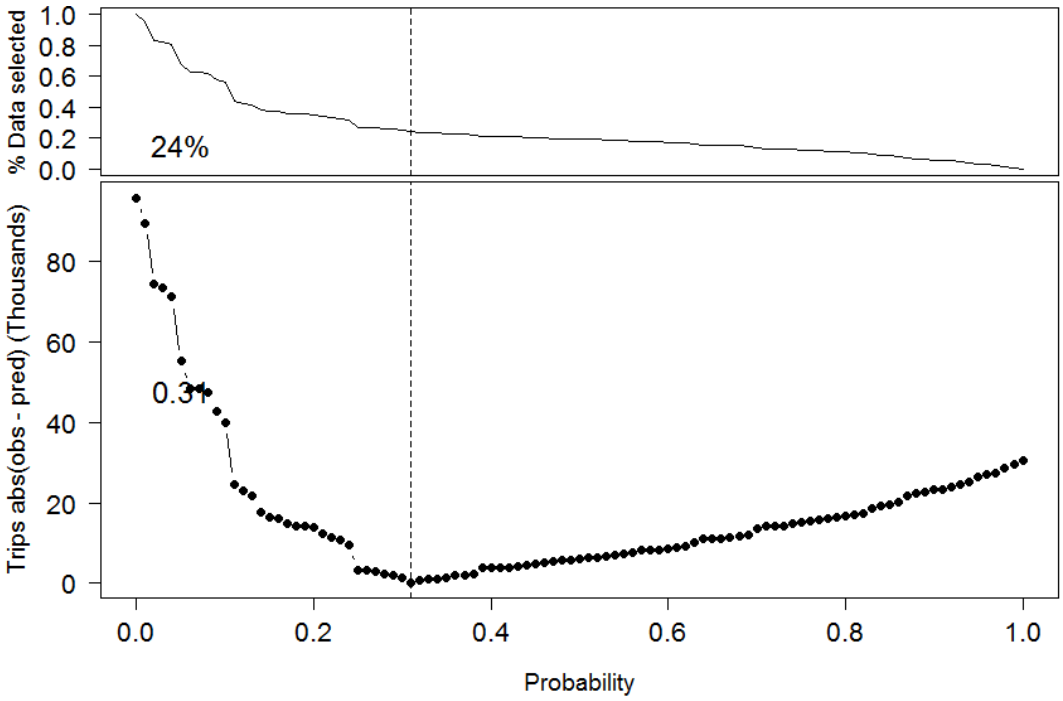
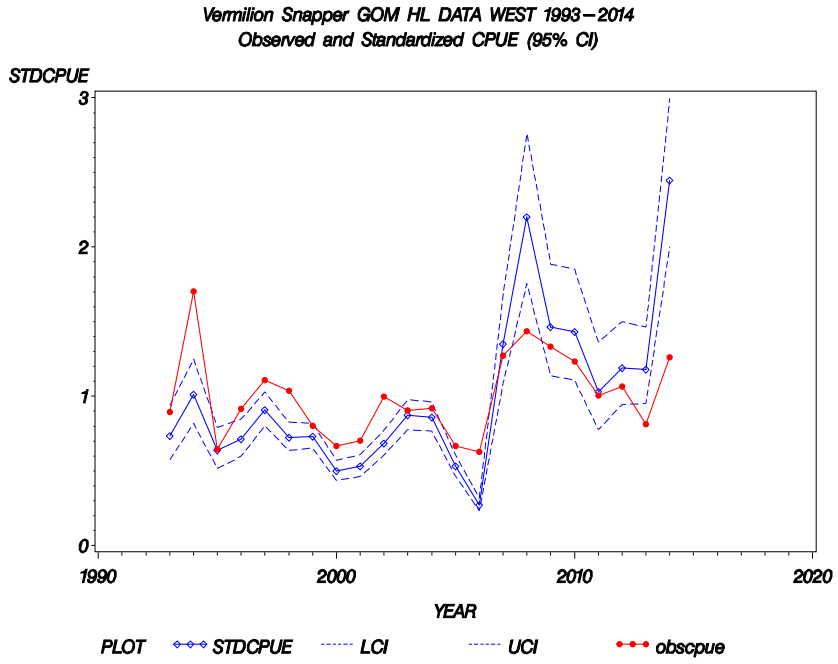


Figure 2: Timeseries plots of nominal (red lines) and standardized (solid blue line) CPUE relative to the mean of the given timeseries for the western Gulf of Mexico (A) and the eastern Gulf of Mexico (B). Standardized indices did not include the variable for Red Snapper IFQ (No IFQ). 95% confidence intervals for the standardized CPUE are given by the dashed blue lines.

A.



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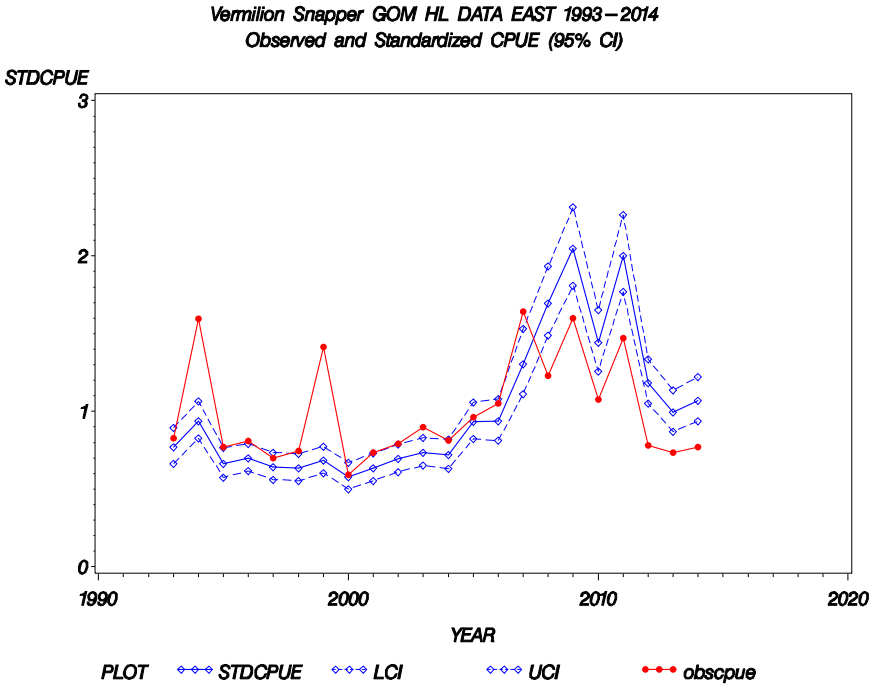
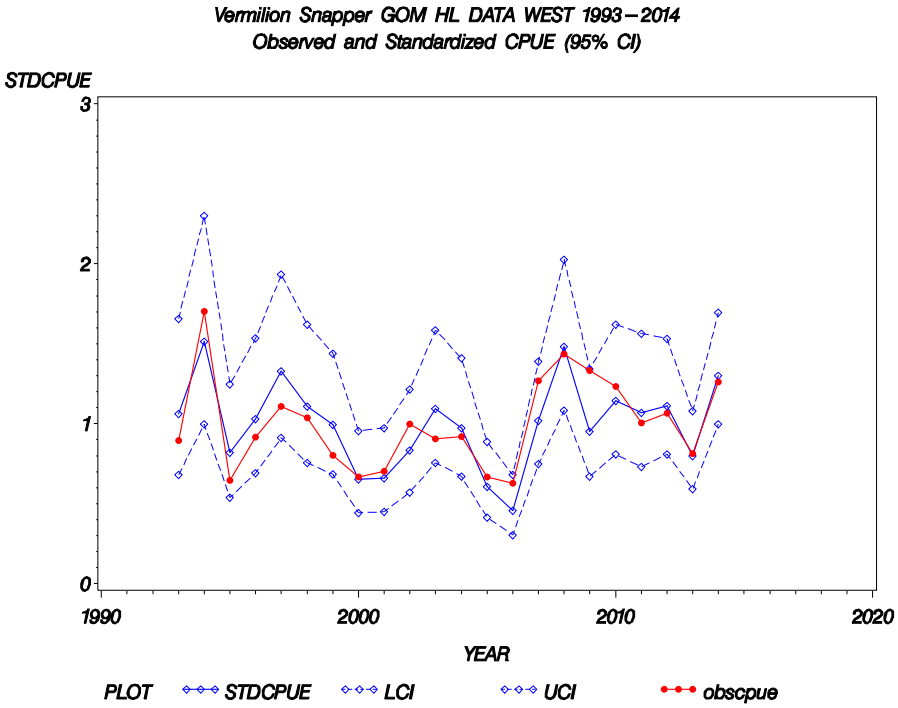


Figure 3: Timeseries plots of nominal (red lines) and standardized (solid blue line) CPUE relative to the mean of the given timeseries for the western Gulf of Mexico (A) and the eastern Gulf of Mexico (B). Standardized indices were forced to include the variable for Red Snapper IFQ (IFQ). 95% confidence intervals for the standardized CPUE are given by the dashed blue lines.

A.



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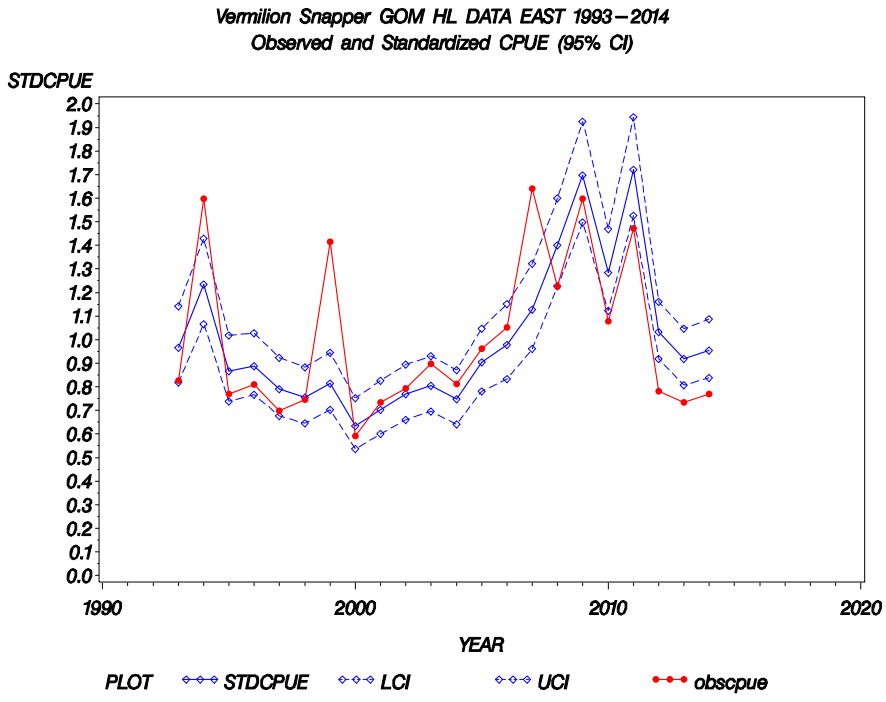
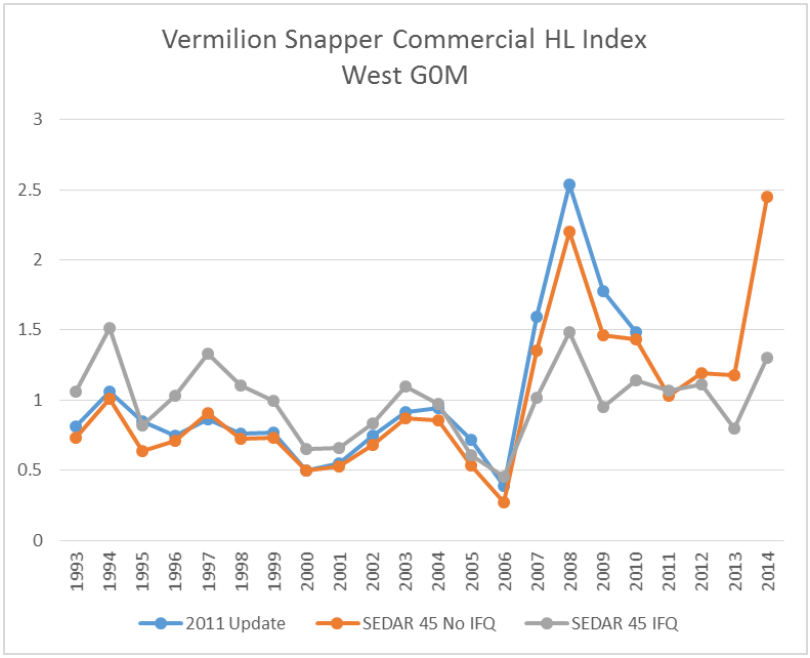


Figure 4: Timeseries plots of the 2011 update (blue line), and the current SEDAR 45 standardized CPUE index without considering red snapper IFQ (orange line) and with red snapper IFQ included (gray line). Indices are for the western Gulf of Mexico (A) and eastern Gulf of Mexico (B).

A.



B.