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Post-IFQ Commercial Vertical Line Abundance Index for Eastern Gulf of America Red Snapper Using Reef Fish Observer Data

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Introduction

There are concerns that catch-per-unit-effort (CPUE) abundance indices based on commercial fleet landings may not be valid after implementation of individual fishing quotas (IFQs) for selected grouper-snapper species in the Gulf of America. For example, discards of Scamp and Yellowmouth Grouper were primarily smaller fish at or below the legal minimum length before IFQs were implemented in 2010; however, discards post-IFQ included larger legal-sized fish as well as sublegal fish (Smith et al. 2020). These findings suggest that a fundamental change may have occurred in the catch-effort relationship of legal-sized fish, the basis for commercial fleet CPUE indices of abundance derived from logbooks, before and after implementation of IFQs.

To address these concerns, a novel CPUE index was developed in 2020-2021 for Scamp and Yellowmouth Grouper for the commercial fleet using data from the reef fish observer program (Smith et al. 2021). Observer observations of catch included both kept and discarded fish, and were thus not directly impacted by changes in management regulations (e.g., minimum size, catch quotas, etc.). The methodology for developing the observer abundance index employed a complementary mixture of parametric regression model techniques and nonparametric survey design techniques. Parametric, model-based analyses were used to analyze species co-occurrence, specify maximum effort thresholds, standardize effort among gears, and identify potential stratification variables and stratification schemes. Nonparametric, design-based analyses were used to test and identify optimal stratification schemes, and to produce the annual estimates of CPUE and associated CV for the abundance index. This approach using a variety of methods was designed with the express purpose of minimizing potential bias and maximizing precision of regional stock annual CPUE estimates.

The methodology was subsequently applied to develop commercial fleet CPUE indices for Red Snapper for SEDAR 74 for the years 2007-2019 (Smith 2022). Due to limited independent datasets in the region and agreement on the appropriateness of the methodology, the Indices Working Group for SEDAR 74 determined that the abundance index for the eastern Gulf was appropriate for use in the Red Snapper stock assessment. This working paper provides an updated abundance index for Red Snapper in the eastern Gulf for 2007-2023.

Methods

The methodology for developing the commercial fleet CPUE index from observer data is detailed in Smith et al. (2021) and Smith (2022). The following is a brief overview. The principal data source was the reef fish observer program in which scientific observers on commercial fishing vessels recorded detailed information on catch and effort for a subset of trips (Scott-Denton et al. 2011). The reef fish observer program began in July 2006; complete calendars years 2007-2023 were used for estimation of an annual index of abundance for Red Snapper in the eastern Gulf (**Fig. 1**). Analyses focused on vertical line gears (e.g., handlines, electric and hydraulic reels aka bandit reels), which accounted for the majority of commercial trips reporting catches of Red Snapper as well as observer observations.

Supplemental data sources were utilized to delineate the Gulf spatial area for analysis, including the commercial coastal logbook program and NOAA bathymetric databases. The spatial sample frame was comprised of 500 x 500m UTM (universal transverse mercator) grid cells, i.e., sample units. Depth at the center point of each grid cell was obtained from NOAA bathymetry data. Initial filtering steps restricted observer data to vertical line gears, and excluded observations with missing location information (i.e., latitude-longitude). This enabled assignment of observations at specific fishing locations to a unique 500 x 500 m grid cell. For analysis, a sample unit was defined as a 500 x 500 m grid cell sampled by observers on a given vertical line trip.

Annual CPUE and associated variance of Red Snapper were estimated using a Horvitz-Thompson ratio-of-means estimator for a stratified sample frame (Pollock et al. 1997; Lohr 2022), which accommodated varying levels of fishing effort among observer samples. Mean catch $\bar{y}$ in stratum h was computed by

$$\bar{y}_h = \frac{1}{n_h}\sum_i y_{hi} \quad ,$$

where y_{hi} is catch per sample unit i in stratum h, and n_h is sample size. Similarly, mean effort $\bar{x}$ in stratum h was computed by

$$\bar{x}_h = \frac{1}{n_h}\sum_i x_{hi} \quad ,$$

in which line-hours was the effort variable. Sample frame mean catch and effort were respectively computed by

$$\bar{y}_{st} = \sum_h w_h \, \bar{y}_h$$

and

$$\bar{x}_{st} = \sum_h w_h \, \bar{x}_h \quad ,$$

with the stratum weighting factor given by

$$w_h = \frac{N_h}{\sum_h N_h} \quad ,$$

the stratum proportion of total possible sample units N in the sample frame. Mean CPUE for the sample frame was estimated as the ratio of mean catch and mean effort,

$$\overline{CPUE}_{st} = \frac{\bar{y}_{st}}{\bar{x}_{st}} \quad . \qquad (1)$$

Computational methods for variance of $\overline{CPUE}_{st}$ are provided in Smith (2022).

The associated length frequency distribution for $\overline{CPUE}_{st}$ was computed in the following manner. Stratum CPUE was scaled to stratum total sample units N_h

$$\hat{Y}_h = \overline{CPUE}_h \times N_h$$

and multiplied by stratum proportion of length L to obtain the stratum total $\hat{Y}$ at length L,

$$\hat{Y}(L)_h = \hat{Y}_h \times p(L)_h \quad .$$

These were summed over all strata to obtain the survey frame total $\hat{Y}$ at each length L

$$\hat{Y}(L)_{st} = \sum_h \hat{Y}(L)_h \quad ,$$

and then converted to relative proportion of length L,

$$p(L)_{st} = \frac{\hat{Y}(L)_{st}}{\sum_h \hat{Y}_h} \quad . \qquad (2)$$

Results

Depth strata and associated weighting factors are described in **Table 1**. As shown in **Fig. 1**, the southern boundary of the East subregion was set at 26 degrees latitude, due to a combination of sparse observer coverage of vertical line trips and near-zero occurrence of Red Snapper in shallow depths in the area south of 26 degrees. Sample sizes by depth strata and year for the East subregion are given in **Table 2**. Estimates of the reef fish observer abundance index for eastern Gulf Red Snapper for 2007-2023 are provided in **Table 3** for the commercial vertical line fleet. The standardized index (scaled to mean CPUE for 2007-2023) time-series is graphed in **Fig. 2**, which also shows the 95% confidence intervals. The estimates indicate that eastern Gulf Red Snapper abundance was relatively low during 2007-2008, increased to a stable level during 2009-2015, and then sharply increased to a higher, more variable level in the most recent years 2016-2023. The annual CVs of the estimates ranged from 5.3 to 27.9%, with an average of 12.9%.

Length observations ranged from 206 to 2,746 per year (**Table 4**). The comparison of cumulative length frequencies for 2009 and 2023 (**Fig. 3**) indicates a shift towards larger fish in more recent years. The standardized CPUE time-series and accompanying length compositions (eq. 2) for the eastern Gulf were provided to the stock assessment analysts via the S-Drive.

Discussion

This study applied the methods of Smith et al. (2021) and Smith (2022) to provide an updated abundance index for Red Snapper in the eastern Gulf for 2007-2023 using data from the reef fish observer program, focusing on the commercial vertical line fleet. Some advantages of these data were that vertical line fishing and corresponding observer sampling locations encompassed the principal geographical and depth range of Red Snapper in the eastern Gulf. Observer catch observations included both kept and discarded fish, and thus were not directly affected by management regulations (e.g., minimum size, IFQs, etc.), which is a common issue identified for indices developed using logbook data. The main disadvantage was that the observer data are fishery-dependent, with the inherent uncertainty as to whether the sampled observations constituted a truly representative sample of the Red Snapper stock. Aside from that fundamental question, analysis techniques accounted for varying gear characteristics (e.g., hook types, hook sizes, reel types) and varying effort (e.g., number of reels, fishing time at a location, etc.), which are typical for fishery-dependent sampling data, in the estimation procedure. The resulting abundance indices indicated generally increasing Red Snapper stocks in the eastern Gulf during 2007-2023. The precision of the estimates was quite good with an average annual CV of 12.9%.

Literature Cited

Lohr, S.L. 2022. Sampling: design and analysis, 3rd ed. Boca Raton: CRC Press.

Pollock, K.H., J.M. Hoenig, C.M. Jones, D.S. Robson, C.J. Greene. 1997. Catch rate estimation for roving and access point estimation. NAJFM 17:11-19.

Scott-Denton, E., Cryer, P.F., Gocke, J.P., Harrelson, M.R., Kinsella, D.L., Pulver, J.R., Smith, R.C., Williams, J. 2011. Descriptions of the U.S. Gulf of Mexico reef fish bottom longline and vertical line fisheries based on observer data. Marine Fisheries Review 73(2):1-26.

Smith, S.G., S. Martinez, K.J. McCarthy. 2020. CPUE expansion estimation for commercial discards of Gulf of Mexico Scamp and Yellowmouth Grouper. SEDAR Working Paper SEDAR68-DW-30. SEDAR, North Charleston, SC. 27 pp.

Smith, S.G., S. Sagarese, S. Martinez-Rivera, K.J. McCarthy. 2021. Estimation of a commercial index for Gulf of Mexico scamp & yellowmouth grouper using reef fish observer data. SEDAR Working Paper SEDAR68-AW-04. SEDAR, North Charleston, SC. 34 pp.

Smith, S.G. 2022. Estimation of post-IFQ commercial vertical line abundance index for Gulf of Mexico Red Snapper using reef fish observer data. SEDAR Working Paper SEDAR74-DW-38. SEDAR, North Charleston, SC. 25 pp.

Table 1. Depth strata possible sample units and associated weighting factors for the eastern Gulf.

Stratum Code	Description	Possible Sample Units N_h	Weighting Factor w_h
D1	10 m ≤ depth < 25 m	45,907	0.2260
D2	25 m ≤ depth < 80 m	157,255	0.7740

Table 2. Observer program sample sizes by depth strata (**Table 1**) and year for the eastern Gulf Red Snapper commercial vertical line index; n_h is primary sample units (500 x 500 m grid cells). Data for 2020 (shaded) were combined with 2019 and 2021 due to limited sampling during COVID.

	Stratum sample size n_h	
Year	D1	D2
2007	8	279
2008	7	303
2009	15	204
2010	66	430
2011	89	661
2012	103	1429
2013	120	540
2014	28	462
2015	28	825
2016	87	784
2017	2	455
2018	10	148
2019	4	77
2020	6	365
2021	2	269
2022	12	338
2023	14	342

Table 3. Reef fish observer CPUE index time-series for eastern Gulf Red Snapper for the commercial vertical line fleet. Nominal CPUE (eq. 1) is catch in number per line-hour, *n* is primary sample units (500 x 500 m grid cells). The relative index was scaled to mean CPUE for 2007-2023.

Year	n	Nominal CPUE	Relative Index	CV
2007	287	0.634	0.397	0.146
2008	310	0.762	0.477	0.140
2009	219	1.312	0.822	0.142
2010	496	1.334	0.835	0.099
2011	750	1.358	0.851	0.073
2012	1532	1.121	0.702	0.053
2013	660	1.194	0.748	0.081
2014	490	1.337	0.837	0.111
2015	853	1.453	0.910	0.190
2016	871	3.236	2.027	0.085
2017	457	2.383	1.493	0.279
2018	158	2.797	1.752	0.141
2019	81	1.836	1.150	0.204
2020	371	2.9905	1.531	0.139
2021	287	3.2732	1.676	0.111
2022	350	3.8279	1.960	0.097
2023	356	2.3466	1.202	0.100

Table 4. Annual number of Red Snapper lengths obtained by onboard observers in the eastern Gulf, 2007-2023. Data for 2020 (shaded) were combined with 2019 and 2021 due to limited sampling during COVID.

Year	Length Observations
2007	246
2008	348
2009	324
2010	810
2011	1,504
2012	2,746
2013	970
2014	788
2015	1,310
2016	2,336
2017	1,360
2018	542
2019	206
2020	1,668
2021	1,312
2022	1,141
2023	1,072

Figure 1. Map of the Gulf spatial sampling frame showing statistical zones and associated subregions: East, zones 4-6; Central, zones 7-12; and West, zones 13-21. Depth strata were assigned to 3 intervals: shallow, 10-25m (red shading); mid-depth, 25-85m (yellow shading); and deep, 85-140m (blue shading). Statistical zones 1-3 (below 26 degrees latitude) in the East subregion were excluded from the sample frame due to a combination of sparse observer coverage of vertical line trips and near-zero occurrence of Red Snapper in shallow depths.

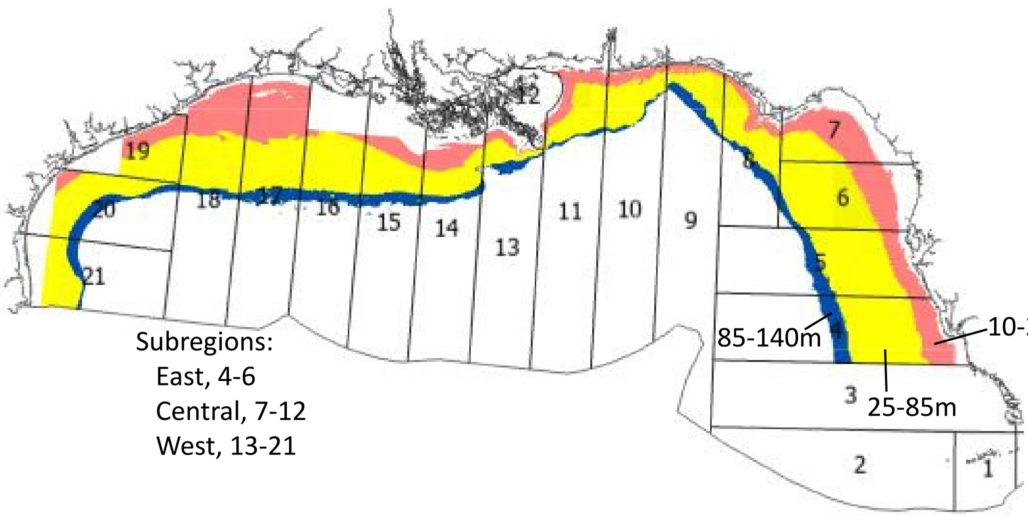

Figure 2. Time-series graph (2007-2023) of reef fish observer standardized CPUE index (±95% CI) for eastern Gulf Red Snapper for the commercial vertical line fleet.

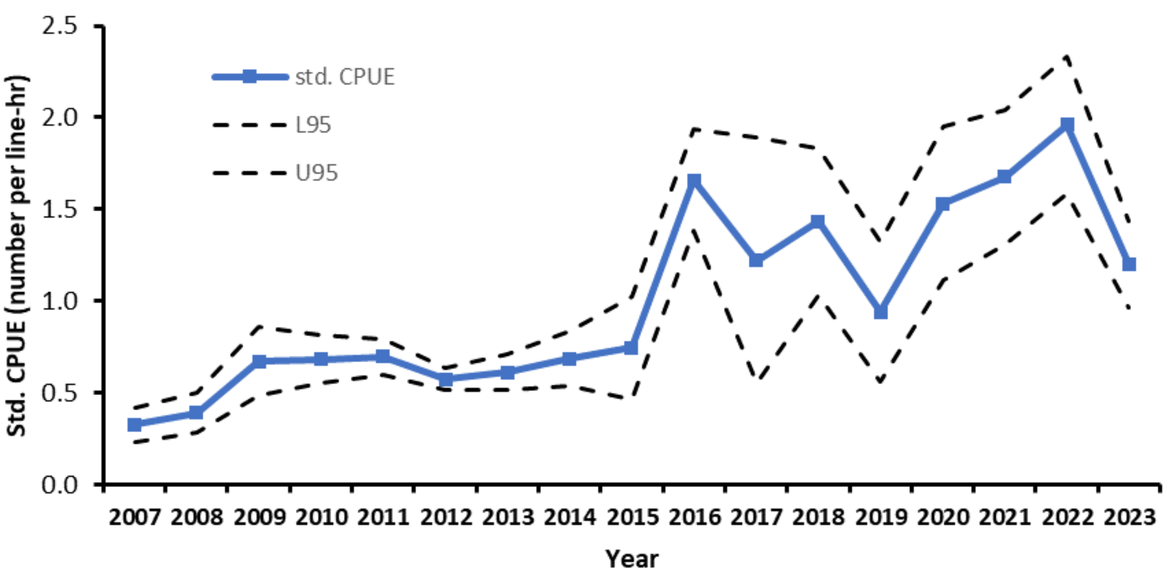

Figure 3. Observer program cumulative length frequencies of Red Snapper in the eastern Gulf for two example years, 2009 and 2023.