A Comparison of Penaeid Shrimp Catch Rates in the Gulf of Mexico Based upon Observer Program Catch Data versus Catch Rates Derived from the Electronic Logbook Program Data

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INTRODUCTION

The federally-permitted penaeid shrimp fishery of the Gulf of Mexico consistently ranks near or, historically, at the top of the list of the nation's most valuable fisheries. However, this fishery is unlikely to be able to meet requirements for certification as a Sustainable Fishery by the Marine Stewardship Council (MSC) or Gulf United for Lasting Fisheries Responsible Fisheries Management (G.U.L.F. RFM) Standard. Major seafood buyers, such as Walmart, Kroger, and Sysco, have made public, time-bound commitments to purchase only from certified sustainable fisheries or fisheries engaged in Fishery Improvement Projects (FIP) that are making good progress towards resolving the barriers to certification. This poses an economic threat to the Gulf of Mexico shrimp fishery.

On 11 July 2018, a Gulf of Mexico Shrimp Bycatch Data Workshop, funded by the Gulf of Mexico Shrimp Supply Chain Roundtable, was held in Galveston, Texas. The purpose of the workshop was to facilitate dialogue between the NOAA observer program staff, a representative from an accredited independent certification agency who is trained on both MSC and G.U.L.F. RFM certification requirements (SAI Global), the supply chain, NGOs, and other knowledgeable parties in order to generate a shared understanding of the current observer program design and methodology, better indicate whether the program currently meets certification requirements, and identify changes or information that would be necessary to allow for certification. Evaluations of the Gulf of Mexico shrimp fishery with respect to the MSC and the G.U.L.F. RFM standards had identified two remaining barriers to certification, both related to shrimp fishery bycatch. The first is that while the data produced by the federal observer program appears to be fairly robust based on the relatively low coefficients of variation for many of the most common bycatch species (Scott-Denton et al., 2012), the observer program coverage rate is low, at most a 2% coverage rate for the fishery. Additionally, at the time, the most recent bycatch data were from 2010. The second barrier was that the observer program utilizes a "modified characterization protocol" resulting in data that contains large categories of unidentified finfish and invertebrates that prevent full identification of non-target species to the specifications required by sustainability certifications.

Workshop participants concluded that the first barrier, low observer coverage rates, should be relatively easy to resolve with a combination of 1) publication of updated coefficients of variation (CVs) for the primary bycatch species (Scott Denton et al. *in press*) and 2) comparison of shrimp catch per unit effort (CPUE) from the small observer program to CPUE estimates from the Electronic Logbook (ELB) program, which has a >20% coverage rate. The CVs serve as a good indicator of precision of the observer program data, while the comparison of CPUE data will serve to verify the accuracy of the observer data.

BACKGROUND

The National Marine Fisheries Services' (NMFS) mandatory observer program for the Gulf of Mexico began in 2007 and the first comprehensive report was provided for the years 2007-2010 by Scott-Denton et al. (2012). The program continues to the present and data for 2011-2016 have been recently approved for publication (Scott-Denton et al. *in press*). Each report is inclusive for the 2007-2010 and 2011-2016 time periods, respectively.

LGL Ecological Research Associates, Inc. (LGL) developed and operated an Electronic Logbook program (ELB) for NMFS for the period 2001-2012 (Gallaway 2003a, b). By 2007 (the start of the mandatory observer program), coverage included approximately 400 vessels and by 2010 well over 500 vessels were equipped with ELBs. The original ELB program recorded and stored data on chips which were periodically retrieved and replaced with new chips by Port Agents. The data collected allow scientists to calculate the location and duration of individual tows, and the start and end times of trips. These trip data are then merged with the landings data files maintained by the Gulf States Marine Fisheries Commission (GSMFC) and NMFS to calculate catch per unit of effort (CPUE) for each trip and determine fleet CPUE and effort for the 36 temporal (trimester) and spatial (4 areas x 3 depth zones) cells used to manage the shrimp fishery in the Gulf of Mexico.

The 2007-2010 portion of the ELB database contains over 5,200 matched trips representing over 5.09 million hours of fishing, representing fleet coverage of over 20%. As described below, we used these data to calculate fleet CPUE for comparison to the values calculated in the NMFS observer bycatch paper (Scott-Denton et al. 2012) which covers the same period. Scott-Denton et al. (2012), provided observer coverage for 380 trips, about 2% coverage of the fleet.

As noted above mandatory observer data were also gathered by NMFS for 2011 to 2016. ELB data are available for 2011 and 2012, but after 2012, NMFS implemented and ran the cELB (cellular electronic log book) program. While this new program is based on the ELB program, it incorporates some significant changes to the methods of data collection. Most of the analysis programs in the new cELB program are the same as those used in the original ELB program, however, the collection methodology changes necessitated some changes in the analysis programs, and NMFS opted to make a few other changes as the overall data set became too large to manage as a single entity. A part of this study was to merge the two datasets.

OBJECTIVES

The first objective of our study was to update the shrimp effort database to include the cELB data. Using these data, we also, 1) compared penaeid shrimp catch rates for the offshore Gulf of Mexico estimated based on mandatory observer data for 2006-2010 to comparative catch rates determined for the same period using ELB data already held by LGL and 2) conducted a similar analysis for 2011 to 2016. While the mandatory observer data are in the same format for the 2006-2010 and the 2011-2016 time periods, the 2011 to 2016 time frame is dominated by cELB data (2013-2016) but also contains ELB data for 2011 and 2012. All ELB data were reconciled to a common format.

METHODS

The NMFS Electronic Logbook Project generates files that list all detected trips which have a matching landing in the landings database. It also generates a file from those matched trips that lists date, location, landings allocated, and effort. LGL possessed those files for the period 2007-2012 from the time when LGL administered the program. We acquired the data for the years 2013-2016 from NMFS to perform this analysis.

The shrimp species targeted by the Gulf of Mexico fishery produce an annual crop, most of which is harvested within the year. This leads to large variability in catch rates across years, seasons and areas fished. For example, the catch rates during the 2007-2010 period ranged from 5.5 kg/net/hr in 2007 off western Louisiana (area 3) in the winter / spring (trimester 1) to 16.1 kg/net/hr in 2009 off Texas (area 4) in the summer (trimester 2). In the 2011-2016 period the catch rates ranged from 4.1 kg/net/hr in 2014 off western Louisiana (area 3) in the winter / spring (trimester 1) to 13.2 kg/net/hr in 2016 off Mississippi and Alabama (area 2) in the summer (trimester 2). Given this spatial and temporal variability, the effort to match NMFS observer program overall catch rates for the years of the two studies to those from the ELB catch rates require that the effort in the ELB programs be adjusted to match the spatial and temporal distributions from the NMFS observer program studies.

The data were analyzed in two sets to match the dates from the Scott-Denton, et al papers, 2007-2010 and 2011-2016. For each data set we calculated the catch rate for each year, area, and trimester as the sum of the catch divided by the sum of the effort. Catch in the ELB database is reported in heads-off equivalent pounds, the effort is reported in nominal days fished (24 hours of fishing activity), and the catch rate is calculated for the entire trip. We converted those values to heads-on kg catch per single net hour by multiplying the ELB catch rate by 1.61 to get heads-on equivalent, then dividing by 24 to get to hours, then dividing by 4 (the number of nets on ELB vessels), and finally dividing by 2.2 to get from pounds to kilograms. The areas used are the four regions of the Gulf of Mexico used in management of the shrimp fishery (Area 1: Statistical Zones 1-9, Area 2: Zones 10-12, Area 3: Zones 13-17, Area 4: Zones 18-21). The trimesters are Jan-Apr, May-Aug, and Sep-Dec. Once the catch rates were calculated we used the NMFS distribution of effort listed in Table 2 of Scott-Denton et al. (2012; *in press*) to weight the catch rates and calculate a weighted mean and weighted standard error of the mean for each data set. We then compared this mean and its 95% confidence interval to the NMFS observer program overall catch rates per net listed in the "Catch Composition" section of each paper.

RESULTS AND DISCUSSION

The new ELB data for 2011 to 2016 reflected over 7,900 trips, and 9.4 million net hours. This compares to over 5,200 trips and 5.09 million net hours during 2007 to 2010. The observer data for 2007 to 2010 reflected 350 trips and 70,000 net hours as compared to 500 trips and 150,000 net hours in 2011 to 2016.

The two data sets yielded very similar estimates of penaeid shrimp catch rates (Figure 1), despite the differences in the level of ELB coverage (>20%) versus observer coverage (~2%). In each case, the catch rate based on the observer coverage is slightly higher than the corresponding ELB catch rate. For the 2007 to 2010 period, the ELB-based estimate was 9.5 kg/net/h versus 9.6 kg/net/h for the observer-based estimate (Table 1). For the 2011 to 2016 period, the corresponding estimates were 8.6 kg/net/h (ELB) versus 8.9 kg/net/h for the observer-based estimate (Table 2). One explanation for the observer catch rate being slightly but consistently higher than the ELB catch rate is that the observers only sampled the outer nets on the vessel, and did not include any bad tows in the overall catch rate estimates. In contrast, in the ELB estimates are based on the actual pounds landed and the effort required to produce those landings. Thus, in the ELB estimates catch rates for all tows, both good and bad are included.

Table 1. Penaeid shrimp catch per unit effort values (kg/tails/net/h) based on Electronic Logbook observations weighted the same as Scott-Denton et al's (2012) observer study effort.

Area	Trimester	Year	CPUE	Effort Weighted Factor	Weighted Value
1	1	2007	5.823882	0	
1	1	2010	7.159887	0	
1	1	2009	6.981192	0	
1	1	2008	8.42679	0	
1	2	2007	8.27407	1.4	11.583699
1	2	2008	8.410862	1.4	11.775206
1	2	2010	10.79924	1.4	15.11893
1	2	2009	9.53253	1.4	13.345543
1	3	2007	7.463637	1.9	14.18091
1	3	2008	10.31022	1.9	19.589415
1	3	2009	7.528358	1.9	14.30388
1	3	2010	10.14301	1.9	19.271724
2	1	2007	5.933531	1.2	7.120237
2	1	2008	8.56062	1.2	10.272744
2	1	2009	8.480572	1.2	10.176687
2	1	2010	8.629379	1.2	10.355255

Area	Trimester	Year	CPUE	Effort Weighted Factor	Weighted Value
2	2	2007	10.12379	3.6	36.445658
2	2	2008	10.5602	3.6	38.01672
2	2	2009	11.00313	3.6	39.611274
2	2	2010	15.86627	3.6	57.118555
2	3	2007	8.062413	3.1	24.993481
2	3	2008	8.325518	3.1	25.809105
2	3	2009	8.881132	3.1	27.53151
2	3	2010	12.94975	3.1	40.144212
3	1	2007	5.510886	3.8	20.941368
3	1	2008	8.69502	3.8	33.041075
3	1	2009	7.748329	3.8	29.443651
3	1	2010	7.011093	3.8	26.642152
3	2	2007	7.952585	12.8	101.793092
3	2	2008	9.102687	12.8	116.514393
3	2	2009	10.02892	12.8	128.370175
3	2	2010	8.054734	12.8	103.10059
3	3	2007	7.769339	14.3	111.101554
3	3	2008	9.072954	14.3	129.743246
3	3	2009	9.956389	14.3	142.376364
3	3	2010	9.502496	14.3	135.885687
4	1	2007	5.542203	8.6	47.662944
4	1	2008	6.98473	8.6	60.068675
4	1	2009	6.790358	8.6	58.397075
4	1	2010	5.752284	8.6	49.469641
4	2	2008	11.2298	15.6	175.184867
4	2	2007	13.44958	15.6	209.81347
4	2	2009	16.05174	15.6	250.407066
4	2	2010	10.32724	15.6	161.104954
4	3	2009	11.54682	14.4	166.274198
4	3	2008	9.175845	14.4	132.132169
4	3	2007	7.377165	14.4	106.23117
4	3	2010	8.945111	14.4	128.809601
				322.8	3071.273922

N	44
Weighted Mean	9.514479
Lower - 95% CI	8.827029
Upper - 95% CI	10.201929

Table 2. Penaeid shrimp catch per unit effort values (kg/tails/net/h) based on Electronic Logbook observations weighted the same as Scott-Denton et al's (2020) observer study effort.

Area	Trimester	Year	CPUE	Effort Weighted Factor	Weighted Value
1	1	2011	7.847712	4.6	36.099476
1	1	2015	9.244785	4.6	42.526012
1	1	2014	6.133297	4.6	28.213165
1	1	2013	5.012874	4.6	23.059221
1	1	2016	6.995132	4.6	32.177606
1	1	2012	6.377719	4.6	29.337507
1	2	2011	11.80505	3.2	37.776161
1	2	2016	9.427172	3.2	30.166951
1	2	2015	8.181178	3.2	26.179770
1	2	2012	6.549449	3.2	20.958235
1	2	2014	9.206405	3.2	29.460497
1	2	2013	6.365305	3.2	20.368976
1	3	2011	7.760323	2.2	17.072711
1	3	2012	6.995191	2.2	15.389421
1	3	2016	5.909566	2.2	13.001046
1	3	2015	9.219335	2.2	20.282536
1	3	2014	8.917784	2.2	19.619124
2	1	2011	9.643918	1.8	17.359052
2	1	2012	6.215144	1.8	11.187260
2	1	2013	10.45688	1.8	18.822376
2	1	2014	5.909752	1.8	10.637554
2	1	2016	6.786476	1.8	12.215658
2	1	2015	6.966629	1.8	12.539932
Area	Trimester	Year	CPUE	Effort Weighted Factor	Weighted Value
2	2	2011	11.91159	9.5	113.160136
2	2	2012	10.91473	9.5	103.689979
2	2	2013	10.52962	9.5	100.031373
2	2	2014	9.236743	9.5	87.749061
2	2	2015	11.65674	9.5	110.739044
2	2	2016	13.24339	9.5	125.812206
2	3	2011	8.66837	5.9	51.143381
2	3	2012	8.914087	5.9	52.593114
2	3	2013	9.323258	5.9	55.007222
2	3	2014	9.737216	5.9	57.449574
2	3	2015	11.2173	5.9	66.182053
2	3	2016	7.905094	5.9	46.640056
3	1	2011	8.160245	6.7	54.673641
3	1	2012	7.568151	6.7	50.706610
3	1	2013	7.829902	6.7	52.460345

Area	Trimester	Year	CPUE	Effort Weighted Factor	Weighted Value
3	1	2014	4.053737	6.7	27.160040
3	1	2015	5.065683	6.7	33.940075
3	1	2016	6.747049	6.7	45.205227
3	2	2011	10.14392	23.4	237.367683
3	2	2012	10.31396	23.4	241.346724
3	2	2013	8.546235	23.4	199.981903
3	2	2014	6.702804	23.4	156.845624
3	2	2015	7.921772	23.4	185.369474
3	2	2016	8.004655	23.4	187.308932
3	3	2012	9.068106	12.6	114.258133
3	3	2011	8.196067	12.6	103.270448
3	3	2013	10.47565	12.6	131.993174
3	3	2014	7.598815	12.6	95.745064
3	3	2015	8.136979	12.6	102.525930
3	3	2016	6.516039	12.6	82.102097
4	1	2013	5.406044	4.2	22.705384
4	1	2014	4.713562	4.2	19.796960
4	1	2012	6.439859	4.2	27.047407
4	1	2011	6.419508	4.2	26.961934
4	1	2015	4.183265	4.2	17.569713
4	1	2016	5.293793	4.2	22.233931
4	2	2014	10.64432	6.3	67.059205
4	2	2013	11.59069	6.3	73.021363
4	2	2015	11.7449	6.3	73.992861
4	2	2012	10.18018	6.3	64.135154
4	2	2011	13.1668	6.3	82.950870
4	2	2016	9.607585	6.3	60.527784
4	3	2015	7.502666	11.7	87.781197
4	3	2011	9.71938	11.7	113.716747
4	3	2014	7.278873	11.7	85.162817
4	3	2013	9.816504	11.7	114.853103
4	3	2012	8.355956	11.7	97.764689
4	3	2016	5.692867	11.7	66.606545
				550.4	4720.796234
			N		71
			Weighted Mean		8.577028
			Lower - 95% CI		8.078096
			Upper - 95% CI		9.075960

The overall confidence interval for the observer-based penaeid shrimp catch rate is not given in Scott-Denton et al. (2012) and Scott-Denton et al. (2020). However, for each species of shrimp (white, browns and pinks) taken in the Gulf shrimp fishery, the corresponding coefficients of variation were all low; i.e. CV <0.1. All things considered, the differences in mean catch rates are remarkably small. Given these findings and the low coefficients of variation observed for all the dominant shrimp (and other) species taken in Gulf shrimp trawls (all had CVs <0.1), we propose that the low observer coverage in the Gulf of Mexico federal penaeid shrimp fishery should not represent a barrier to certifying this fishery as a sustainable one.

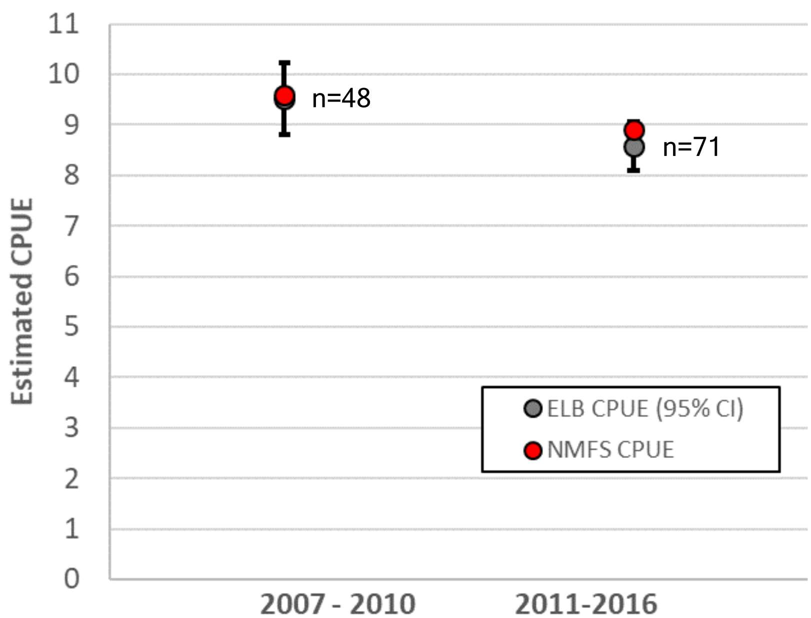

Figure 1. Weighted Mean ELB program CPUE compared to point estimate catch rate from NMFS papers. N value represents the number of year, area, trimester cell catch rates included in the weighted mean value. ELB program cell means were weighted by the percentage of NMFS observer program effort that occurred in each cell.

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