Shrimp Aggregate MSY and Aggregate OY Working Group Summary
Gulf Council Office
Tampa, FL
March 2, 2016
9:00 a.m. - 5:00 p.m.

Members Present:
Ben Blount
Benny Gallaway
Rick Hart
Christopher Liese
Jim Nance
Mike Travis

Council Staff
Morgan Kilgour
Phyllis Miranda

Council Member
Leann Bosarge

NMFS-SERO Staff
Susan Gerhart

Others present
John Williams
James Primrose

The shrimp aggregate maximum sustainable yield (MSY) and aggregate optimum yield (OY) working group met on March 2, 2016, at the Gulf Council office in Tampa, Florida. The group had been provided with the draft options paper for Shrimp Amendment 17B and was tasked with developing a method for determining an aggregate MSY and an aggregate OY for the Gulf shrimp fishery.

Rick Hart had used the methodology from the Ad Hoc Shrimp Effort Working Group (GMFMC Ad Hoc Shrimp Effort Working Group, 2006) to calculate aggregate MSY using data from 1990-2013 from offshore landings, and this information was provided to the working group. The working group approved using this methodology and approved the model outputs for an aggregate MSY of 109,237,618 pounds (tails); effort at this aggregate MSY is 143,756 days fished (Appendix A). It was clarified that the landings and effort estimates cover all activity in offshore waters (i.e., waters outside the COLREGS line), which means that it does include activity from non-federally permitted vessels, but it does not include landings from inshore waters by federally permitted vessels.

Because the offshore landings have not been at or near aggregate MSY for some time, and are not expected to be in the near future, there was discussion on the possibility of foreign vessels being able to harvest that portion of MSY that isn't harvested by the domestic fleet. However, it was clarified this is not allowable under Magnuson. Whether or not the juvenile red snapper bycatch reduction target should still be 67% or further reduced was discussed, but this issue is outside the scope of the working group. It was noted that it may be appropriate to reduce this target as the status of red snapper improves.

Aggregate OY was then discussed. Previously, OY had been set equal to MSY at the stock level for each of the federally managed shrimp stocks. The group discussed the two different sectors of the shrimp fishery: the harvesting sector and the onshore sector (dealers, processors, etc.).

While the objective of businesses in each sector is generally the same (i.e., to earn as much profit as possible), profitability in these two sectors is primarily driven by different factors, at least with respect to factors that management can affect (i.e., excluding shrimp prices, fuel prices, and general macroeconomic conditions). Profitability for dealers and processors is primarily determined by volume (i.e., higher landings lead to higher profits), whereas profitability in the harvesting sector is primarily determined by catch per unit of effort (CPUE) (i.e., higher CPUE leads to higher profits). Thus, in general, the onshore sector prefers higher levels of effort and higher landings while the harvesting sector prefers lower levels of effort and a higher CPUE. CPUE was identified as one metric to help determine the appropriate aggregate OY. From the economic standpoint, revenue per vessel needs to be maintained to prevent the loss of more fishery participants. Right now, the economics are driving the fishery and keeping the effort low. In years prior to the moratorium, when effort was much higher, shrimp prices were much higher and fuel prices were much lower, and so it was possible for businesses in the harvesting sector to be profitably with a much lower CPUE. Under current conditions, businesses could not be profitable with a low CPUE. The group discussed that the CPUE observed in 2014 likely allowed businesses in the harvesting sector to be profitable because economic conditions were a little more favorable than some of the other recent years (e.g., shrimp prices increased significantly), but even this 2014 year CPUE was well above those observed prior to the moratorium. The group discussed that consistency as well as high volume in the pounds of shrimp landed would be preferable to dealers and processors from a planning/investment perspective.

Economic conditions are currently constraining effort by the harvesting sector in the shrimp fishery. From an economic perspective, the only condition that can be “controlled” is the CPUE, as shrimp and fuel prices are set by global markets beyond the control of the Gulf Council. CPUE increases with lower overall effort. On the other hand, high poundage (through more effort) and revenue help maintain dealers, shore-side infrastructure, and associated communities and helps build in some protection for the social sector. To quantitatively model OY, in light of competing interests possibly including distributional issues, would require a very complicated bio-socioeconomic model. Given available data, it is unlikely that such a model is feasible at this time. Yet even if a complex bi--socioeconomic model were built, the choice of objectives---and their relative weights/priorities with respect to each other---would be the central determinants driving the model results. Different value judgement may result in very different outcomes. For example, 1) prioritizing dealer/community interests above all else leads to OY equal MSY, i.e., the highest possible effort and landings; 2) prioritizing the harvesting sector’s interest above all else would argue for lower effort, more likely to maximize CPUE; and 3) prioritizing turtle preservation above all else would possibly close the fishery.

After discussion, four competing goals were decided upon for determining aggregate OY for the Gulf shrimp fishery: high CPUE, high landings, and an effort target that is unlikely to result in a closure for both juvenile red snapper bycatch and sea turtle bycatch. . In the absence of specific Council guidance on relative priorities among these goals, the work group decided to take a balanced approach, looking at recent years with actual data. These four goals are realized in a qualitative manner in 2009. Therefore, the group recommended that the aggregate OY be the predicted landings based on the model output from 2009 because the model takes into account variability among years (Appendix A). The observed landings in 2009 are higher than predicted because it was an above average shrimp abundance year. It was discussed that there is no action triggered if the fishery were to exceed the aggregate OY. Therefore, the recommended aggregate OY is 85,368,059 pounds of tails; effort for this aggregate OY is 76,508 days fished.

The group discussed a range for aggregate OY using confidence intervals around the point estimate for effort in 2009, but decided that this was not really an alternative as it is still using the same reference point. The confidence limits are based on the effort and it would be inappropriate because the recommendation is based on a point that meets the criteria that the group outlined. It was also discussed that the years used for input into the model to calculate aggregate MSY and aggregate OY should be 1990-2013. Incorporating one or two years of additional data would only be expected to result in trivial changes to the various models' parameters and the resulting estimates, but would create a significant amount of extra work that would not produce better or additional information for the Council. These years are also consistent with the years used in the model to establish the overfished and overfishing definitions outlined in Shrimp Amendment 15.

The meeting adjourned at 12:30 p.m.

References

GMFMC Ad Hoc Shrimp Effort Working Group, 2006. Estimation of Effort, Maximum Sustainable Yield, and Maximum Economic Yield in the Shrimp Fishery of the Gulf of Mexico. Gulf of Mexico Fishery Management Council, Tampa, FL, 85 pp.

Appendix A.

Analysis of the Gulf of Mexico Shrimp Offshore Fishery - Preliminary Results

The Gulf of Mexico (Gulf) shrimp moratorium permit and royal red shrimp endorsement manage the harvest of all federally managed shrimp species in Gulf federal waters. The permit and endorsement are not needed to harvest the same species in state waters. However, it is not possible to estimate effort[1] and catch (landings)[2] of shrimp in federal waters with a reasonable degree of scientific certainty due to data limitations. Specifically, some state trip tickets do not require dealers to report whether landings come from federal or state waters. Further, although ELB data can determine if effort is taking place in federal or state waters, not all permitted vessels have ELBs and only about 70% of ELB trips can be matched to trips and thus to landings in the Gulf Shrimp System (GSS) data. Conversely, it is possible to generate estimates of effort and landings in offshore waters (i.e., waters outside the COLREGS lines[3]) with a relatively high

[1] Effort is measured in "days fished," where a day fished equals 24 hours of trawling time.
[2] Catch and landings are used interchangeably as discarding of shrimp is insignificant.
[3] The COLREGS lines are the set of demarcation lines that have been established by the Convention on the International Regulations for Preventing Collisions at Sea, 1972 (commonly called COLREGS). COLREGS define boundaries across harbor mouths and inlets for navigation purposes.

degree of scientific certainty. Thus, the National Marine Fisheries Service (NMFS) decided that estimates for the offshore fishery are the best available proxy for estimates in federal waters and thus most appropriate for Amendment 17B purposes. Hence, this analysis encompasses effort and landings in all offshore waters (i.e., the combination of federal waters and state waters out to 3 or 9 nm, depending on the state). Because the data used in this analysis includes effort and landings from state offshore waters, the estimates in this analysis are most likely <u>overestimates</u> of what is actually occurring in federal waters.

Further, although landings information can be obtained from both the (GSS) and Annual Landings Form (ALF) databases, effort is not reported on the ALF and it is not possible to determine whether the reported landings on the ALF came from offshore or inshore waters. Thus, the results in the accompanying figures and tables only use GSS data.[4] GSS data is a combination of state trip ticket and port agent collected data from dealers in the Gulf. As such, only shrimp landed at Gulf ports is taken into account.[5] Landings from the GSS are always reported in terms of tail (i.e., heads-off) weight. Further, because separate permits are not required to harvest each of the penaeid species and multiple species of shrimp are harvested simultaneously or on the same trip, this analysis includes data for all shrimp harvested from offshore waters, regardless of whether or not they are federally managed. Consistent with the Ad-Hoc Shrimp Effort Working Group Report (2006), the first year of data used for this analysis was 1990. Because GSS data for 2014 was not complete at the time this analysis was conducted, the analysis only used data through 2013.

Although the analyses conducted so far are scientifically acceptable for use in this amendment, additional research is being conducted to provide additional guidance and support to the Council as it continues developing this amendment. The following constitutes some of the key findings of the research that has been completed to date that relate to the Council's current set of actions and alternatives.

First, according to Figure 2.1, the estimated yield curve for the offshore fishery indicates that aggregate MSY is 109,237,618 pounds (tails) and effort at MSY is 143,756 days fished.[6] The model results should only be used within the range of the observed data, and thus should not be used to predict what landings would be at effort levels above or below observed levels. These results also indicate that recent levels of effort have been well below the level needed to achieve

[4] Previous analyses (Travis, 2010) have shown that only using GSS data will likely underestimate the actual number of permitted vessels active in the Gulf shrimp fishery as a whole (i.e., in offshore and inshore waters combined) because, in a given year, some vessels report they had landings on the ALF form but do not have landings according to state trip ticket and port agent dealer reports. Whether the exclusion of ALF data would also result in an underestimate of the number of permitted vessels active in offshore waters cannot be determined because the ALF form does not indicate where the landings came from in the Gulf.

[5] A minor if not trivial of amount of shrimp harvested from Gulf waters is landed in South Atlantic ports each year.

[6] Personal Communication, Rick Hart, NMFS Galveston Laboratory, July 15, 2015.

aggregate MSY in the offshore fishery. According to Figure 2.1 and Table 2.1, the level of effort needed to achieve aggregate MSY in the offshore fishery was most closely observed in 2004. Based on effort observed in 2013, effort would need to increase by more than 126% from current levels to achieve aggregate MSY.

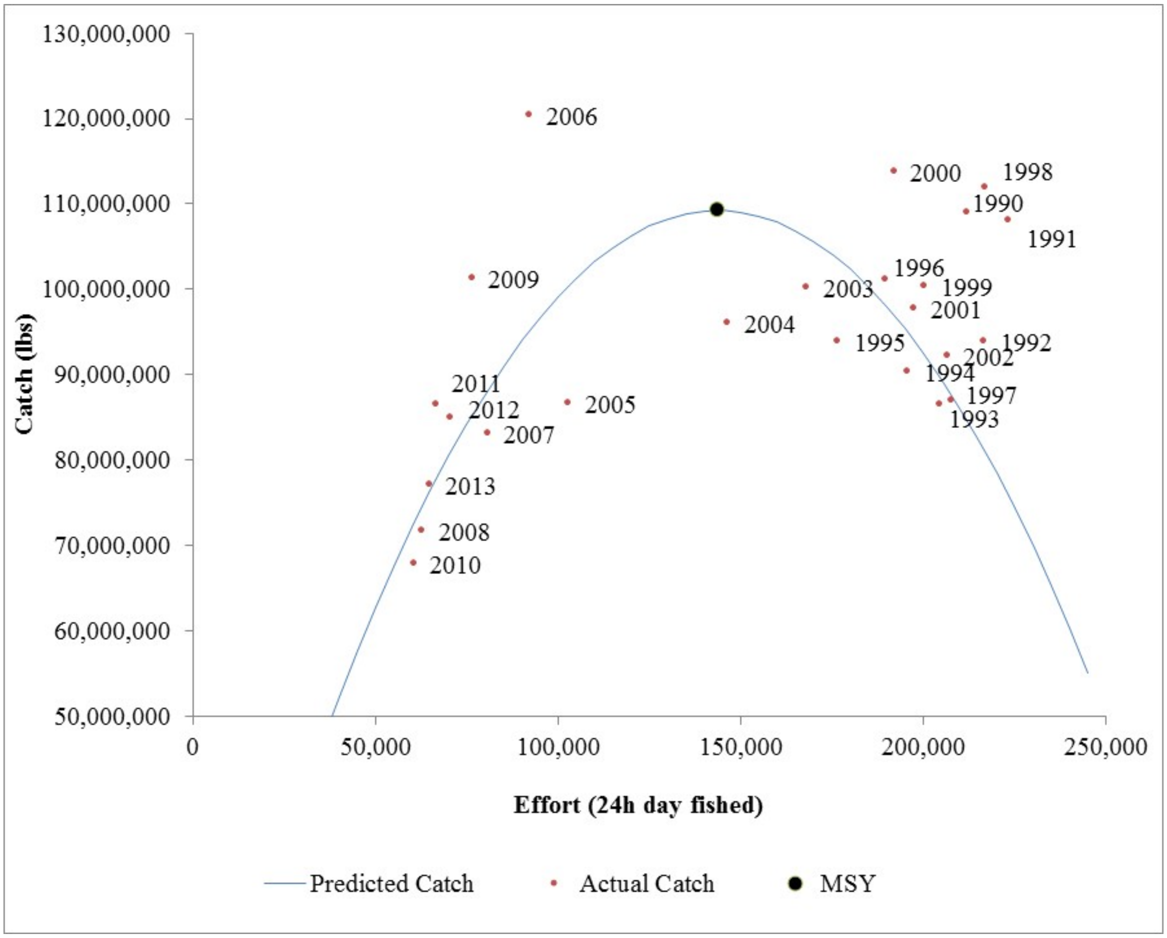

Figure 2.1. Yield curve for the offshore Gulf shrimp fishery. Estimates are based on catch and effort data for all shrimp species caught in offshore Gulf waters and landed in Gulf ports, 1990-2013.[7] Catch=1519.7665*effort+-0.00528*effort^2

Figure 2.2 illustrates the trends in observed landings, effort, and catch per unit effort (CPUE).[8] The most noticeable trends are with respect to observed effort and CPUE, with observed effort decreasing significantly from 2002 until 2008 and CPUE increasing significantly from 2002

[7] Rick Hart, personal communication, July 15, 2015. For current purposes, "Gulf waters" includes all areas of statistical zones 1 and 2, consistent with and for reasons explained in a previous analysis of latent permits (Travis, 2010).
[8] Personal Communication, Rick Hart, NMFS Galveston Laboratory, July 15, 2015.

through 2006. Both have been relatively stable since 2008. Conversely, observed landings were relatively stable for many years, but appear to have declined slightly in recent years.

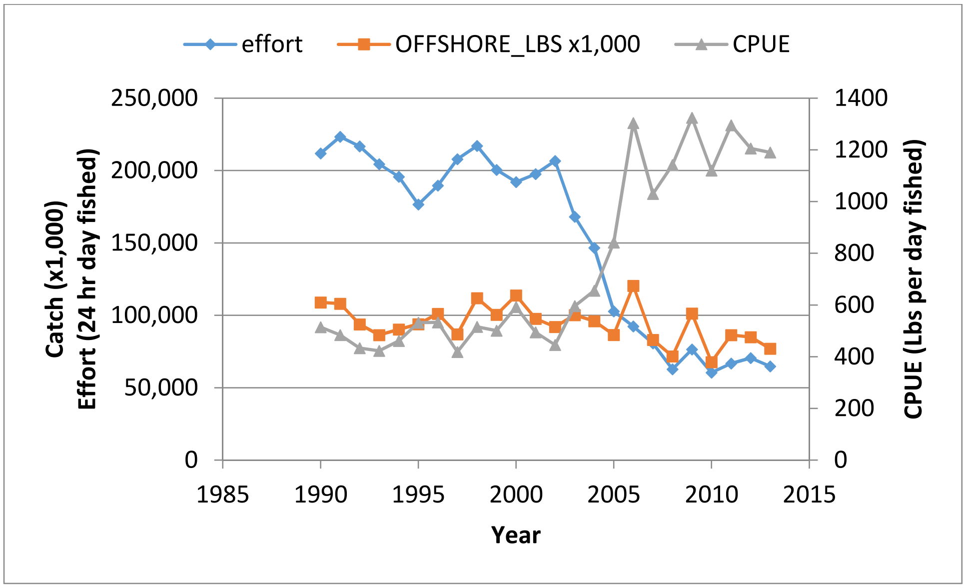

Figure 2.2. Catch, effort and CPUE for the offshore Gulf shrimp fishery. Estimates are based on catch and effort data for all shrimp species caught in offshore Gulf waters and landed in Gulf ports, 1990-2013.

Figure 2.3 illustrates a very strong, inverse relationship between effort and CPUE in the offshore fishery.[9] Thus, as effort decreased, CPUE increased. The regression model has an unusually high ability to explain variability in CPUE. As with the model for the yield curve, the model results should only be used within the range of the observed data, and thus should not be used to predict what CPUE would be at effort levels above or below observed levels. However, the clustering of data points in the upper left portion of the curve suggests a potential change in the relationship at lower levels of effort (i.e., CPUE may be approaching an asymptote).

For annual crop species like penaeid shrimp, care must be exercised in relying on trends in observed landings as they are subject to year to year variations in abundance. For example, although observed landings exceeded MSY in 2006 (Table 2.1), this was due to abundance being above the long-term average. The level of effort in 2006 would not be expected to generate that level of landings or MSY under long-term average levels of abundance. Thus, observed levels should not be used to predict what would be expected under average abundance conditions in the future. The same caution applies to using observed levels of CPUE. Although observed CPUE

---

[9] Personal Communication, Rick Hart, NMFS Galveston Laboratory, July 15, 2015.

was highest in 2009, this result was similarly driven by above average abundance. It is not prudent to expect or rely on above average abundance conditions in the future.

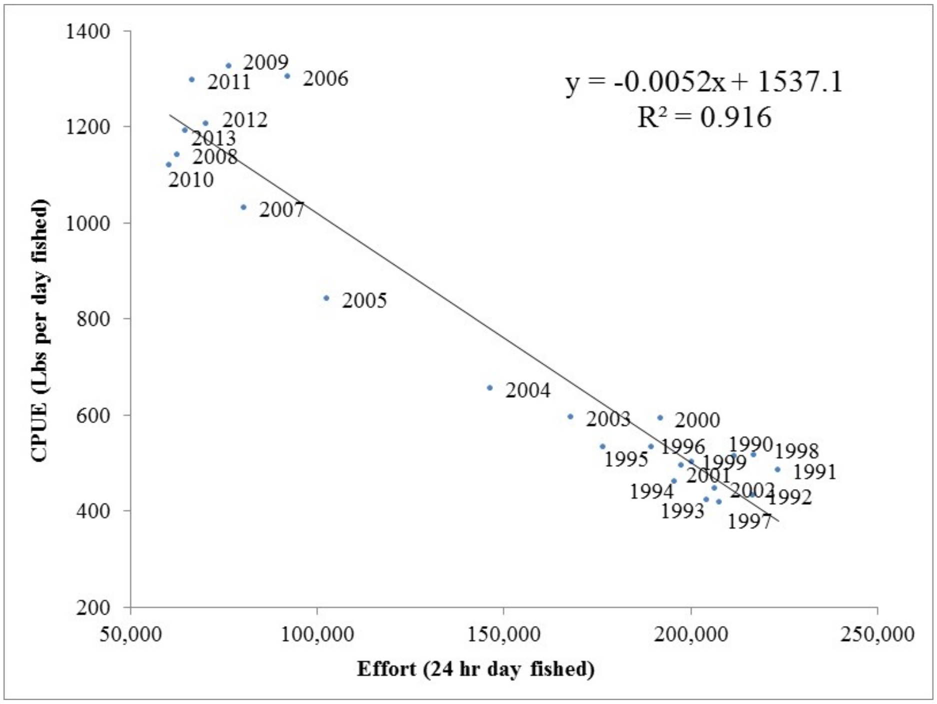

Figure 2.3. Relationship between CPUE and Effort in the offshore Gulf shrimp fishery, 1990-2013.

The models for landings and CPUE can be used to generate predicted values that correct for changes in abundance over time and thus are more reliable with respect to determining the actual trends in those values and expected values in the future.[10] According to the information in Table 2.1, these predicted values confirm that CPUE significantly increased from 2002 through at least 2006, and possibly 2007, but remained relatively stable thereafter. Predicted CPUE was at its highest level in 2010, but this finding must be viewed with caution given the effects of the DWH event on fishing behavior in 2010. It would be safer to conclude that predicted CPUE was at its maximum in 2008. These results suggest that additional increases in CPUE from further effort reductions are likely to be minor.

The predicted values also better illustrate that landings have indeed been on a downward trend since 2006. Under the moratorium, although the highest level of observed landings was in 2009, this result was driven by above average abundance in that year. The highest level of landings

[10] However, these estimates do not account for changes in technology that have likely occurred over time and caused effort to become more efficient.

under the moratorium would have been expected under effort levels seen in 2007, the first year of the moratorium.

Table 2.1. Effort, Landings, CPUE, Predicted CPUE, and Predicted Landings in the Offshore Gulf Shrimp Fishery, 1990-2013.

Year	**Effort**	**Landings (tails)**	**CPUE**	**Predicted Landings (tails)**	**Predicted CPUE**	**Predicted Active Permitted Vessels**
1990	211,860	109,017,807	515	84,986,857	435	N/A
1991	223,388	108,127,144	484	76,013,621	375	N/A
1992	216,669	93,878,905	433	81,414,352	410	N/A
1993	204,482	86,465,838	423	89,992,830	474	N/A
1994	195,742	90,292,943	461	95,179,257	519	N/A
1995	176,589	93,907,727	532	103,724,402	619	N/A
1996	189,653	101,091,922	533	98,315,856	551	N/A
1997	207,912	86,992,070	418	87,736,988	456	N/A
1998	216,999	111,930,612	516	81,160,530	409	N/A
1999	200,475	100,419,269	501	92,470,953	495	N/A
2000	192,073	113,783,105	592	97,116,225	538	N/A
2001	197,644	97,706,647	494	94,119,050	509	N/A
2002	206,621	92,119,199	446	88,600,977	463	N/A
2003	168,135	100,203,686	596	106,263,503	663	2,361

2004[11]	146,624	96,079,478	655	109,321,652	775	2,059
2005	102,840	86,571,515	842	100,451,078	1,002	1,444
2006	92,372	120,437,081	1304	95,332,055	1,057	1,297
2007	80,733	83,126,655	1030	88,281,093	1,117	1,133
2008	62,797	71,689,314	1142	74,615,625	1,211	882
2009	76,508	101,339,883	1325	85,368,059	1,139	1,074
2010[12]	60,518	67,790,473	1120	72,635,863	1,222	850
2011	66,777	86,482,240	1295	77,941,409	1,190	938
2012	70,505	85,004,590	1206	80,904,495	1,170	990
2013	64,764	77,063,083	1190	76,280,038	1,200	909

These findings are consistent with what would be expected given where the fishery has been operating on the yield curve (see Figure 2.1). However, these findings should not be used to conclude the moratorium is the cause of the changes in observed or predicted CPUE and landings. In general, the effort reductions that have occurred during this time have been caused by poor economic conditions in the harvesting sector, particularly events that have caused increases in costs (e.g., fuel prices) and decreases in shrimp prices (e.g., increased imports and a recession). These poor economic conditions changed somewhat in 2013 because the average, real (inflation adjusted) ex-vessel shrimp price increased by 34% compared to 2012 and to a level not seen since 2001 (see Table 2.2). Although gross revenue did not increase as much (22%) in 2013, because landings fell by more than 9%, it was still at its highest level since 2001. Preliminary data suggests ex-vessel shrimp prices continued to increase in 2014, likely resulting in increased gross revenue as well, and fuel price decreased somewhat as well. However, preliminary data also suggests ex-vessel prices have abruptly turned downward in 2015, potentially erasing the increases from the two previous years. Thus, the economic turnaround in 2013-2014 may be short-lived with 2013 economic conditions likely representing a best-case scenario in the reasonably foreseeable future.

In general, it appears that observed reductions in effort from 2002 through at least 2004 and possibly 2006-07 were beneficial to the fishery due to the significant increase in CPUE without a noticeable and concomitant decrease in landings. Assuming other factors are constant (e.g., shrimp prices, fuel prices, etc.), increases in CPUE caused by a decrease in effort and the number

[11] Most closely approximates MSY conditions.
[12] DWH event

of active vessels would be expected to economically benefit the harvesting sector of the fishery by increasing the average gross revenue and net revenue/profit per vessel. Although decreases in ex-vessel price between 2001 and 2003 caused gross revenue per vessel from the offshore shrimp fishery to decrease, the positive effect of the fleet reduction on gross revenue per vessel are evident thereafter, with the level in 2013 being the highest observed in the 1990-2013 time series. Net revenue per vessel estimates are only available for 2006-2013, and only apply to permitted vessels, but reflect a similar trend.

Recent analysis demonstrates the importance of maintaining a relatively high CPUE with respect to profitability in the offshore fishery. Although other factors may play a minor role, theory suggests net revenue per vessel should be primarily a function of CPUE, ex-vessel shrimp price, and fuel price. Based on limited data (2006-2013), a linear regression model determined that net revenue is primarily driven by CPUE, with ex-vessel shrimp price also being important though slightly less so, and fuel price of less significance.[13] As expected, CPUE and ex-vessel shrimp price are positively related to net revenue per vessel (i.e. net revenue will increase as a result of an increase in CPUE and/or ex-vessel shrimp price), while fuel price is inversely related to net revenue (i.e., an increase in fuel price will decrease net revenue). More specifically, for every one pound increase in CPUE, net revenue per vessel is expected to increase by $55. A $1 increase in ex-vessel shrimp price would increase net revenue by almost $11,200, while a $1 increase in fuel price would decrease net revenue by $6,486. Of these three factors, management can only affect CPUE, and only indirectly by using direct or indirect controls on effort.

However, reductions in observed effort and fleet size after 2007 have not caused any significant improvements in CPUE, but they have caused noticeable reductions in landings. Landings reductions would be expected to cause adverse economic impacts in the onshore sector (i.e., dealers and processors) as profitability in that sector is mainly determined by physical volume and gross revenue from the harvesting sector. Thus, landings reductions would be expected to reduce employment, income, sales, and value-added in the onshore sector and thus in associated communities, states, and the Gulf region. Though not strong, Figure 2.4 illustrates a statistically significant inverse relationship between landings and CPUE. Specifically, the model suggests that an increase in landings of 1 million pounds would only reduce CPUE by 8.2 pounds per day fished, resulting in a decrease in net revenue per vessel of about $450.

[13] The regression equation is as follows: net revenue per vessel=-87654.299+(54.874*CPUE)+(11197.63*ex-vessel price)+(-6486.055*fuel price). All dollar values in real terms; n=8; R^2=.875. CPUE and ex-vessel price are statistically significant at .05 confidence level. Fuel price was not statistically significant but the model's explanatory power was noticeably higher with its inclusion.

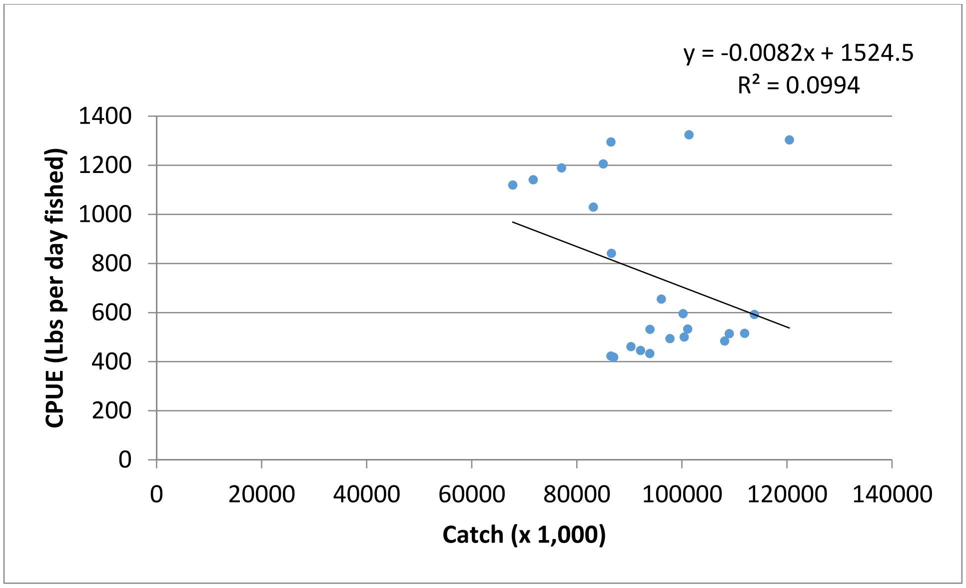

Figure 2.4. Relationship between Catch and CPUE in the offshore Gulf shrimp fishery, 1990-2013.

In general, the Council does not directly control effort in the offshore fishery, although the bycatch reduction target for juvenile red snapper places a limit on effort in certain areas of the offshore fishery. The moratorium permit is intended to indirectly control or limit effort. By limiting the number of permits and thus vessels, the moratorium on permits is expected to have placed a limit on effort in the federal waters component of the offshore fishery. By establishing a target number of moratorium permits and thus vessels, the Council could more precisely target some desired level of effort in the offshore fishery that would lead to an acceptable level of landings and CPUE, under certain economic conditions and given its management objectives for the fishery.

In order to establish such a target, the relationship between permits and/or vessels and effort needs to be determined. That is, it would be helpful to know how many permits/vessels are needed to achieve alternative levels of effort that may be desired by the Council. Information on permitted and active vessels in the offshore fishery is provided in Table 2.3 and should be considered in conjunction with effort information in Table 2.1.

Because moratorium permits are transferable and thus more than one vessel can possess the same valid permit in a given year, the number of vessels with a valid permit in a year will be greater than the number of valid permits in that year, as demonstrated by the differences in permit and vessel counts in Table 1.1.1 in Amendment 17B and Table 2.3 in this document. Effort should be more closely related to the number of vessels with permits than the number of permits. A preliminary model of the relationship between the number of permitted vessels and effort indicates such a relationship does exist and, rather surprisingly, the relationship is not only positive but relatively strong. This finding was not expected because a previous analysis showed that all permits or permitted vessels were not active each year (i.e., some were "latent"), and some were not active in any of the first three years of the moratorium (SERO 2010). However, even though the estimated model explained much of the variability in effort, it also consistently overestimated observed effort and thus is not considered reliable for policy purposes. Further, in theory, effort should be more closely related to the number of active vessels rather than the number of permitted vessels in the fishery. Thus, a model that examines the relationship between active vessels and effort is expected to yield better results (i.e., it will explain as much if not more of the variability in effort, but also generate more accurate predictions of effort).

For current purposes, a vessel is only considered to be "active" in a particular year if it had shrimp landings from Gulf offshore waters according to the most currently available GSS data for 1990-2013. Thus, for example, if a vessel only had landings from inshore waters or in another region (e.g., South Atlantic), it is not considered "active" in this analysis.

In Table 2.3, "permitted vessels" refers to the number of vessels that held a valid open access or moratorium permit in each specific year from 2003 through 2014. The significant decrease in permitted vessels between 2007 and 2008 reflects the effect of the moratorium. As with the number of permits, the number of permitted vessels has continuously declined from the time permits were first required throughout the moratorium, though the rate of decline decreased in 2013 and 2014. Though most of these vessels had federal permits between 2003 and 2013, a federal permit is not required to harvest shrimp in state offshore waters. Thus, the number of active vessels in the offshore fishery will generally exceed the number of permitted or active permitted vessels. The number of active vessels in the offshore fishery declined significantly (49%) between 2002 and 2008, but has remained relatively stable since, with the notable exception of 2010 which was undoubtedly due to the DWH event.

Table 2.2. Gross Revenue, Ex-Vessel Price, Fuel Price, and Net Revenue per Active Permitted Vessel in the Offshore Gulf Shrimp Fishery, 1990-2013.

Year	Gross Revenue (Nominal)[14]	Gross Revenue (Real)[15]	Ex-Vessel Price (Nominal)	Ex-Vessel Price (Real)	Fuel Price (Nominal)[16]	Fuel Price (Real)	Gross Revenue per Vessel (Real)	Net Revenue per Vessel (Real)[17]
1990	$314,929,509	$395,009,857	$2.89	$3.62	N/A	N/A	$115,130	N/A
1991	$347,842,006	$422,256,220	$3.22	$3.91	N/A	N/A	$125,113	N/A
1992	$285,251,679	$338,565,605	$3.04	$3.61	N/A	N/A	$103,474	N/A
1993	$259,664,115	$301,031,922	$3.00	$3.48	N/A	N/A	$93,256	N/A
1994	$353,105,982	$400,828,640	$3.91	$4.44	N/A	N/A	$115,846	N/A
1995	$349,558,754	$388,692,294	$3.72	$4.14	N/A	N/A	$116,935	N/A
1996	$332,150,302	$362,716,414	$3.29	$3.59	N/A	N/A	$106,964	N/A
1997	$340,213,595	$365,263,356	$3.91	$4.20	N/A	N/A	$112,493	N/A
1998	$380,646,267	$404,289,093	$3.40	$3.61	N/A	N/A	$129,001	N/A
1999	$373,675,269	$390,906,424	$3.72	$3.89	N/A	N/A	$126,058	N/A
2000	$485,387,192	$496,473,444	$4.27	$4.36	N/A	N/A	$166,100	N/A

[14] Nominal gross revenue and ex-vessel price estimates are based on GSS data, James Primrose, personal communication, July 10, 2015.
[15] All real estimates have been adjusted for inflation into 2001 dollars using the GDP deflator.
[16] Fuel prices and net revenue per vessel estimates are only for active permitted vessels rather than all active offshore vessels and are based on Liese, 2011, 2013, 2014, 2015 (forthcoming); Liese and Travis, 2010; Liese et al., 2009a, 2009b. The Annual Economic Survey of Federal Gulf Shrimp Permit Holders, NMFS-SEFSC.

[17] Net revenue estimates are for permitted vessels with landings from the Gulf shrimp fishery in general as opposed to the offshore fishery because net revenue estimates have not been estimated for permitted vessels that were active in the offshore fishery.

2001	$355,064,936	$355,064,936	$3.63	$3.63	N/A	N/A	$117,923	N/A
2002	$281,472,047	$277,219,500	$3.06	$3.01	N/A	N/A	$82,826	N/A
2003	$270,635,465	$261,349,710	$2.70	$2.61	N/A	N/A	$84,964	N/A
2004	$268,840,649	$252,667,408	$2.80	$2.63	N/A	N/A	$87,640	N/A
2005	$262,002,593	$238,565,881	$3.03	$2.76	N/A	N/A	$98,297	N/A
2006	$297,644,024	$262,927,126	$2.47	$2.18	$2.06	$1.82	$117,221	-$6,562
2007	$252,184,090	$216,996,016	$3.03	$2.61	$2.39	$2.05	$112,317	-$16,893
2008	$255,638,060	$215,722,859	$3.57	$3.01	$3.08	$2.60	$126,228	-$7,313
2009	$228,596,619	$191,456,058	$2.26	$1.89	$2.05	$1.72	$101,730	-$2,823
2010	$237,689,580	$196,678,235	$3.51	$2.90	$2.46	$2.03	$144,192	-$3,657
2011	$320,788,313	$260,069,814	$3.71	$3.01	$3.17	$2.57	$159,552	$1,113
2012	$291,314,188	$232,004,546	$3.43	$2.73	$3.24	$2.58	$135,517	-$7,856
2013	$359,631,710	$282,212,386	$4.67	$3.66	$3.19	$2.51	$171,662	$1,212

Table 2.3. Number of Permitted and Active Vessels by Size Category in the Offshore Gulf Shrimp Fishery, 1990-2014.

Year	Active Vessels	Large Active Vessels	Small Active Vessels	Permitted Vessels	Active Permitted Vessels	Large Active Permitted Vessels	Small Active Permitted Vessels
1990	3,431	2,034	1,397	N/A	N/A	N/A	N/A
1991	3,375	1,954	1,421	N/A	N/A	N/A	N/A
1992	3,272	1,916	1,356	N/A	N/A	N/A	N/A
1993	3,228	1,894	1,334	N/A	N/A	N/A	N/A
1994	3,460	1,912	1,548	N/A	N/A	N/A	N/A
1995	3,324	1,929	1,395	N/A	N/A	N/A	N/A
1996	3,391	2,022	1,369	N/A	N/A	N/A	N/A
1997	3,247	2,011	1,236	N/A	N/A	N/A	N/A
1998	3,134	1,981	1,153	N/A	N/A	N/A	N/A
1999	3,101	1,920	1,181	N/A	N/A	N/A	N/A
2000	2,989	1,918	1,071	N/A	N/A	N/A	N/A
2001	3,011	2,032	979	N/A	N/A	N/A	N/A
2002	3,357	1,956	1,401[18]	N/A	N/A	N/A	N/A
2003	3,085	1,810	1,275	2,688	1,953	1,656	297

[18] Reflects artificial increase due to change in Gulf Shrimp System (GSS) data protocols wherein landings data came from LA and AL trip tickets, rather than port agents, which explicitly identified state registered boats. Florida trip ticket data was also incorporated over the next few years.

2004[19]	2,888	1,658	1,230	2,791	1,833	1,548	285
2005	2,427	1,493	934	2,713	1,676	1,405	271
2006	2,250	1,252	998	2,578	1,426	1,182	244
2007[20]	1,940	1,137	803	2,514	1,283	1,084	199
2008[21]	1,714	994	720	1,930	1,059	942	117
2009	1,891	1,001	890	1,764	1,075	959	116
2010[22]	1,365	902	463	1,685	951	865	86
2011[23]	1,638	929	709	1,641	1,013	898	115
2012	1,724	938	786	1,587	1,014	885	129
2013	1,649	904	745	1,544	970	858	112
2014[24]	N/A	N/A	N/A	1,515	N/A	N/A	N/A

[19] MSY
[20] Max predicted landings under moratorium and high predicted CPUE.
[21] Max predicted CPUE but significantly lower predicted landings.
[22] DWH event
[23] Effort in juvenile red snapper areas at highest level during moratorium without triggering a closure
[24] GSS data for 2014 was not finalized when this analysis was conducted.

Historically, economic analyses of the Gulf shrimp fishery have separated vessels in the fishery by size category, where “large” vessels are those 60 ft or greater in length and “small” vessels are less than 60 ft in length. For Coast Guard documented vessels, length is the vessel’s registered length.[25] For state registered vessels with federal permits, length is what permit holders provide on their applications. NMFS does not possess length data for non-permitted vessels. Since vessels with a net tonnage greater than 5 net tons must be documented, and vessels less than 5 net tons are typically less than 60 ft in length, state registered vessels without permits are assumed to be small vessels in this analysis. As expected, large vessels represent the majority of vessels in the offshore fishery. The number of active large vessels declined from 2002-2008, but has remained relatively stable thereafter. Participation by small vessels has also declined over time, but is more variable and more susceptible to major events, such as the hurricanes in 2005 and the DWH event in 2010.

Changes in active permitted vessels basically mimic the trends for all offshore vessels, with the same holding true for large and small vessels, though small permitted vessels represent a somewhat smaller percentage of active permitted vessels in 2013 (11.5%) than they did back in 2003 (15%). Small vessels can more effectively operate in inshore waters than large vessels, and have likely been more inclined to do so given economic conditions over the past decade.

An analysis of the relationship between the various estimates of active vessels in the offshore fishery (i.e., all active, large active, active permitted, and large active permitted) was conducted to see whether any had a strong, direct relationship with offshore effort. Though theory would suggest the strongest relationship should be between all active vessels and offshore effort, that relationship is likely confounded by a change in data protocols that affected the estimate of small active vessels as state registered vessels were not explicitly identified in the GSS data until 2002 and thus the number of small vessels was systematically underestimated in previous years. As such, the estimates of large active vessels are more reliable over the time period considered in this analysis. In addition, the relationship between all active vessels and offshore effort would be expected to be stronger than the relationship between active permitted vessels and offshore effort since permitted vessels only account for a percentage of effort in offshore waters.

These hypotheses were only partly confirmed by the empirical findings. All models were statistically significant and found a strong, direct relationship between offshore effort and the specific number of active vessels under consideration. Though the models are essentially equivalent with respect to statistical significance, the strongest relationships were found between active permitted vessels and offshore effort [26] and between large active vessels and offshore

[25] Length data was missing from the CG database for a small number of CG documented vessels that did not have permits, and thus this analysis assumed these vessels are large vessels.
[26] Model is offshore effort=71.225*number of active permitted vessels. R^2 is .982.

effort.[27] The relationship between large active permitted vessels and offshore effort[28] is somewhat stronger than the relationship between all active vessels and offshore effort.[29]

These results suggest the Council can indirectly control or at least limit offshore effort by controlling the number of vessels with federal permits. If a particular level of offshore effort is desired based on various management objectives, these results are suggestive of what the target number of federally permitted vessels should be. However, these models were developed and should generally be used for predictive purposes only and interpretation should be made with care.

For example, for the model that estimates the relationship between offshore effort and the number of active permitted vessels, it is not appropriate to conclude that the average number of days fished per active permitted vessel is 71.2 days because active permitted vessels are not solely responsible for all of the offshore effort (i.e., some unknown percentage of offshore effort comes from active non-permitted vessels). On the other hand, according to the model that estimates the relationship between offshore effort and the number of active vessels (permitted and non-permitted) in offshore waters, it is accurate to conclude that the predicted number of days fished by active vessels (permitted and non-permitted) in offshore waters is approximately 57.8 days. That said, this predicted value is based on data from 1990-2013 and the average number of days fished in offshore waters per active vessel has changed significantly over that time period, as can be seen in Table 2.4. Table 2.4 combines information on offshore effort from Table 2.1 and the number of active vessels in offshore waters from Table 2.3. Between 1990 and 2001, the average annual days fished per vessel was about 63 days fished. Although the decline in the average days fished per active vessel from 2001 to 2002 is likely an artifact of changes in data collection protocols, the declines from 2002 to 2005 are likely real changes caused by the same economic factors that led to the declines in effort and active vessels during that time. Average annual effort per vessel has been relatively stable since 2005, and has averaged around 41 days between 2006 and 2013.

Of greatest interest to management is the model that estimates the relationship between offshore effort and the number of active permitted vessels as it predicts the number of active permitted vessels that would be needed to achieve a specific level of offshore effort, such as the level of offshore effort associated with a particular management objective or in a given year. For example, because effort at MSY was estimated to be approximately 143,756 days fished, the number of active permitted vessels needed to achieve MSY would be 2,018, somewhat higher

[27] Model is offshore effort=97.283*number of large active vessels. R^2 is .982.
[28] Model is offshore effort=83.03*number of large active permitted vessels. R^2 is .980.
[29] Model is offshore effort=57.773*number of active vessels. R^2 is .976.

than the number of permits initially issued at the beginning of the moratorium. If MSY is the management objective, the number of active permitted vessels and thus the number of valid permits would have to increase significantly from current levels.

The predicted number of active permitted vessels needed to attain levels of actual offshore effort in each year between 2003 and 2013 is provided in Table 2.1. Predicted CPUE is maximized in 2008, but with significantly lower predicted landings compared to 2007. The number of active permitted vessels needed to achieve actual effort in 2008 is 882. Alternatively, predicted CPUE is relatively high in 2007, but with a significantly higher level of predicted landings. The number of active permitted vessels needed to achieve effort in 2007 is 1,134. The number of active permitted vessels needed to achieve effort in 2009 is 1,074, which may be important for management objectives other than a high CPUE or relatively high landings and is also almost exactly the number of permitted vessels that were in fact active in offshore waters that year (1,075 vessels).

These potential targets presume all permitted vessels will in fact be active in the offshore fishery, which is consistent with a desire to not have any inactive or "latent" federally permitted vessels. In a given year, a federally permitted vessel may not be active in the offshore fishery for a number of potential reasons, including but not necessarily limited to: illness of the vessel owner, temporary loss of the vessel (e.g., due to repairs or damage from a storm), poor economic conditions in the offshore fishery, a decision to temporarily use the permitted vessel in another fishery (including the inshore fishery), etc. This is an issue for the Council to consider when potentially establishing a threshold level of permits in Amendment 17B.

Table 2.4. Effort, Active Vessels, and Average Effort per Vessel in the Offshore Gulf Shrimp Fishery, 1990-2013.

Year	**Effort**	**Active Vessels**	**Average Effort per Vessel**
1990	211,860	3,431	61.7
1991	223,388	3,375	66.2
1992	216,669	3,272	66.2
1993	204,482	3,228	63.3
1994	195,742	3,460	56.6
1995	176,589	3,324	53.1

1996	189,653	3,391	55.9
1997	207,912	3,247	64.0
1998	216,999	3,134	69.2
1999	200,475	3,101	64.6
2000	192,073	2,989	64.3
2001	197,644	3,011	65.6
2002	206,621	3,357	61.5
2003	168,135	3,085	54.5
2004	146,624	2,888	50.8
2005	102,840	2,427	42.4
2006	92,372	2,250	41.1
2007	80,733	1,940	41.6
2008	62,797	1,714	36.6
2009	76,508	1,891	40.5
2010	60,518	1,365	44.3
2011	66,777	1,638	40.8
2012	70,505	1,724	40.9
2013	64,764	1,649	39.3