Evaluation of Golden Tilefish Season Length under Regulatory Amendment 23 Alternatives

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August 20, 2015

Introduction

The South Atlantic Fishery Management Council (Council) manages golden tilefish (*Lopholatilus chamaeleonticeps*) in federal waters from East Florida to North Carolina. The current fishing season begins January 1 and ends December 31. Historically, the commercial portion of the snapper-grouper fishery for golden tilefish has been managed under a single quota, and has often been subjected to quota closures prior to the end of the calendar year (10/23/06, 10/3/07, 8/17/08, 7/15/09, 4/12/10, 3/9/11, 2/17/12, 5/5/13). In 2012, separate quotas were specified for the hook-and-line sector and longline sector through Regulatory Amendment 12 to the Fishery Management Plan for the Snapper-Grouper Fishery of the South Atlantic Region (Snapper-Grouper FMP). The longline sector was closed on 3/5/14 and the hook-and-line sector was closed on 8/29/14 due to quota overages. The longline sector was closed 2/19/15 to avoid a quota overage. As of 8/6/15, the hook-and-line sector was at 71% of the quota and remained open.

The Council is currently considering altering the fishing year for the hook-and-line sector (includes all gear types except longline) through Regulatory Amendment 23 to the Snapper-Grouper FMP (Regulatory Amendment 23). The Council's Snapper-Grouper Advisory Panel members stated that the intent of modifying the fishing year start date for the hook-and-line sector is to allow fishermen to target golden tilefish in the fall, which is the time of the year they had historically caught this species. There are three proposed alternatives for this action:

Alternative 1 (No action). Do not modify the fishing year start date for the hook-and-line sector of the commercial golden tilefish fishery. The fishing year begins on January 1 and ends on December 31.

Alternative 2. Change the fishing year for the hook-and-line sector of the commercial golden tilefish fishery to:
Sub-alternative 2a. March 1 to February 28/29
Sub-alternative 2b. April 1 to March 31
Sub-alternative 2c. May 1 to April 30

Alternative 3. Allow the start date of the fishing year for the hook-and-line sector to coincide with closure of the longline sector.

This report analyzes the cumulative landings and proposed closure dates for the longline and hook-and-line sectors of the commercial golden tilefish portion of the snapper-grouper fishery.

Methods

Golden tilefish data for 2000-2013 were obtained from the NOAA Fisheries Southeast Fisheries Science Center (SEFSC) annual catch limit (ACL) Dataset (accessed July 2014). The SEFSC commercial ACL dataset provides additional quality control for data collected via state trip ticket programs. Additional data for 2014 and 2015 were provided in separate files by SEFSC in August 2015 (pers. comm), and originated from the Atlantic Coastal Cooperative Statistics Program (ACCSP) trip ticket data warehouse. Data were summarized as landings whole weight by month and gear (i.e., 'longline' and 'other'). Gear other than longline were assigned to the 'hook-and-line' ACL and included hook-and-line, handline, and trawls. Effort and catch-per-unit effort (CPUE) data were attained from the SEFSC's commercial Coastal Logbook program (accessed July 2015), which summarizes landings on a trip level, with information including landings in pounds whole weight (lb ww), primary gear used, and primary area and depth of capture.

Due to the numerous quota closures in the golden tilefish commercial landings time series, a variety of projection methods were used to capture the uncertainty in monthly catch rates:

1) Constant 2015 catch rates
2) Constant 2014 catch rates
3) Average 2012-2014 catch rates
4) Seasonal Auto-Regressive Integrated Moving Average (SARIMA) regression model

To predict precise closure dates and to utilize landings data from months subject to historical quota closures, projections were run on daily catch rates that assumed landings were uniformly distributed within months. For scenarios using observed historical catch rates, months without data were backfilled using SARIMA model fits for that month. The SARIMA model is described in detail by Farmer and Froeschke (2015). A SARIMA model can be thought of as a multiple regression model with lagged values as covariates. SARIMA models are flexible and assume that future conditions are similar to the past conditions that generated the observed data. Farmer and Froeschke (2015) demonstrated that SARIMA models provide good fits to historical data (including gap filling) and provide useful fisheries forecasts.

SARIMA models can be fit to covariates so long as future values are known or can be predicted. Several covariates were explored for SARIMA model fits to the hook-and-line and longline catch-per-day regression time series:

1) Mean monthly price per pound
2) Total effort by gear
3) Standardized catch per unit effort (CPUE)
4) Per capita gross domestic product (PC-GDP)
5) Mean fuel prices
6) Total fishing season days

Mean monthly price per pound was derived from the SEFSC ACL Dataset and values from 2013 were assumed to persist for 2014-2016 for projection purposes. Total effort from the Coastal Logbook was expressed as hook-hours. Standardized CPUE was computed by gear following methods described in SEDAR (2008) and Farmer (2014), with landings data aggregated at the (year, area) level to ensure regression bins were filled for the delta-lognormal standardization approach. Standardized CPUEs for 2014 were assumed constant for 2015-2016. PC-GDP was obtained from the World Bank; 2015 PC-GDP was computed from a linear regression on 2000-2014 data (R^2=95.7%, $F_{1,13}$=288, P<0.0001). Mean U.S. fuel prices were obtained from the U.S. Energy Information Administration; 2015 mean fuel price was computed from a linear regression on 2000-2014 data (R^2=86.3%, $F_{1,13}$=82, P<0.0001). Total fishing

season days were computed by summing the number of days open to golden tilefish harvest, by gear, in federal waters, for each season; 2015 fishing season days were assumed to be 365 for both gear types.

Following Farmer and Froeschke (2015), eight different permutations of single-difference SARIMA models were run for the commercial golden tilefish 'longline' and 'hook-and-line' sectors. Models were fit using custom software with Proc ARIMA in SAS (SAS Institute Inc., Cary, NC), with only significant covariates retained. The best-fitting models were selected based on significance of regression parameters, goodness-of-fit, and Akaike information criterion (Akaike 1974). Negative model fits were replaced with the values for the previous observed catch rate for that month. Goodness of fit was measured by regressing observed against predicted values and measuring R^2. Finally, projections were performed using a custom program in Microsoft Excel that tracked daily catch rates and cumulative landings relative to the ACL for the various season start dates proposed in Regulatory Amendment 23 under the various catch rate scenarios described above.

Results

Monthly commercial longline landings for golden tilefish have historically been higher than hook-and-line landings (Figure 1), with a monthly peak of 314,480 lb ww in January 2014. The onset of early closures appears to have created a derby condition (i.e., "a race to fish") for both gear types, which was characterized by high monthly landings at the opening of the fishing season and early quota closures. This condition appears somewhat reduced for hook-and-line in 2015.

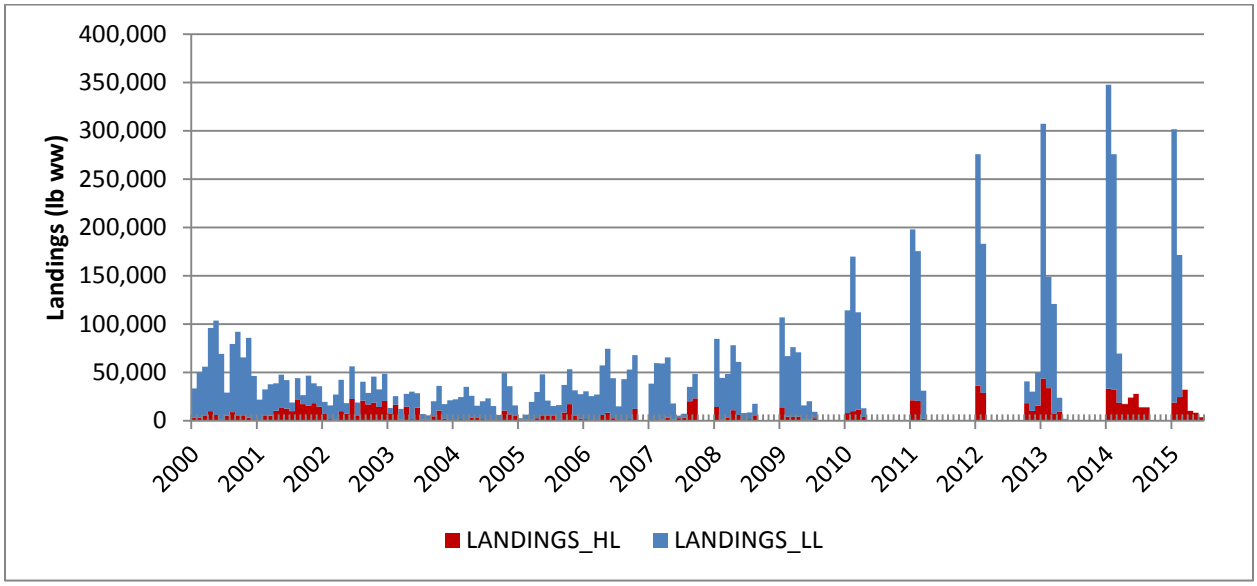

Figure 1. Monthly commercial landings, in pounds whole weight, of golden tilefish in South Atlantic waters by longline and hook and line gear. Source: SEFSC ACL Data and ACCSP Trip Tickets.

Monthly price per pound has increased through time, with hook and line sometimes earning slightly more per pound (Figure 2). Pricing has been consistent between the two gear types in recent years and has been relatively high despite possible market saturation.

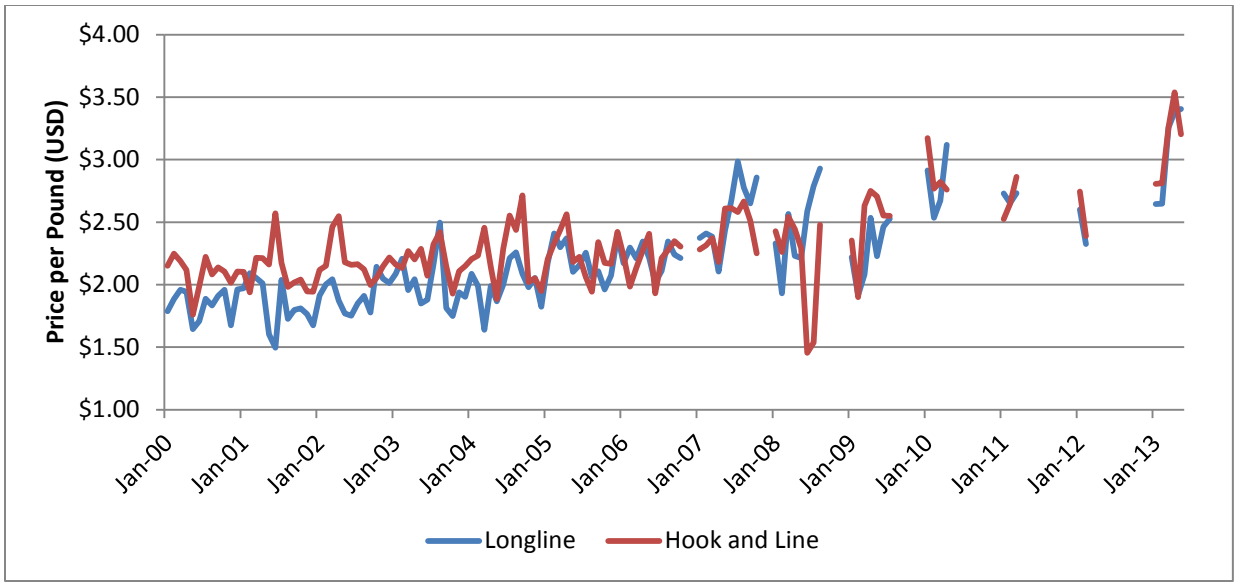

Figure 2. Monthly commercial price per pound, in non-adjusted U.S. Dollars, of golden tilefish in South Atlantic waters for longline and hook and line gear. Source: SEFSC ACL Data.

Standardized CPUE for commercial golden tilefish landed by longline was relatively low until 2005, then increased through 2010 and fell from 2010-2014 (Figure 3). Standardized CPUE for commercial golden tilefish landed by hook and line has increased steadily since 2003 (Figure 4).

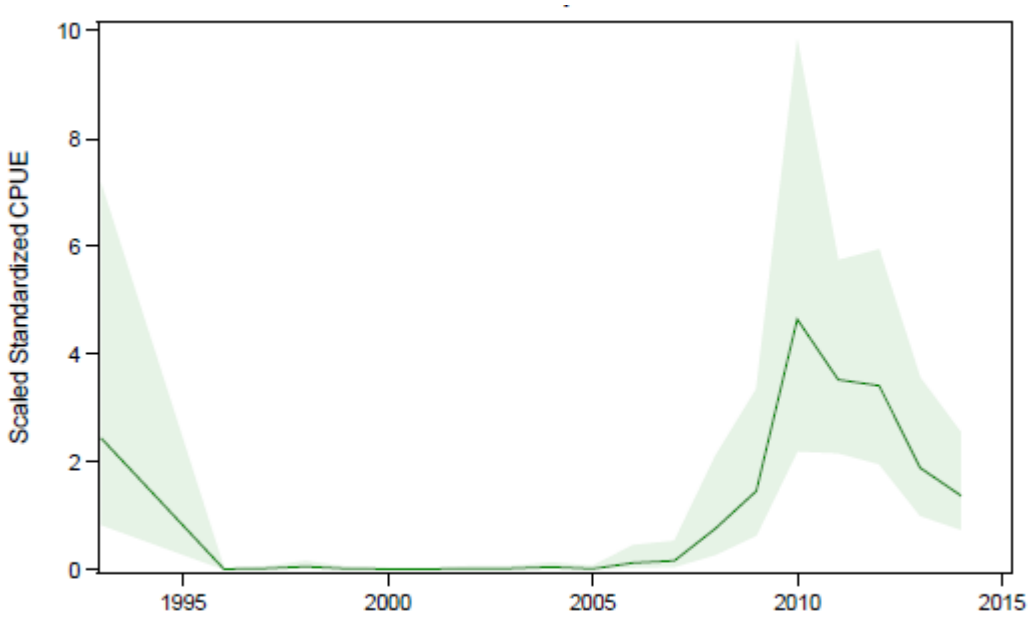

Figure 3. Monthly commercial standardized CPUE for golden tilefish in South Atlantic waters for longline gear, with delta-lognormal regression model factors of year and area. Green band denotes 95% confidence interval. Source: SEFSC Coastal Logbook (July 2015).

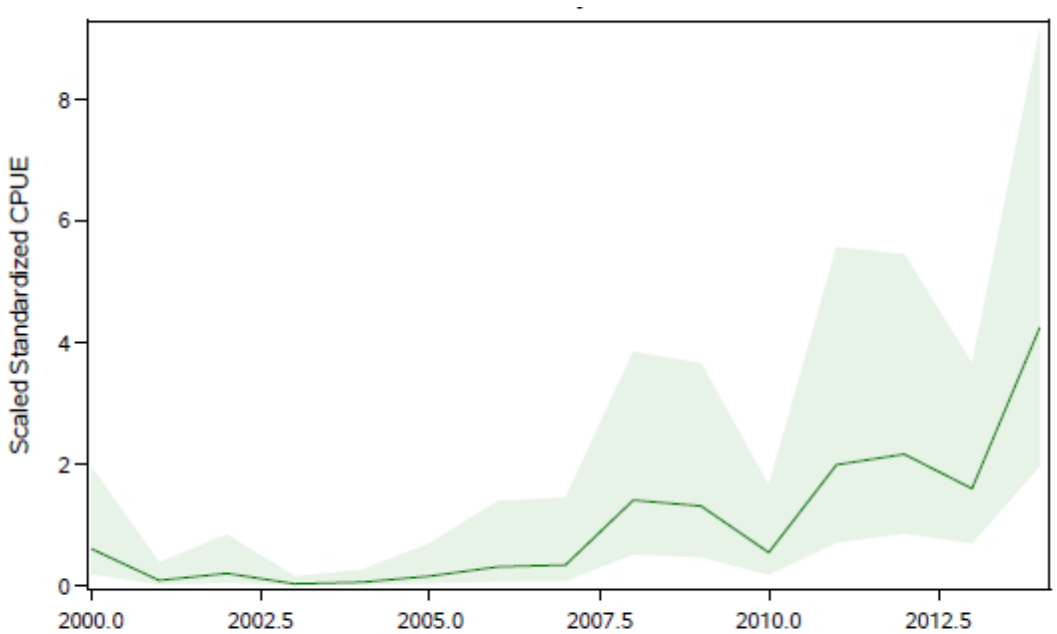

Figure 4. Monthly commercial standardized CPUE for golden tilefish in South Atlantic waters for hook-and-line gear, with delta-lognormal regression model factors of year and area. Green band denotes 95% confidence interval. Source: SEFSC Coastal Logbook (July 2015).

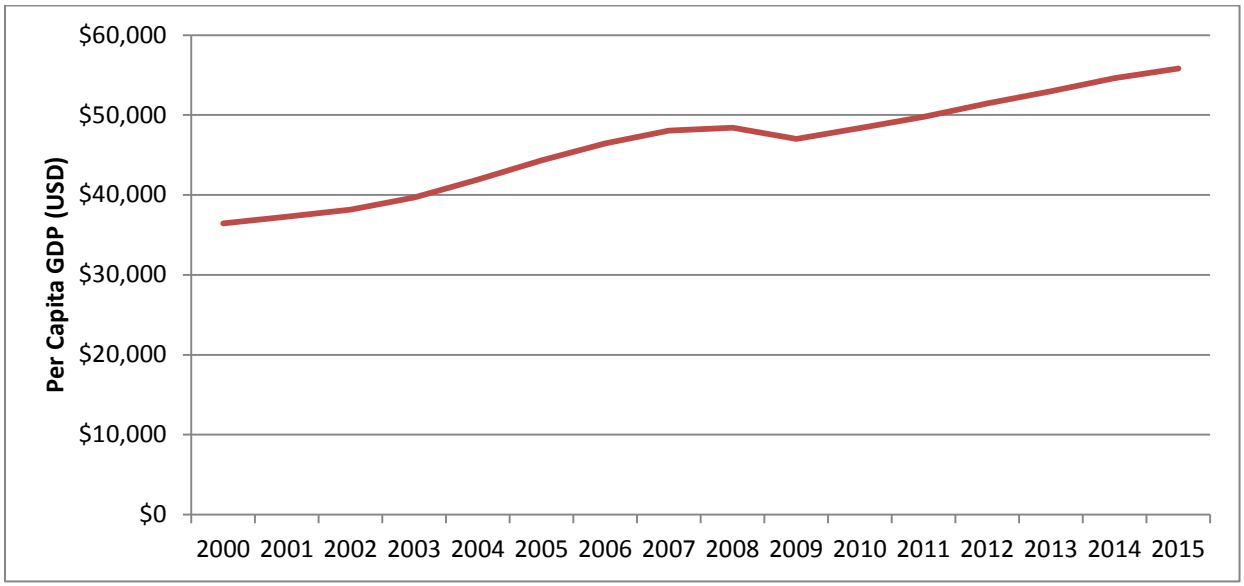

Figure 5. Per capita U.S. Gross Domestic Product (Source: http://data.worldbank.org/country/united-states).

Per capita GDP has increased relatively steadily across the 2000-2015 period (Figure 5). Mean U.S. fuel prices took a dip in 2009 and 2014, but increased steadily during most of the time series (Figure 6). Due to quota closures, the length of the federal fishing season for golden tilefish (both gear types combined) declined steadily from 2005-2012. In 2012, separate quotas were specified for the hook-and-line sector and longline sector. The length of the hook-and-line fishing season has increased steadily since 2012 (Figure 7). The longline season increased slightly 2012-2013, but declined from 2013-2015.

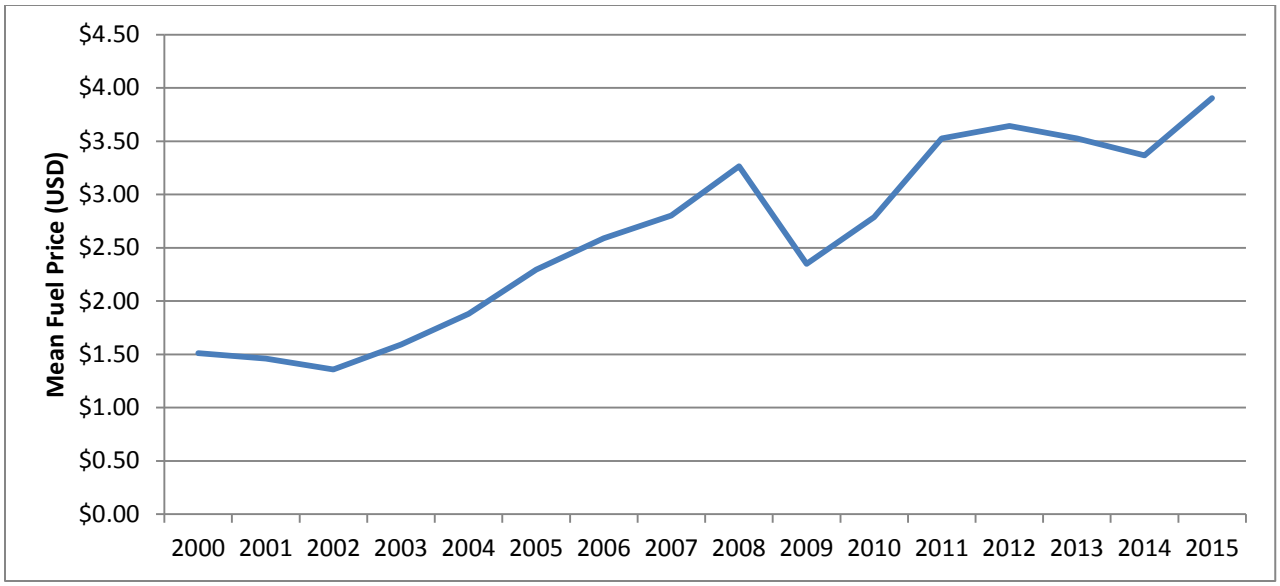

Figure 6. Mean U.S. fuel domestic fuel prices (Source: http://www.eia.gov/petroleum/data.cfm#prices).

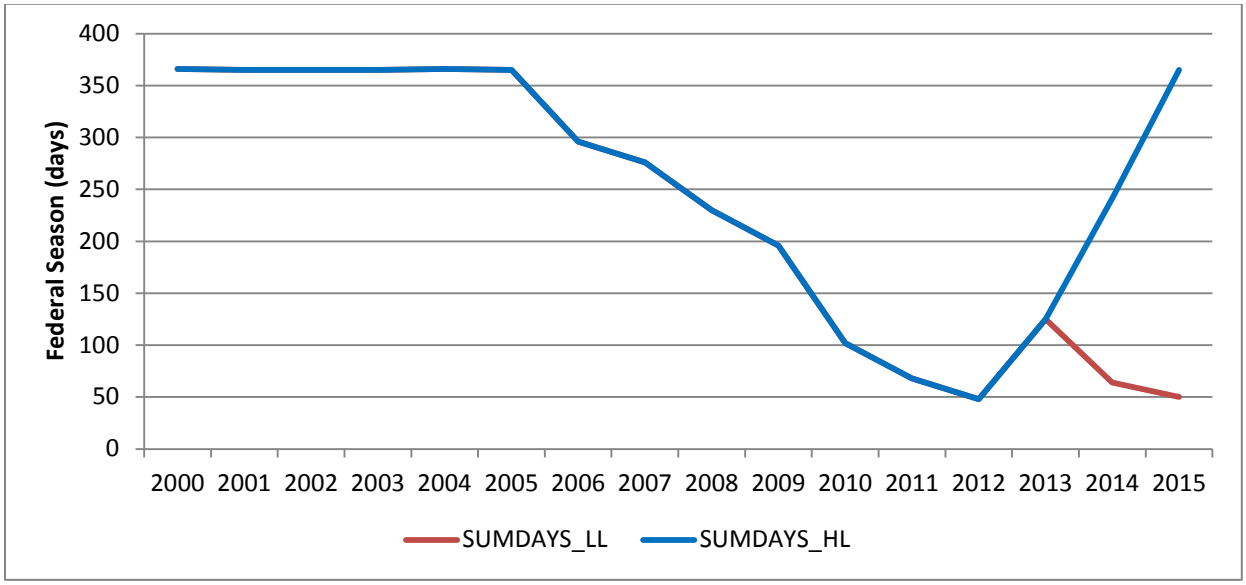

Figure 7. Monthly commercial effort for golden tilefish in South Atlantic waters, by gear. Source: SEFSC Coastal Logbook (July 2015).

The best-fitting SARIMA model for hook-and-line gear was differenced at 1 and 12 month intervals, and had a moving average parameter for these intervals (Table 1). No permutations of the SARIMA model for hook-and-line gear contained all significant parameter estimates; thus, this final model was somewhat unsatisfactory. No covariates were significant. Regression diagnostic figures are provided in Figure 8. Goodness of fit was fair (R^2=74%). Regression fits to observed catch rate data are provided in Figure 9. Most observations were within the 95% confidence band. The model overestimated early season catch rates in 2014 but provided reasonably good fits to 2015 data. The model predicts 2016 early season catch rates will be higher than 2015 (Figure 9).

Table 1. Conditional least squares estimates for SARIMA model parameters fit to golden tilefish commercial hook and line data. Note model included two moving average terms, lagged at 1 and 12 months, respectively, and no significant covariates.

Parameter	Estimate	Standard Error	t Value	Pr > |t|	Lag
MU	11.43334	65.5564	0.17	0.8624	0
MA1,1	-0.50644	0.16829	-3.01	0.0044	1
MA2,1	-0.43256	0.23808	-1.82	0.0762	12

The best-fitting SARIMA model for longline gear was differenced at 1 and 12 month intervals and had a moving average parameter for these intervals (Table 2). All parameter estimates were significant, and a covariate for mean fuel price was a significant predictor. Regression diagnostic figures are provided in Figure 10. Goodness of fit was excellent (R^2=95%). Regression fits to observed catch rate data are provided in Figure 11. All observations were within the 95% confidence band. The model provided good fits to recent data. The model predicts 2016 early season catch rates will be higher than 2015 (Figure 11).

Table 2. Conditional least squares estimates for SARIMA model parameters fit to golden tilefish commercial longline data. Note model included two moving average terms, lagged at 1 and 12 months, respectively, and a significant covariate for mean U.S. fuel price.

Parameter	Estimate	Standard Error	t Value	Pr > |t|	Lag
MU	-2092.2	747.1103	-2.8	0.0079	0
MA1,1	-0.79745	0.1436	-5.55	<.0001	1
MA2,1	0.89623	0.16582	5.4	<.0001	12
Fuel Price	975.1517	250.9388	3.89	0.0004	0

Predicted monthly catch rates for the four scenarios and two gear are presented in Table 3. In general, projections for late season catch rates were less robust than projections for early season catch rates, which would be expected given the many years of early quota closures in the input data. Longline catch rates were much higher than hook and line daily catch rates. SARIMA modeled catch rates were higher than catch rates based on recent landings for most months.

Projected landings and closure dates are presented in Table 4. Longline projections were robust to uncertainty, with closure dates ranging from February 1-15. Projected closure dates for hook-and-line gear were more uncertain. Under Alternative 1 (January 1 opening), hook-and-line closure dates for the 2016 fishing year ranged from May 28-October 28, 2016. Under Alternative 2a (March 1 opening), projected hook-and-line closure dates for the 2016/17 fishing season ranged from October 31-February 11. Under Alternative 2b (April 1 opening), projected hook-and-line closure dates for the 2016/17 fishing season ranged from January 5, 2017-March 18, 2017. Under Alternative 2c (May 1 opening), projected hook-and-line closure dates for the 2016/17 fishing season ranged from January 21, 2017-March 27, 2017. Under Alternative 3, which would start the hook-and-line fishing year to start when the longline sector closed, projected hook-and-line closure dates for the 2016/17 fishing season ranged from August 23, 2016 to January 26, 2017.

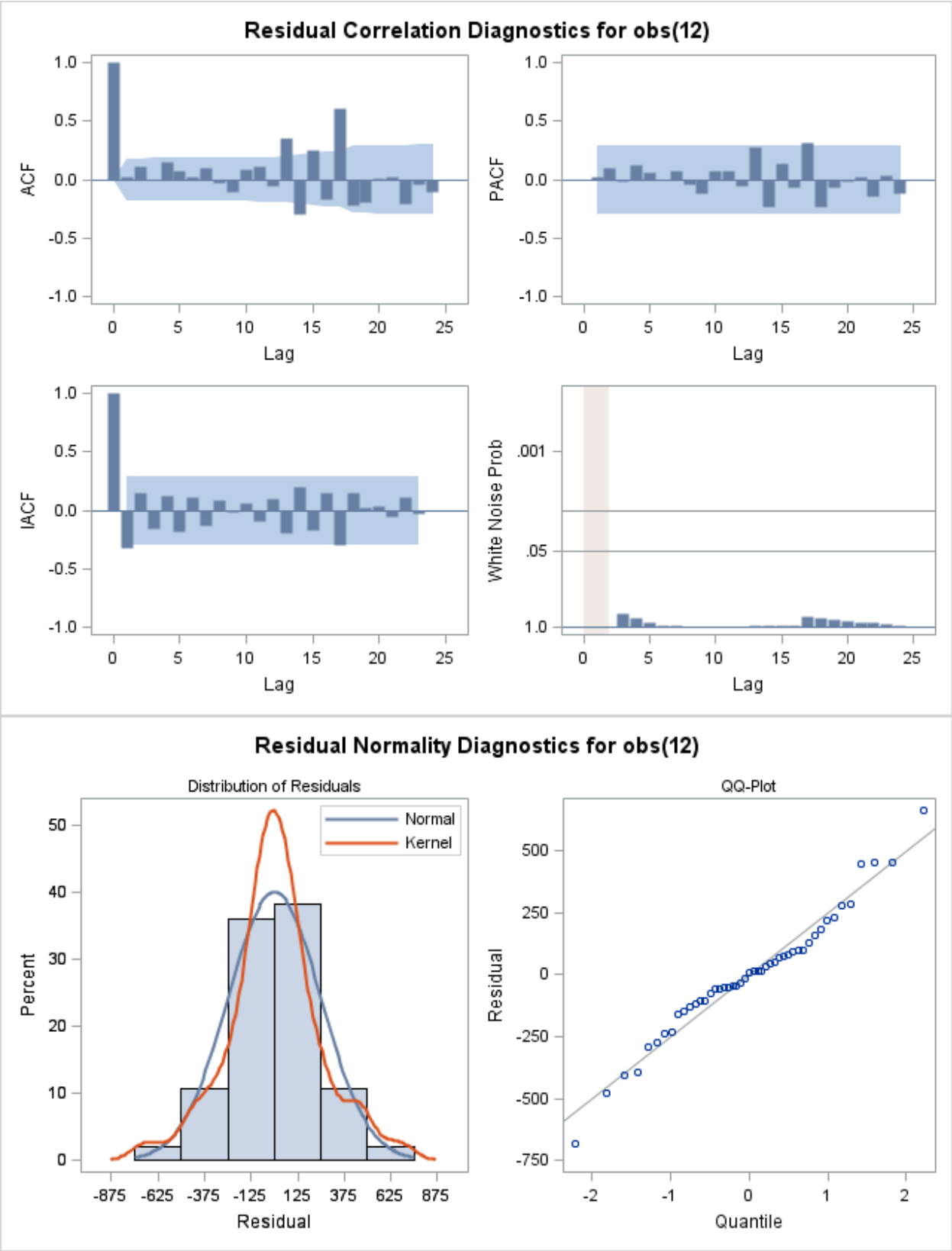

Figure 8. Golden tilefish commercial hook and line SARIMA model fit diagnostic plots, indicating differencing yielded appropriate model fit.

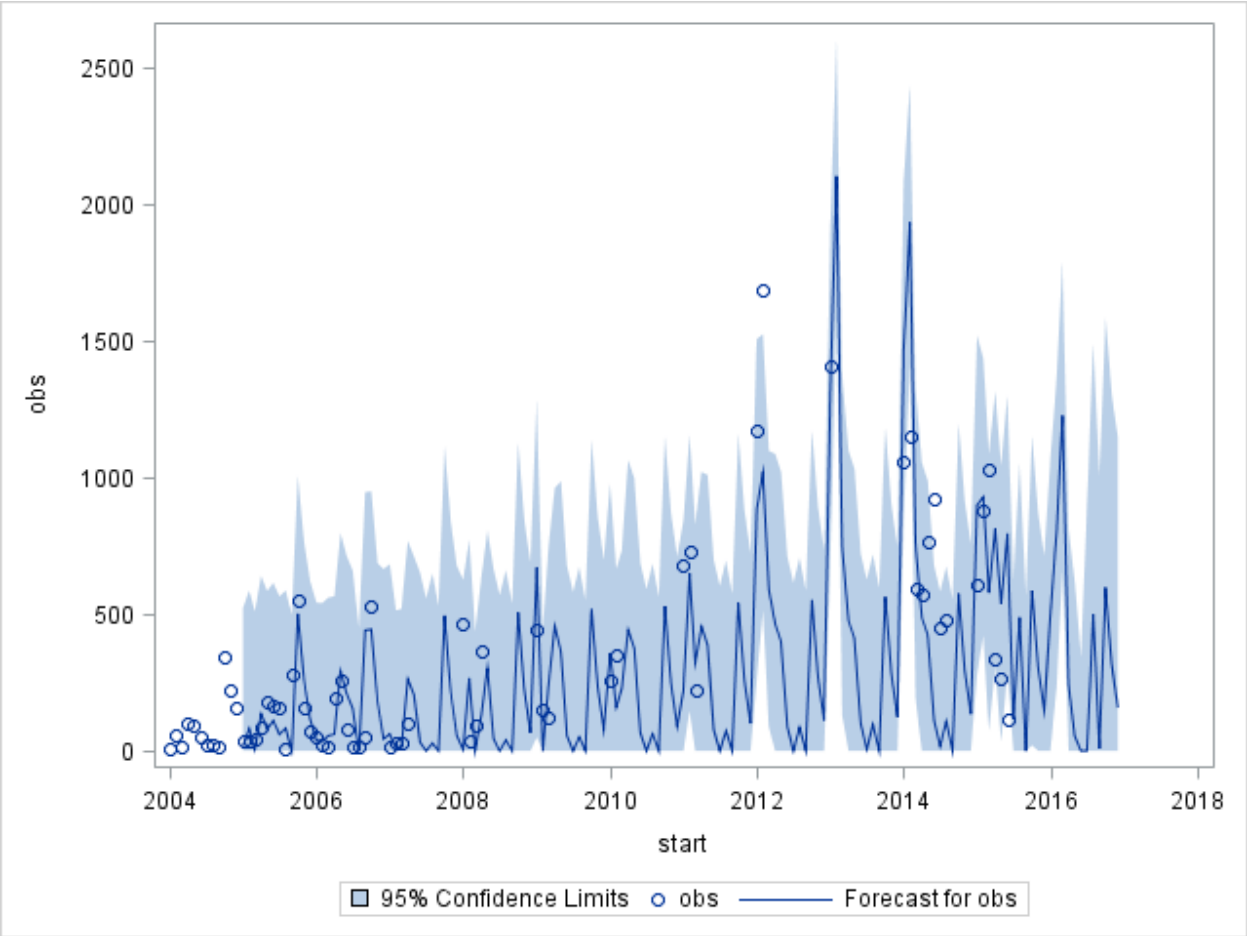

Figure 9. Golden tilefish commercial hook and line SARIMA model fit to observed data (open circles) and predicted catch rate for 2016.

Table 3. Predicted catch rates (lb ww/day) for commercial golden tilefish in 2016, by month and gear.

	Hook and Line				Longline			
Month	const 2015	const 2014	avg '12-'14	SARIMA	const 2015	const 2014	avg '12-'14	SARIMA
1	611	1,061	1,213	498	9,120	10,145	8,787	12,534
2	877	1,152	1,648	802	7,730	8,700	8,822	11,248
3	1,031	594	646	1,227	11,533	10,218	7,521	13,605
4	337	572	505	242	10,881	9,167	7,924	12,596
5	265	768	526	54	10,852	9,138	7,895	12,567
6	116	922	370	116	10,816	9,101	7,858	12,530
7	117	450	150	450	10,785	9,070	7,827	12,499
8	489	477	220	500	10,683	8,969	7,726	12,398
9	49	49	49	9	10,535	8,820	7,577	12,249
10	587	575	564	598	11,486	9,771	8,528	13,200
11	304	292	281	315	11,176	9,462	8,219	12,891
12	147	136	124	158	10,583	8,868	7,625	12,297

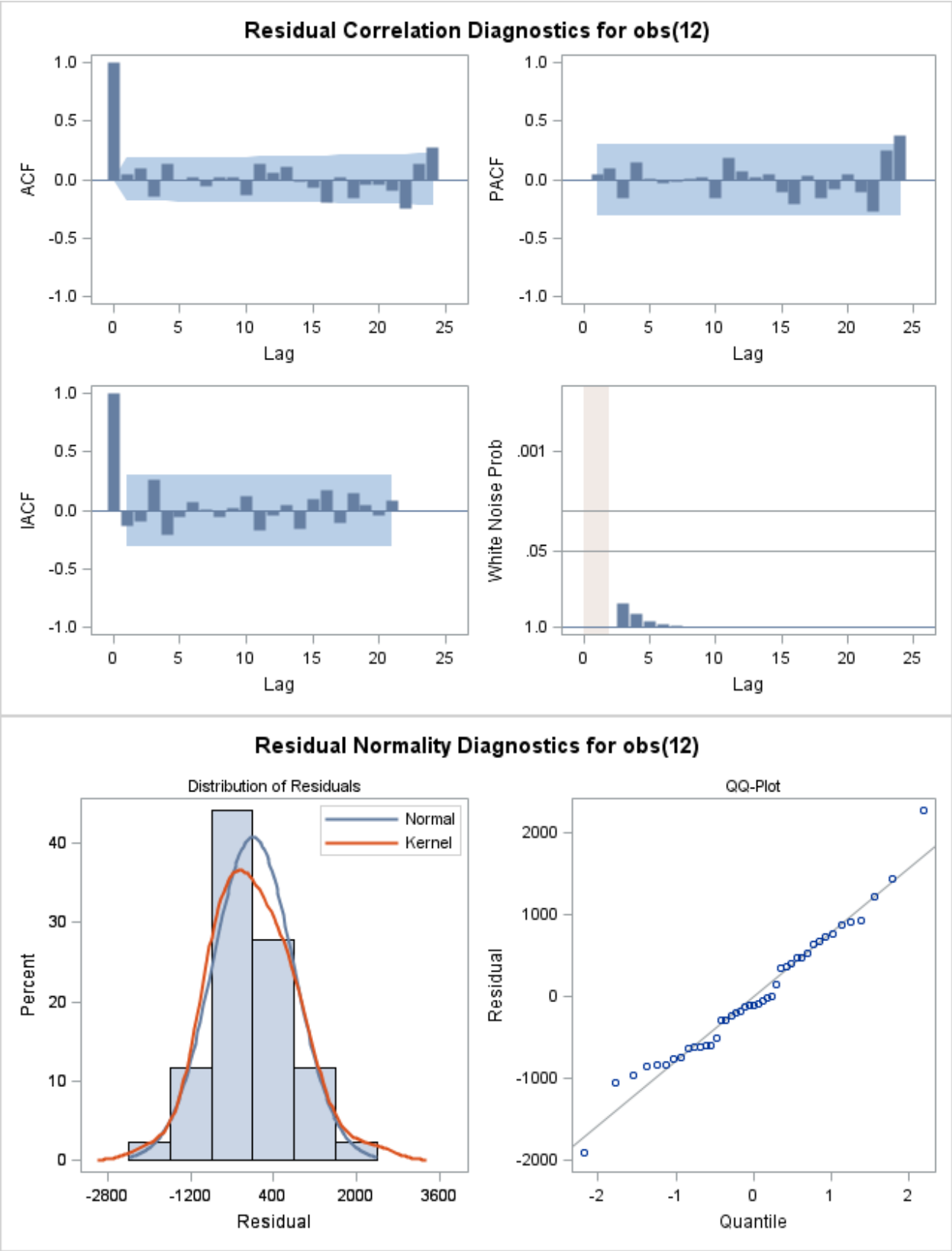

Figure 10. Golden tilefish commercial longline SARIMA model fit diagnostic plots, indicating differencing yielded appropriate model fit.

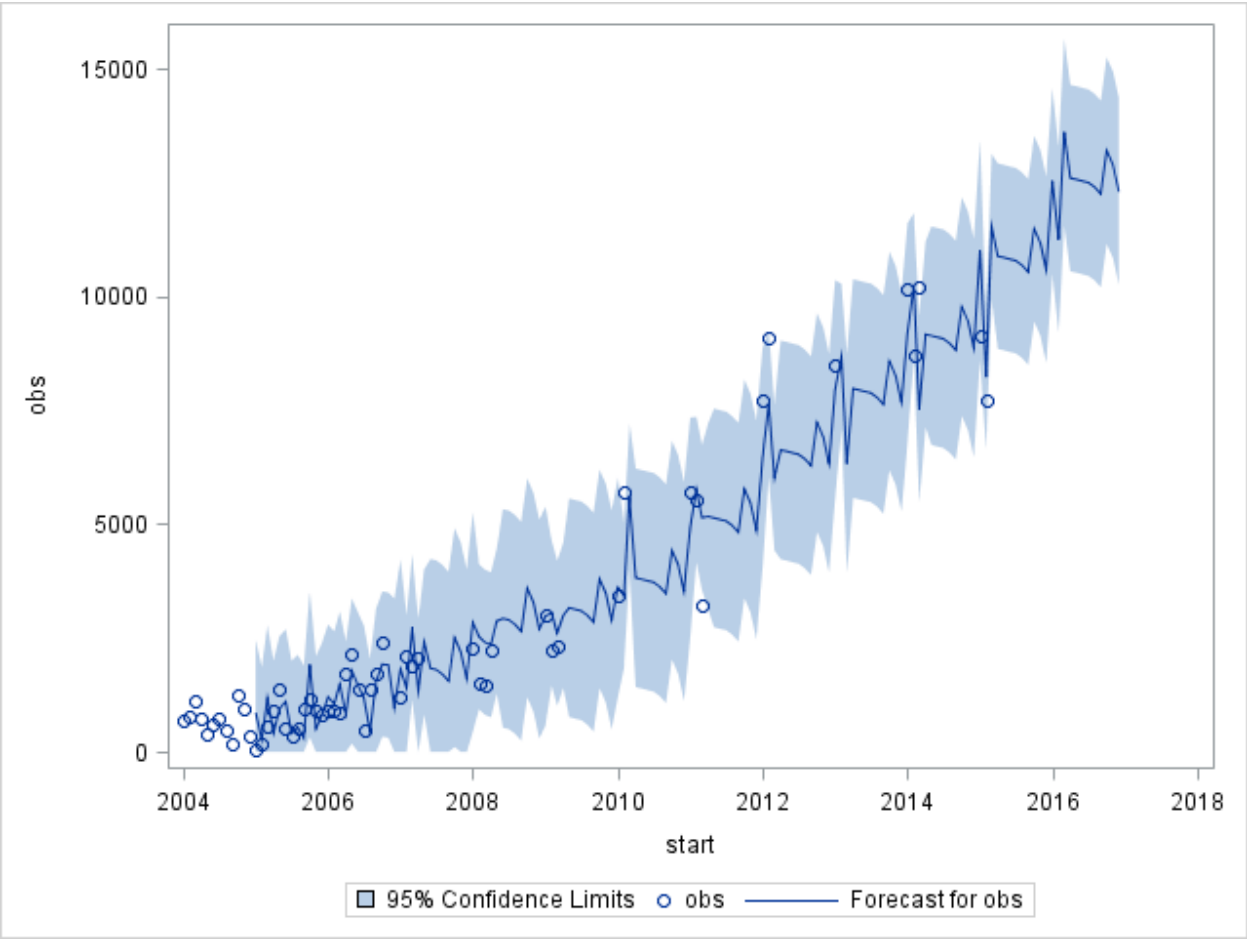

Figure 11. Golden tilefish commercial hook and line SARIMA model fit to observed data (open circles) and predicted catch rate for 2016.

Table 4. Predicted commercial golden tilefish landings (lb ww) and quota closure dates for the 2016/17 season under different Regulatory Amendment 23 alternatives, by month and gear (HL: hook-and-line, LL: longline).

		HOOK AND LINE				LONGLINE			
Alternative	**Variable**	**constant 2015**	**constant 2014**	**avg 2012-2014**	**SARIMA**	**constant 2015**	**constant 2014**	**avg 2012-2014**	**SARIMA**
Alt. 1: Both Jan 1-Dec 31	Landings	135,275	135,288	135,306	135,182	127,683	131,879	131,804	125,340
	Closure	10/28/16	06/10/16	05/28/16	10/27/16	No Closure	No Closure	No Closure	No Closure
Alt. 2a: LL Jan 1-Dec 31, HL Mar 1-Feb 28/29	Landings	134,477	135,198	134,406	134,942	398,676	401,478	404,718	399,801
	Closure	02/11/17	10/31/16	01/24/17	02/08/17	02/15/16	02/10/16	02/15/16	02/01/16
Alt. 2b: LL Jan 1-Dec 31, HL Apr 1-Mar 31	Landings	134,944	134,922	135,054	135,038	398,676	401,478	404,718	399,801
	Closure	03/17/17	01/05/17	02/07/17	03/18/17	02/15/16	02/10/16	02/15/16	02/01/16
Alt. 2c: LL Jan 1-Dec 31, HL May 1-Apr 30	Landings	135,146	135,305	135,236	135,147	398,676	401,478	404,718	399,801
	Closure	03/27/17	01/21/17	02/16/17	03/24/17	02/15/16	02/10/16	02/15/16	02/01/16
Alt. 3: LL Jan 1-Dec 31, HL opens when LL closes	Landings	135,314	135,280	135,281	135,317	398,676	401,478	404,718	399,801
	Closure	01/26/17	08/23/16	01/04/17	12/24/16	02/15/16	02/10/16	02/15/16	02/01/16

Discussion

Predicting angler responses to new management regulations is difficult. Predicting commercial golden tilefish landings in future fishing seasons is further complicated by a decade of in-season quota closures and recent changes to quota management. The commercial golden tilefish portion of the snapper-grouper fishery has experienced in-season quota closures since 2006, and the associated derby fishery conditions make it difficult to determine whether season trends in catch rates exist. The recent change to managing golden tilefish under separate quotas for longline and hook-and-line gear may reduce the pressure to fish before the quota is met, and appears to be reducing derby conditions in the hook-and-line sector in 2015; however, it is difficult to conclude much based on these limited data.

SARIMA model fits were fair for hook-and-line and excellent for longline. The poor hook-and-line fit may be driven by the recent reductions in derby conditions promoted by the splitting of separate quotas for the hook-and-line and longline sectors. The hook-and-line season has been much longer in the past two years, which is a relatively limited time period to inform a lagged model. The excellent fit for longline gear is driven by the progressively shorter seasons, meaning the model has little in the way of gaps to fit relative to observed data in subsequent years. The significance of fuel price as a covariate could be due to the regulations on longline use in the South Atlantic exclusive economic zone, which require fishermen to travel out to charted depths beyond 50 fathoms to deploy the gear. The transit required may be a disincentive when fuel prices are high.

When faced with substantial uncertainty, often the best assumption is that landings in recent years are the best predictor of future performance. An examination of the data suggests that 2015 catch rates for both gears were slightly lower than 2014 catch rates; however, the SARIMA model predicts early season catch rates will continue to increase. Due to the changes in management that may reduce derby conditions and the limited amount of 'informative' data to the projection model, it is suggested that the SARIMA model predictions be viewed as a worst-case scenario for longline season length. The hook-and-line projections are highly uncertain, and the Council is encouraged to use caution when evaluating the season lengths projected in Table 4.

References

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