Retrospective analysis of combined effects of amendment 31 regulations upon effective effort impacting sea turtle takes in the Gulf of Mexico Reef Fish Bottom Longline Fishery

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Introduction

In 2009, analyses of Southeast Fishery Science Center (SEFSC) observer program data indicated the number of loggerhead sea turtle takes authorized in the 2005 Biological Opinion (BiOp) by the bottom longline component of the reef fish fishery in the Gulf of Mexico were exceeded (SEFSC 2009). Section 7(a)(2) of the ESA requires all federal agencies to ensure any action authorized, funded, or carried out is not likely to jeopardize the continued existence of any endangered or threatened species or to result in the destruction or adverse modification of habitat of such species. Additionally, National Standard 9 (NS9) of the Magnuson Stevens Fishery Conservation and Management Act (MSFCMA) requires that conservation and management measures, to the extent practicable, minimize bycatch and to the extent bycatch cannot be avoided, minimize the mortality of such bycatch. In response to these mandates, per the Gulf of Mexico Fishery Management Council (Gulf Council)'s request, the National Marine Fisheries Service (NMFS) published a temporary emergency rule on May 1, 2009 (74 FR 20229). Effective May 18, 2009, through October 28, 2009, the rule prohibited the use of bottom longline gear to harvest reef fish east of 85° 30'W longitude in waters less than 50 fathoms until the 2009 deepwater grouper and tilefish quotas were met, and in water of all depths east of 85° 30'W longitude thereafter. In the rule, NMFS specified that if it determined that less restrictive measures would suffice to adequately reduce turtle takes by the longline component of the reef fish fishery, NMFS could rescind the closure before the 180-day effective period of the emergency rule was reached and potentially implement less restrictive measures. Subsequent to the expiration of the emergency rule, the Gulf Council finalized Amendment 31 to the Reef Fish Fishery Management Plan (RF31) to implement conservation and management measures that minimize bycatch and bycatch mortality of sea turtles (Gulf Council 2010).

The following measures were applied in RF31 to the bottom longline component of the reef fish fishery (RF-BLL) in the eastern Gulf of Mexico (east of 85° 30' W):

1. Prohibit the use of bottom longline gear shoreward of a line approximating the 35-fathom depth contour from June through August;
2. Require an endorsement to harvest reef fish using bottom longline gear in the eastern Gulf of Mexico. Only federally-permitted vessels with demonstrated average annual landings of 40,000 pounds of reef fish taken by fish traps or longlines during 1999-2007 qualify for an endorsement; and
3. Restrict the number of hooks that may be possessed onboard each reef fish bottom longline vessel operating in the eastern Gulf of Mexico to 1,000 hooks total, only 750 of which may be fished or rigged for fishing at any given time.

The combined effects of these actions upon effective effort in the RF-BLL as it impacts loggerhead sea turtles were evaluated by SERO-LAPP/DM (2009). The purpose of this retrospective analysis is to evaluate actual levels in RF-BLL effort reported by captains and observers since these regulations became effective on May 26, 2010.

Methods

Data Sources

There are two primary data sources for RF-BLL effort data. Since 1991, all commercial RF-BLL captains have been federally mandated to submit catch and effort information for each trip through the commercial fisheries logbook program (CFLP). The CFLP (obtained from SEFSC 6 Nov 2017) provides self-reported trip-level information for each species encountered, including landings (to the nearest pound), the primary gear used, and the primary area and depth of capture (feet). Additionally, in July 2006, the National Marine Fisheries Service (NMFS) implemented a mandatory commercial reef fish observer program (RFOP) to characterize the reef fish fishery operating in the U.S. Gulf of Mexico. The RFOP (obtained from SEFSC 16 May 2017) provides set-level information on species encountered on trips using bottom longlines, electric (bandit) reels, and handlines for a randomly-selected subsample (~5%) of commercial reef fish trips.

Subsets of CFLP and RFOP data were created for the RF-BLL fishery if they landed managed reef fish (50 CFR 622, App. A) using bottom longline gear. For most analyses, only vessels associated with a 40,000 pound qualifying endorsement were evaluated. Trips with obvious effort reporting errors (e.g., <30 hooks per longline, <1 set per trip, >24 sets per day, >25 miles of longline) were also eliminated from consideration consistent with SEFSC (2009) and SERO-LAPP/DM (2009). Effort was only evaluated for CFLP areas 1-8 (e.g., east of Cape San Blas, Florida).

Because the closure applied to the 35-fathom contour, the accuracy of depth reported in the logbook dataset was an important consideration. Several steps were taken to diagnose and correct misreporting. The deepest depth was retained to avoid problems with depths associated with shark landings being assigned to a trip that primarily targeted reef fish in deeper water. In SERO-LAPP/DM (2009) there was no significant difference between outputs from runs retaining deepest depth as compared to outputs from runs retaining shallowest depth. Depth was consistently reported in the CFLP starting in 2007 (<1% of trips without depth records); thus, any comparisons involving depth were restricted to 2007 or later. Additionally, reef fish longline fishing is prohibited within 20 fathoms. Misreporting in fathoms, rather than feet, was expected to be the cause of reported fishing in <120 ft (20 fathoms). Records reporting depths fished >120 ft were assumed to be correctly reported, as the distribution of the reef fish fishery does not extend far beyond 720 ft. Following SERO-LAPP/DM (2009), reported depths in records indicating RF-BLL fishing with maximum depths <120 ft were multiplied by six, assuming depth was misreported in fathoms. See SERO-LAPP/DM (2009) for detailed validation of this assumption. Longline trips were considered to be targeting Gulf reef fish if Gulf reef fish comprised the majority of the reported landings.

Data Analyses

The primary assumptions in SERO-LAPP-DM (2009) related to the combined effects of RF31 were as follows:

a) 2007-2008 longline effort, as modified by proposed regulations, is representative of future effort.
b) 100 percent of longline effort shifts from 20-35 fathoms to 35-50 fathoms during bathymetric closures (i.e., no fishermen stop fishing during seasonal closures).
c) No longline effort shifts outside of 50 fathoms.
d) Fishermen previously using greater than 1,000 hooks per set compensate for the 750 hook restriction by making additional sets as follows:
    i) *No effort compensation* – each set in the baseline data with >750 hooks was reduced to 750 hooks, and the number of sets-per-trip remained at baseline levels despite hook reduction.
    ii) *Low effort compensation* – each set in the baseline data with >750 hooks was reduced to 750 hooks, and if this set had >2000 hooks and less than 2.07 sets per day, effort was increased as follows:
        scalar = 2.07 / (sets per day)
        hooks = scalar * (hooks per set)(sets per trip)
    iii) *High effort compensation* - On reef fish bottom longline trips between 2007-2008 using between 650-850 hooks per set, the average number of sets per day was 2.56 (±0.14, 95% CI). Under the 'high effort compensation' scenario, each set in the baseline data with >750 hooks was reduced to 750 hooks, and if this set had >1000 hooks and less than 2.56 sets per day, effort was increased as follows:
        hooks = (hooks per set)(2.56 sets per day)(days at sea)

Retrospective analyses were conducted to determine the validity of assumptions (a)-(d). Effort was evaluated as total hooks, computed from CFLP records of number of hooks used per set (e.g., "numgear") and number of sets made per trip (e.g., "effort").

Additionally, anecdotal information from industry leaders indicates that reef fish longline fishers have voluntarily changed the way they fish, including using shorter cables (less than 4), horseshoe- versus straight-shaped sets, and much shorter soak times (less than an hour). To verify how representative this is of the entire longline fleet, CFLP and RFOP data were summarized pre (2004-2009) and post (2011-16) implementation of RF31 to evaluate:

a) Minimum, maximum, and average cable length
b) Average and maximum number of sets per day
c) Average and maximum soak times
d) Average and maximum hooks lost per set and per trip

Results and Discussion

As noted in SERO-LAPP/DM (2009), the majority of RF-BLL effort, expressed as total hooks, takes place East of Cape San Blas, Florida (**Figure 1**). However, it is noteworthy that in 2007-2008, 9±1% (mean ± SD) of effort was West of Cape San Blas, Florida; whereas in 2015-2016, 27±3% of effort was in this area. This represents a tripling of the relative RF-BLL effort West of Cape San Blas, Florida from the 2007-2008 baseline in SERO-LAPP/DM (2009). Overall RF-BLL effort dropped substantially from 2008 to 2009, and dropped even further in 2010. The decline from 2008 to 2009 was almost exclusively in the East and can

be attributed to the passage of the emergency rule discussed previously. The decline in 2010 was Gulf-wide and can be attributed to the large fishery closures enacted in response to the Deepwater Horizon oil spill that began on April 20, 2010. From 2011-2016, effort gradually increased in both the East and West, with a more rapid relative rate of increase in the West. This may reflect a rebuilding of the market following the oil spill as well as a redistribution of effort following the implementation of the Grouper-Tilefish Individual Fishing Quota (IFQ) Program in January 2010. Additionally, there was a gradual decline in effort amongst qualified endorsement holders from 2006-2008, prior to any new regulations (**Figure 2: blue**). The baseline period used in SERO-LAPP/DM (2009) applied proposed regulations to the 2007-2008 reported effort levels of qualified endorsement holders. Applying these simulated regulations substantially reduces the baseline effort levels (**Figure 2: green**).

The oil spill and IFQ Program implementation introduce confounding factors that make the 2007-2008 baseline a relatively poor predictor for the effort levels observed immediately following the implementation of RF31. Observed effort levels are significantly higher than predicted with no and low effort compensation (**Figure 3**). The no- and low-effort compensation scenarios have minimal contrast, and observed effort levels 2011-2016 suggest higher sea turtle encounter probabilities than predicted under these scenarios (SERO-LAPP/DM 2009). The high-effort compensation scenario appeared to provide robust projections for 2011-2013, but effort has continued to increase in recent years beyond even the upper confidence limit of this scenario (**Figure 3**).

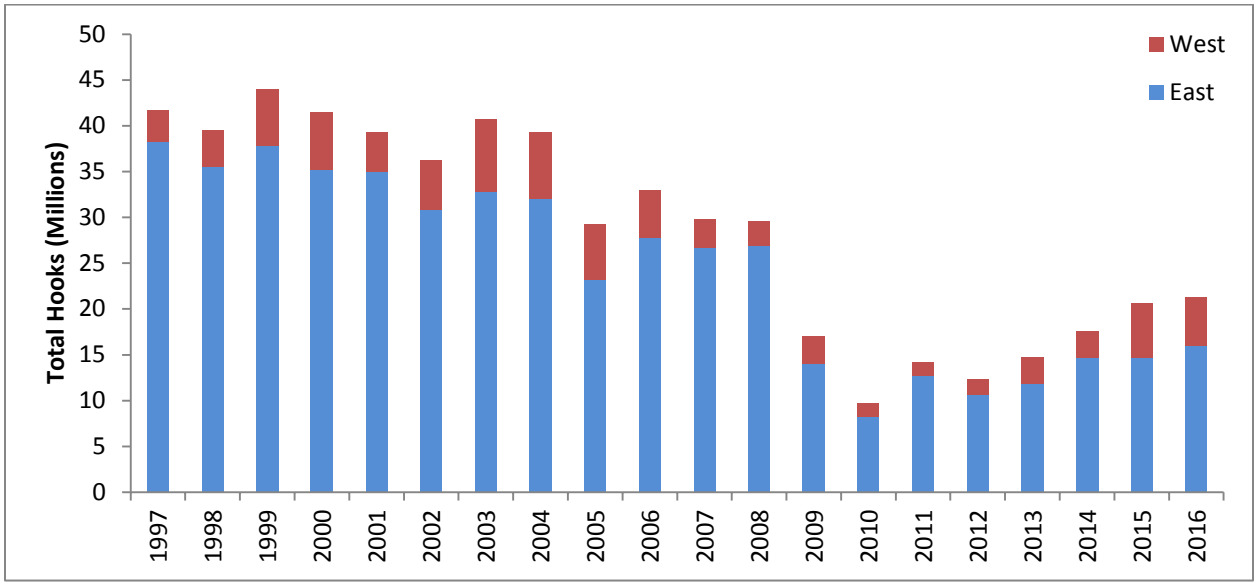

Figure 1. Total hooks (hooks per set x sets per trip) on reef fish bottom longline trips reported through the Commercial Fisheries Logbook Program in areas East (blue) and West (red) of Cape San Blas, Florida.

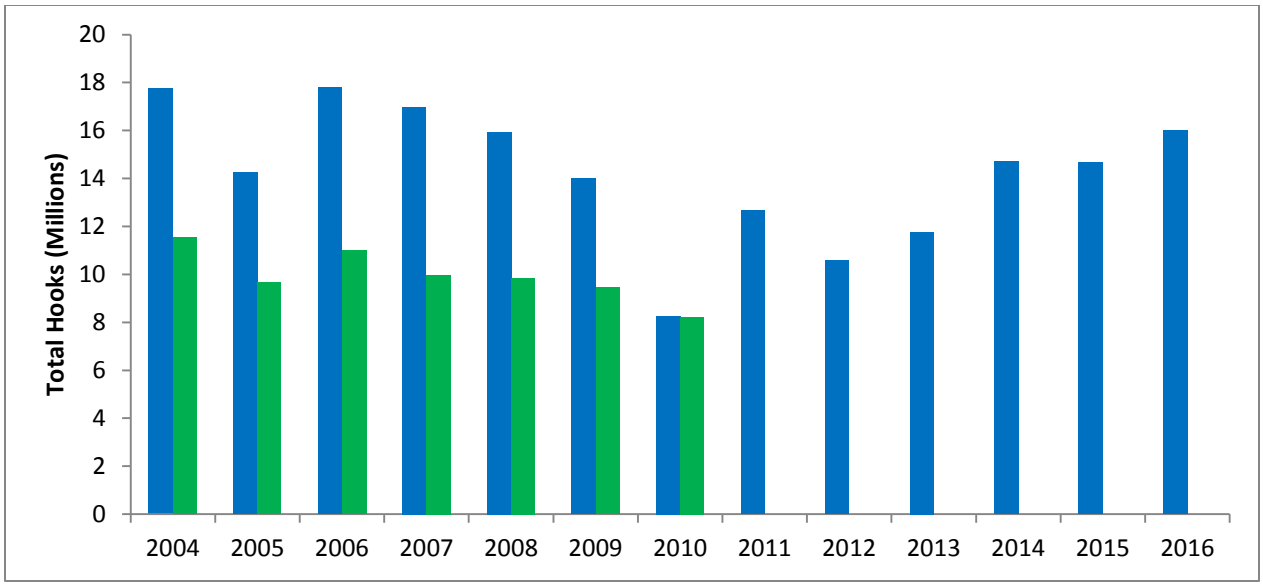

Figure 2. Qualified endorsement holder total effort (total hooks) on reef fish bottom longline trips reported (blue) through the Commercial Fisheries Logbook Program in areas East of Cape San Blas, Florida. Simulated application of RF31 regulations to pre-implementation data shown in green.

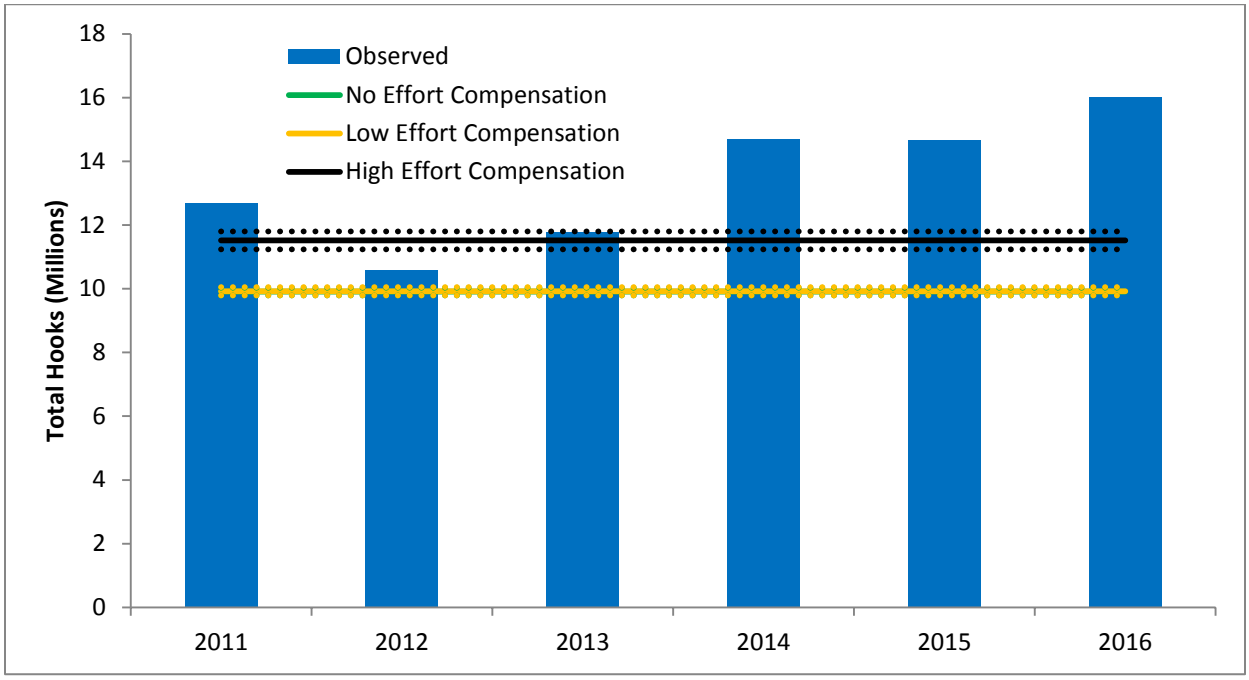

Figure 3. Total hooks set on reef fish bottom longline trips East of Cape San Blas, Florida reported by qualified endorsement holders through the Commercial Fisheries Logbook Program for 2011-2016 relative to projected effort levels from the pre-implementation period 2007-2008 under simulated RF31 regulations, with no (green), low (orange), and high (black) effort compensation scenarios. Dashed lines denote 95% confidence limits. Note there is minimal contrast between the no and low compensation scenarios.

Due to the changes in overall effort and the confounding factors of the oil spill and IFQ Program implementation, it is difficult to draw definitive conclusions of causation for the various analyses proposed. To control for the changes in overall effort, comparisons were made on a relative basis using the percentage of effort by depth during the closed season (June-August) and the remainder of the year. During the baseline years of 2007-2008, 26% of endorsement holder effort occurred between June-August, with 78% of that effort in the 20-35 fathom zone (**Figures 4-5**). By contrast, post-implementation, only 18% of effort took place during these months, with only 15% of that effort in the 20-35 fathom zone (**Figures 4-5**). Because the 20-35 fathom restriction only applies to RF-BLL fishing and we applied a somewhat liberal criterion for this categorization (e.g., at least 1 pound of managed reef fish landed), the effort in the 20-35 fathom zone may be trips that could be categorized as Shark Bottom Longline trips with incidental reef fish catch. These findings suggest that effort shifting was both spatial and temporal, with a decrease in relative June-Aug effort, a corresponding increase in effort outside of June-Aug, and a redistribution of remaining June-Aug effort into both the 35-50 and >50 fathom depth ranges, with the largest increase observed in the >50 fathom depth range. These findings suggest several assumptions in SERO-LAPP/DM (2009) regarding effort shifting were violated; however, the directionality of these changes would all result in lower effective effort for loggerhead sea turtles by shifting effort outside of the most vulnerable time period and into deeper waters with lower encounter rates during the most vulnerable time period.

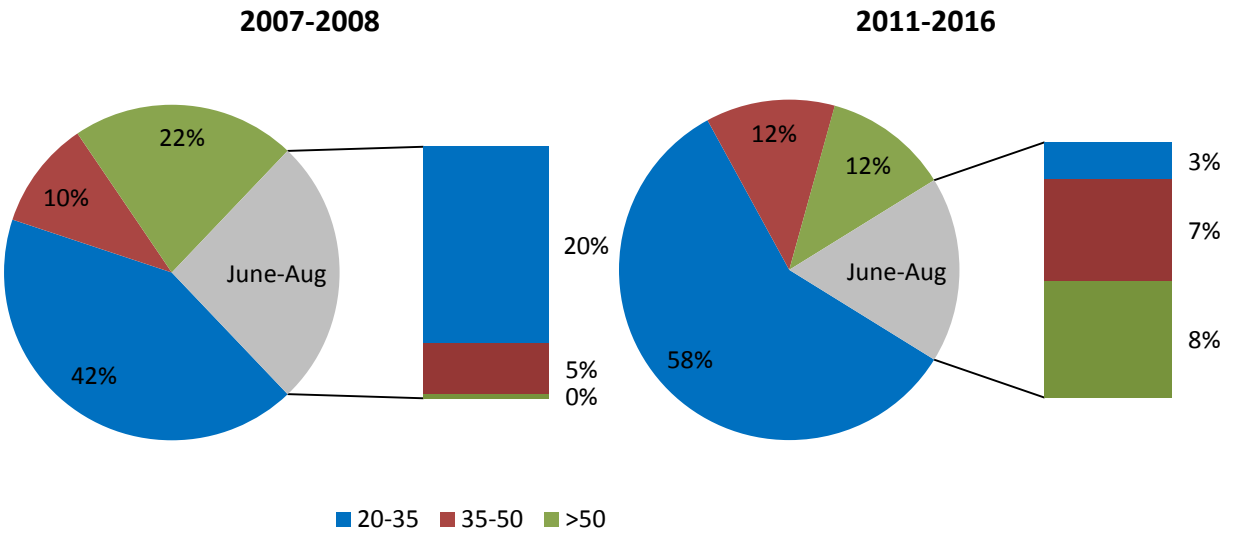

Figure 4. Percent of mean annual total effort (total hooks) for endorsement holders during the baseline period of 2007-2008 relative to the post-implementation period of 2011-2016, by depth bin (blue: 20-35 fathoms, red: 35-50 fathoms, green: >50 fathoms), during the 20-35 fathom closure months of June-Aug (bar chart) relative to the rest of the fishing year (pie chart).

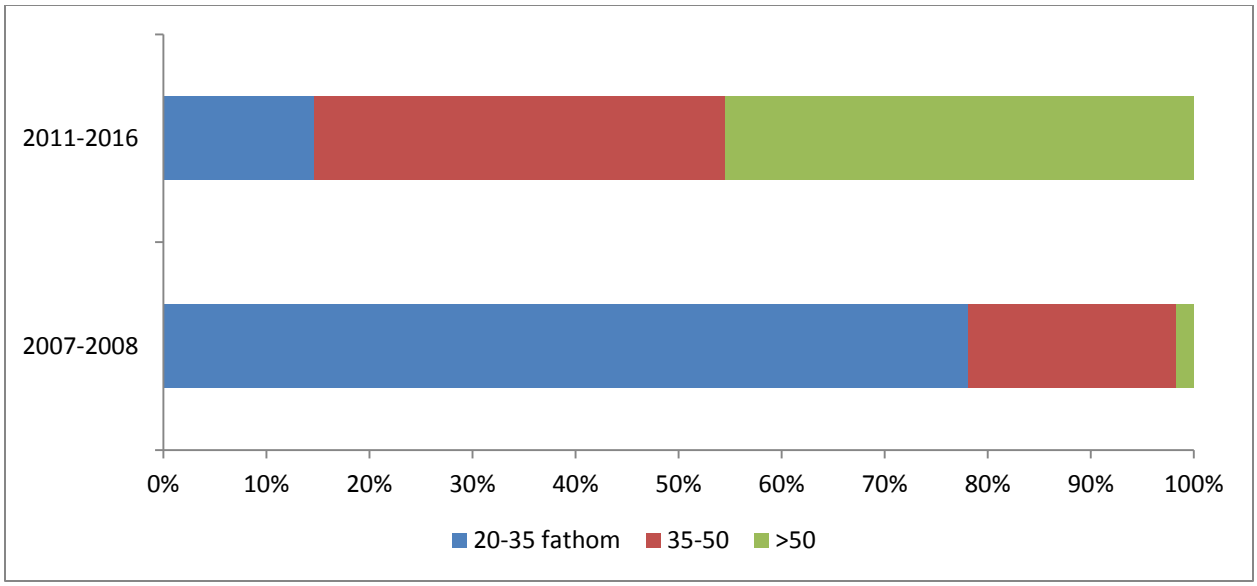

Figure 5. Percent of mean June-August total effort (total hooks) for endorsement holders during the baseline period of 2007-2008 relative to the post implementation period of 2011-2016, by depth bin.

The characteristics of the fishery have changed in response to the regulations implemented by RF-31 (**Figures 6-7**). To compensate for a 35% mean reduction in hooks used per set 2004-2009 versus 2011-2016, fishermen operating East of Cape San Blas, Florida, have increased their mean trip duration reported to the CFLP by 11%. Additionally, they have increased their mean sets per trip reported to the CFLP by 29% and mean sets per day by 12%. Maximum sets per day reported to the CFLP dropped drastically following RF-31 implementation but has steadily risen, exceeding 2008 levels in 2016. The hook restriction may be the reason for the observed 29% reduction in mean longline lengths reported to the CFLP; however, minimum and maximum lengths in 2015-2016 are the highest they have been since 2004. Possibly due to the shorter longline length and a published study indicating shorter soaktimes are more efficient at capturing red grouper while minimizing bycatch (Foster et al. 2017), mean soak time reported to the CFLP is also 12% lower in the post-implementation period. Some of the highest maximum soak times on record took place between 2014-2016. All of these changes took place immediately following implementation of RF-31 (**Figure 6**), and all are statistically significant (**Figure 7**).

From 2004-2009, reef fish bottom longline trips in the Eastern Gulf of Mexico averaged 8% (range: 4-10%) of the total commercial reef fish fishing trips taken in the Gulf of Mexico (**Table 1**). Reef fish bottom longline trips have only averaged 5% (range: 4-5%) of the total commercial reef fish fishing trips taken from 2011-2016 (**Table 1**). The number of reef fish trips has declined across all gear types and areas from the 2004-2009 baseline to the 2011-2016 period following the implementation of RF-31 and the IFQ programs.

The RFOP provides somewhat more robust documentation of fishing effort for a randomly selected subset of commercial longline fishermen. Observer coverage averaged 2% (range: 0-4%) of reef fish bottom longline trips in the Eastern Gulf of Mexico from 2006-2009, and increased to an average of 7% (range: 3-13%) from 2011-2016 (**Table 1**). The trends revealed by RFOP data are similar to those from

the CFLP (**Table 2**). Mean cable length and soak times in the Eastern Gulf of Mexico declined following the implementation of RF-31, and sets per day increased. By contrast, mean cable length and soak times in the Western Gulf of Mexico increased, with little change in sets per day.

Regulatory changes in participation levels (e.g., endorsements) and fishing opportunities (e.g., depth restrictions) for the longline fleet have led to changes in the vertical line (i.e., hook-and-line and bandit rig) fleet's operations. An evaluation of effort characteristics by depth bin and area (i.e., East vs. West of Cape San Blas, Florida) indicates that there have been many significant changes in operations from the pre-RF-31 period (2004-2009) to post-RF-31 (2011-2016), as indicated by the summary arrows in **Table 3**. The mean number of lines fished in the East has increased in all but the deepest zone, but decreased in the 20-50 fathom zones in the West. The mean number of hooks per line and mean total soaktime have both increased in the East. The total number of vertical line trips increased in 2009 but declined following the DeepWater Horizon oil spill in 2010 and has remained at this lower level. There was a slight increase in proportional trip effort in the 20-35 fathom zone in 2011-2012 and again in 2016 (**Figure 8**).

References

Foster DG, Pulver JR, Scott-Denton E, Bergmann C. 2017. Minimizing bycatch and improving efficiency in the commercial bottom longline fishery in the Eastern Gulf of Mexico. Fisheries Research, 196, 117-125.

SEFSC (Southeast Fisheries Science Center). 2009. Estimated takes of sea turtles in the bottom longline portion of the Gulf of Mexico reef fish fishery July 2006 through December 2008 based on observer data. NMFS Southeast Fisheries Science Center Contribution PRD-07/09-07. 23 p. plus appendices.

SERO-LAPP/DM-2009. Combined Effects of Amendment 31 Regulations upon Effective Effort Impacting Sea Turtle Takes in the Gulf of Mexico Reef Fish Bottom Longline Fishery (with Supplement). NMFS Southeast Regional Office, St. Petersburg, Florida, August 27, 2009, 36 pp.

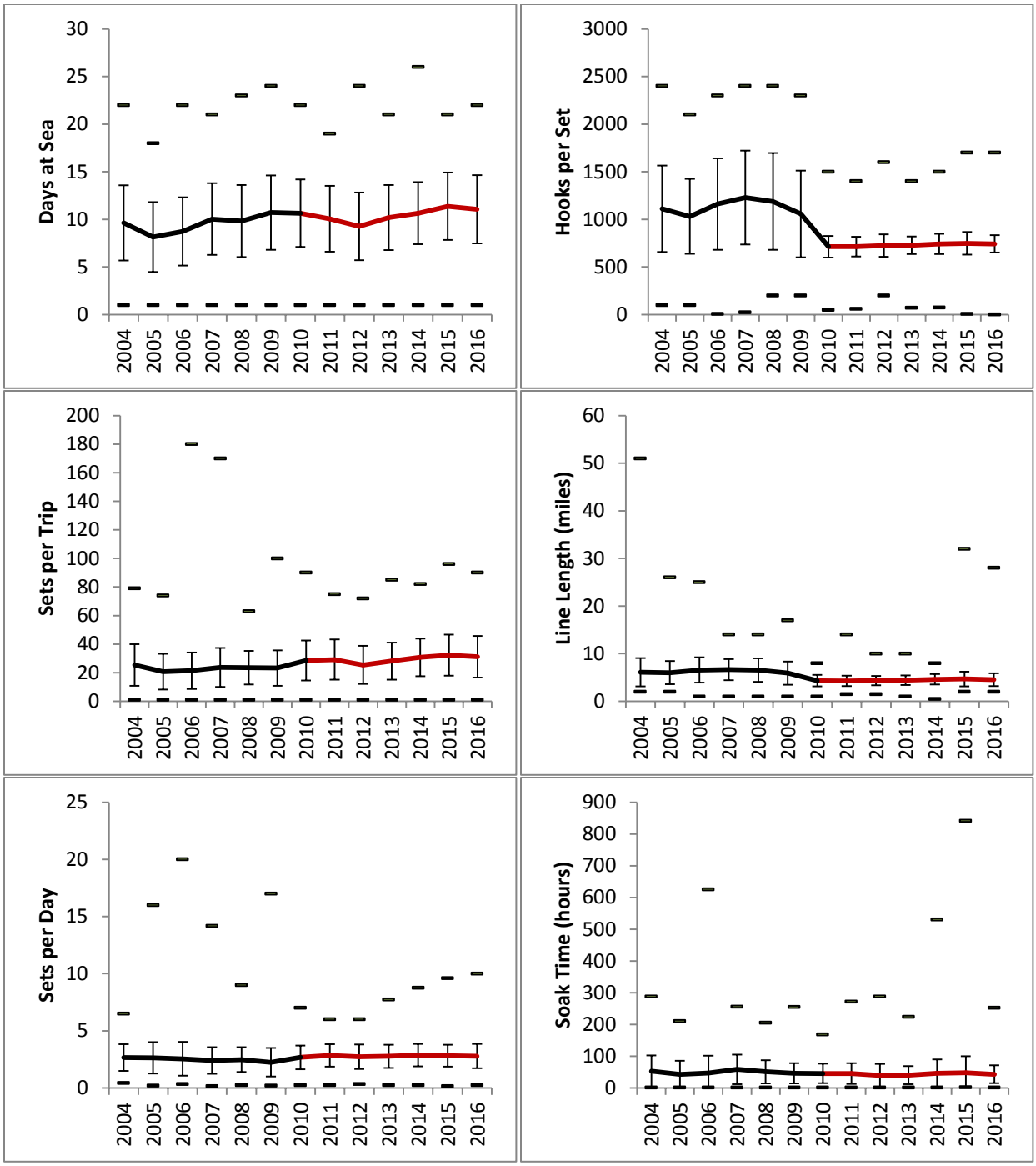

Figure 6. Mean fishing effort characteristics for reef fish bottom longline trips East of Cape San Blas, Florida reported by qualified endorsement holders through the Commercial Fisheries Logbook Program, prior to (black) and following (red) implementation of Reef Fish Amendment 31. Error bars denote standard deviation, markers denote minimum and maximum reported effort levels.

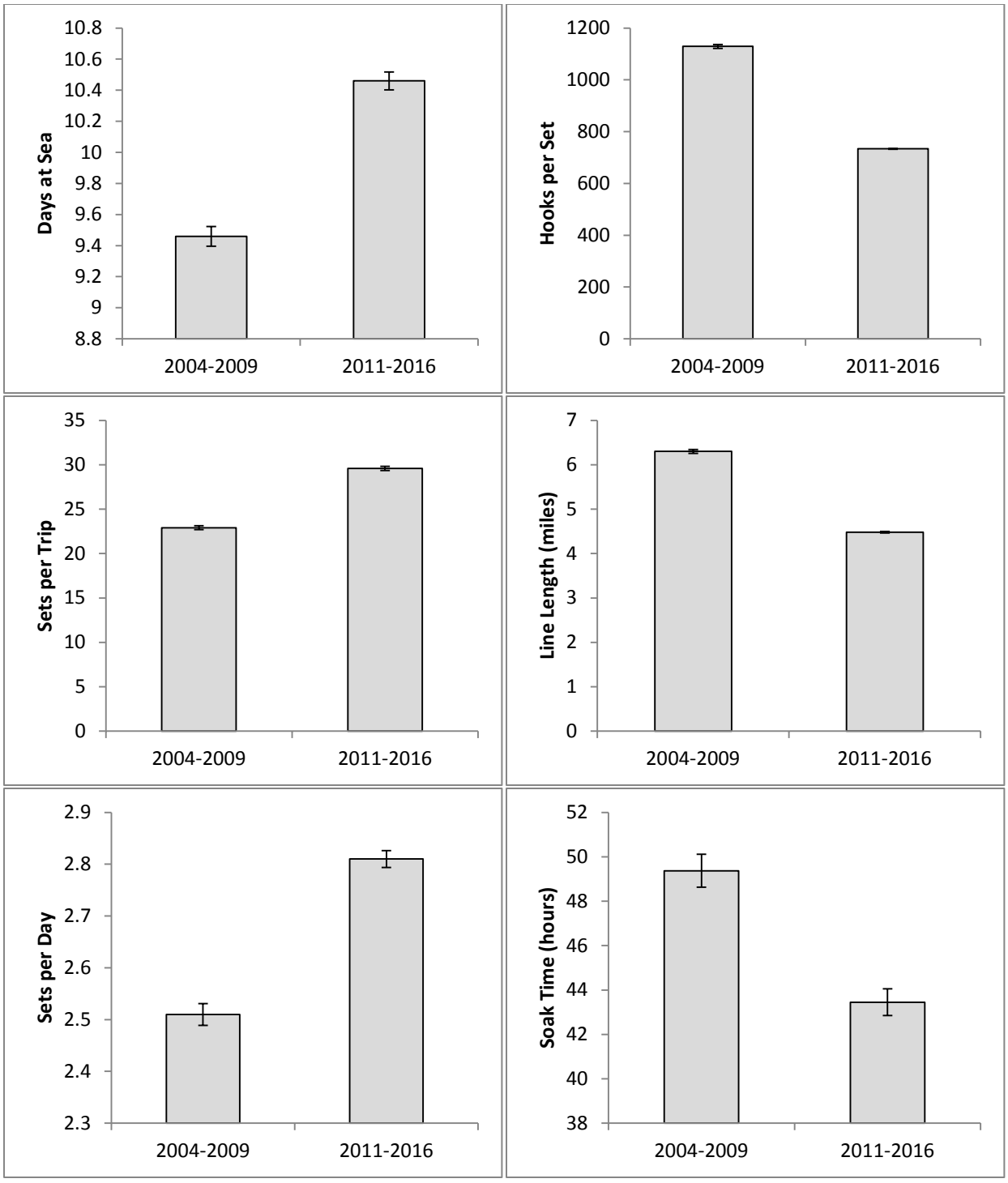

Figure 7. Mean fishing effort characteristics for reef fish bottom longline trips East of Cape San Blas, Florida reported by qualified endorsement holders through the Commercial Fisheries Logbook Program, prior to (2004-2009) and following (2011-2016) implementation of Reef Fish Amendment 31. Error bars denote 95% confidence limits.

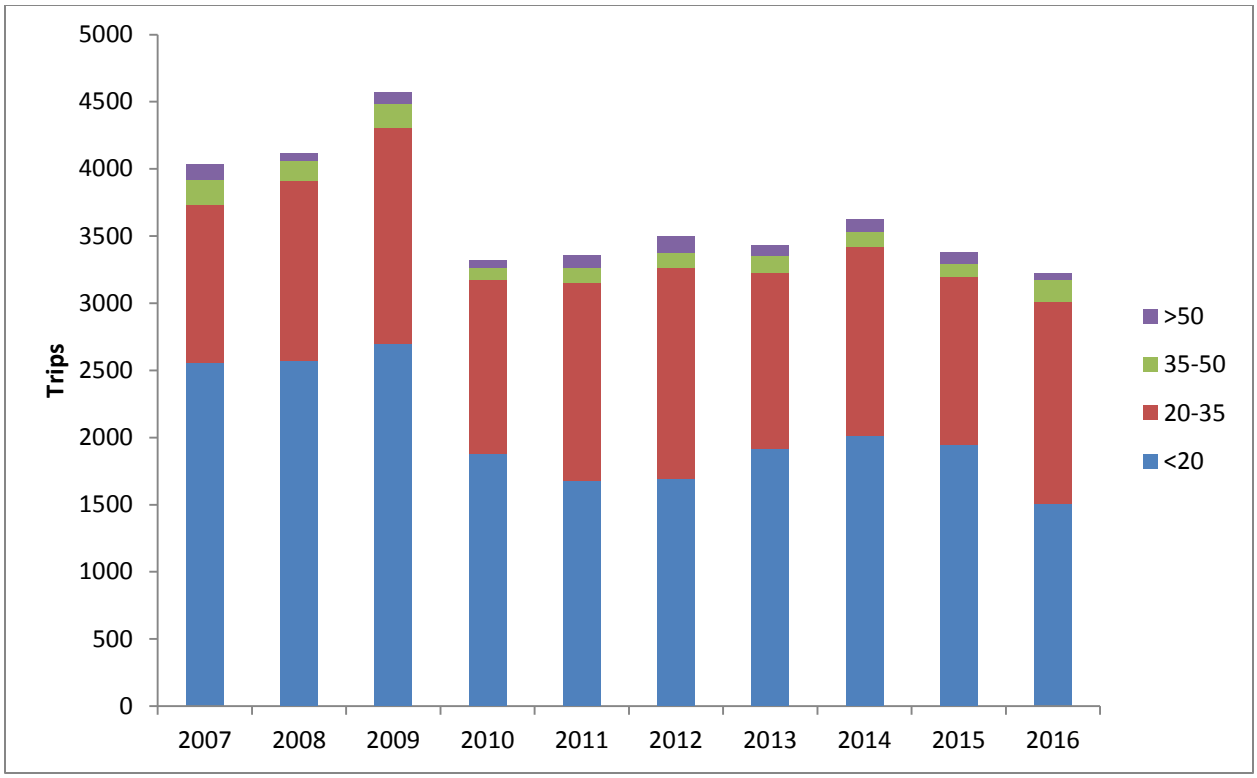

Figure 8. Total reported commercial vertical hook and line (including bandit) fishing trips in the Gulf of Mexico with the majority of landings comprised of managed Reef Fish species, for areas East of Cape San Blas, Florida, by depth bin in fathoms. Source: SEFSC Commercial Fisheries Logbook Program (Nov 2017).

Table 1. Total commercial reef fish trips (majority of landings comprised of managed Gulf Reef Fish), by gear, 1997-2016, East and West of Cape San Blas, Florida. Note vertical line includes bandit gear and handline; diver includes powerhead and spear.

	Vertical Line		Longline		Diver		Other		Observed Longline	
Year	**E**	**W**	**E**	**W**	**E**	**W**	**E**	**W**	**E**	**W**
1997	5856	4475	1388	219	354	3	641	27		
1998	6020	4740	1262	214	299	1	474	15		
1999	6882	4622	1236	303	352	16	567	16		
2000	7103	4534	1177	422	557	30	672	34		
2001	6883	4332	1227	331	542	29	492	33		
2002	6985	4727	1179	372	564	20	511	7		
2003	6720	4821	1260	366	419	11	327	10		
2004	6630	4644	1352	382	517	21	277	4		
2005	5544	3885	1205	305	423	19	239	2		
2006	5291	3800	1218	257	398	14	207	0	12	0
2007	4418	1894	1041	120	350	3	35	1	11	0
2008	4489	1787	1097	103	421	1	22	0	3	2
2009	4922	2010	576	108	410	10	33	1	24	9
2010	3526	1398	408	76	386	9	58	1	46	8
2011	3495	1845	608	74	370	28	8	1	75	6
2012	3638	1794	573	82	387	23	8	0	16	3
2013	3526	1675	577	102	286	21	12	1	77	7
2014	3727	1810	646	74	441	10	45	2	23	4
2015	3467	2140	615	113	466	6	42	0	22	4
2016	3291	2279	695	112	450	12	54	0	44	11
2004-2009	**5215.7**	**3003.3**	**1081.5**	**212.5**	**419.8**	**11.3**	**135.5**	**1.3**	**12.5**	**2.8**
2011-2016	**3524.0**	**1923.8**	**619.0**	**92.8**	**400.0**	**16.7**	**28.2**	**0.7**	**42.8**	**5.8**

SOURCE: SEFSC Commercial Fisheries Logbook Program (Nov 2017), SEFSC Reef Fish Observer Program (Dec 2017)

Table 2. Summary statistics for cable length, soak times, and sets per day on observed mandatory longline (code GL) trips in the Gulf of Mexico reef fish bottom longline fishery 2006-2016, East and West of Cape San Blas, Florida.

	Cable Length (miles)						Soak Time (hours)						Sets per Day					
	Mean		Min		Max		Mean		Min		Max		Mean		Min		Max	
Year	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W
2006	5.9		3.5		10.0		4.7		1.1		14.5		2.5		1.0		6.0	
2007	7.0		2.3		13.8		5.5		1.1		17.8		2.1		1.0		4.0	
2008	5.5	4.8	4.6	2.0	8.1	5.8	3.9	4.0	2.6	2.4	6.6	5.5	2.9	2.6	1.0	1.0	5.0	4.0
2009	6.6	4.8	1.7	2.5	13.8	13.0	5.5	4.7	1.1	2.2	19.2	28.0	2.4	2.6	1.0	1.0	6.0	5.0
2010	4.9	4.6	1.0	1.5	8.1	11.5	3.7	5.5	1.1	1.5	19.5	18.6	3.0	2.9	1.0	1.0	8.0	8.0
2011	4.5	4.9	0.4	0.2	12.1	8.1	3.4	6.4	1.2	0.9	19.2	34.3	3.2	2.6	1.0	1.0	6.0	6.0
2012	4.0	6.1	1.7	3.0	6.0	12.7	3.0	7.5	1.6	2.7	11.7	14.7	3.7	2.4	1.0	1.0	7.0	6.0
2013	4.6	6.6	1.2	1.2	8.1	9.0	3.7	5.6	0.9	1.2	72.9	9.5	3.0	2.4	1.0	1.0	6.0	4.0
2014	4.5	6.8	0.6	3.0	9.2	13.8	3.5	7.2	1.2	4.1	16.3	11.6	3.2	2.2	1.0	1.0	7.0	4.0
2015	4.8	6.9	0.3	1.0	8.1	11.0	3.7	6.7	0.4	3.5	13.6	14.9	3.1	2.4	1.0	1.0	6.0	6.0
2016	4.7	5.2	0.5	1.2	8.6	8.6	3.6	6.4	1.5	2.3	22.9	38.3	3.2	3.4	1.0	1.0	5.0	6.0
2006-09	**6.5**	**4.8**	**1.7**	**2.0**	**13.8**	**13.0**	**5.2**	**4.6**	**1.1**	**2.2**	**19.2**	**28.0**	**2.4**	**2.6**	**1.0**	**1.0**	**6.0**	**5.0**
2011-16	**4.6**	**5.7**	**0.3**	**0.2**	**12.1**	**13.8**	**3.5**	**6.5**	**0.4**	**0.9**	**72.9**	**38.3**	**3.2**	**2.7**	**1.0**	**1.0**	**7.0**	**6.0**

SOURCE: SEFSC Reef Fish Observer Program (Dec 2017)

Table 3. Descriptive characteristics for commercial vertical hook and line (including bandit) fishing trips in the Gulf of Mexico with the majority of landings comprised of managed Reef Fish species, for areas East and West of Cape San Blas, Florida, by depth bin in fathoms (NRPT = depth not reported). Arrows denote significant change, NSD: No Significant Difference.

	Number of Lines Fished (Mean ± SD)									
	E					**W**				
year	**00-20**	**20-35**	**35-50**	**>50**	**NRPT**	**00-20**	**20-35**	**35-50**	**>50**	**NRPT**
1997	.±.	.±.	.±.	.±.	2.71±1.25	.±.	.±.	.±.	.±.	3.87±1.76
1998	.±.	.±.	.±.	.±.	2.78±1.21	.±.	.±.	.±.	.±.	3.91±2
1999	.±.	.±.	.±.	.±.	2.79±1.29	.±.	.±.	.±.	.±.	3.95±1.96
2000	.±.	.±.	.±.	.±.	2.82±1.36	.±.	.±.	.±.	.±.	3.92±1.98
2001	.±.	.±.	.±.	.±.	2.76±1.25	.±.	.±.	.±.	.±.	3.97±2.04
2002	.±.	.±.	.±.	.±.	2.63±1.26	.±.	.±.	.±.	.±.	3.91±2.04
2003	.±.	.±.	.±.	.±.	2.58±1.19	.±.	.±.	.±.	.±.	3.95±2.13
2004	2.5±0.74	3.08±1.04	4±0	2±.	2.55±1.2	3.4±0.89	3.03±1.24	6±2	5±1.41	3.76±2
2005	2.18±0.91	2.79±1.29	2.83±1.19	2.74±1.05	2.62±1.21	3.02±1.4	3.73±2.35	4.15±2.2	3.58±1.31	4.33±2.44
2006	2.22±0.92	2.86±1.25	2.97±1.25	2.64±0.99	3.21±1.39	3.45±1.81	3.61±1.64	5.07±2.47	3.84±1.63	5.66±2.18
2007	2.55±1.14	3.13±1.39	3.4±1.58	2.77±1.24	.±.	3.29±1.46	3.51±1.49	4.36±2.14	3.95±1.69	.±.
2008	2.46±1.05	3.12±1.33	3.86±1.62	2.74±1.08	2±.	3.08±1.39	3.43±1.48	4.31±2.04	3.52±1.93	.±.
2009	2.38±1.12	3.15±1.35	3.89±1.6	3.17±1.43	.±.	2.95±1.45	3.38±1.51	4.15±1.8	3.49±1.7	.±.
2010	2.32±1.05	3.27±1.23	3.82±1.84	2.65±0.92	.±.	3.16±1.55	3.43±1.47	4.51±2.14	3.88±1.71	.±.
2011	2.45±1.09	3.38±1.32	3.6±1.61	2.73±0.95	.±.	2.93±1.28	3.03±1.3	4.03±2.04	3.01±1.23	.±.
2012	2.48±1.11	3.43±1.27	3.51±1.54	2.85±1.29	.±.	3.05±1.24	3±1.34	4.22±2.08	3.89±1.6	.±.
2013	2.56±1.1	3.43±1.43	3.56±1.41	2.43±1.48	.±.	2.92±1.25	3.2±1.19	4.02±2.25	3.63±1.61	.±.
2014	2.64±1.13	3.46±1.48	4.11±1.53	2.21±1.28	.±.	3.21±1.22	3.03±1.17	3.85±2.34	3.9±1.89	.±.
2015	2.65±1.01	3.27±1.27	3.8±1.7	2.31±1.58	.±.	3.22±1.47	3.13±1.32	4.15±2.28	3.7±1.85	.±.
2016	2.6±0.97	3.22±1.2	3.66±1.51	3.09±1.18	.±.	3.42±1.4	3.23±1.25	3.97±2.21	3.57±2.03	.±.
2004-2009	**2.38±1.05**	**2.98±1.32**	**3.34±1.5**	**2.8±1.18**	**2.58±1.21**	**3.19±1.56**	**3.56±1.78**	**4.44±2.17**	**3.67±1.67**	**3.96±2.15**
2011-2016	**2.57±1.07**	**3.36±1.33**	**3.69±1.55**	**2.57±1.34**	**.±.**	**3.16±1.34**	**3.11±1.26**	**4.05±2.19**	**3.64±1.73**	**.±.**
Change	↑	↑	↑	↓		NSD	↓	↓	NSD	

Table 3 (con't).

	Mean Number of Hooks Per Line									
	E					W				
year	**00-20**	**20-35**	**35-50**	**>50**	**NRPT**	**00-20**	**20-35**	**35-50**	**>50**	**NRPT**
1997	.±.	.±.	.±.	.±.	2.08±2.76	.±.	.±.	.±.	.±.	14.83±9.56
1998	.±.	.±.	.±.	.±.	2.16±3.25	.±.	.±.	.±.	.±.	14.69±10.14
1999	.±.	.±.	.±.	.±.	2.19±3.07	.±.	.±.	.±.	.±.	14.21±9.85
2000	.±.	.±.	.±.	.±.	2.24±3.04	.±.	.±.	.±.	.±.	13.29±9.73
2001	.±.	.±.	.±.	.±.	1.94±2.45	.±.	.±.	.±.	.±.	13.45±9.66
2002	.±.	.±.	.±.	.±.	1.98±2.76	.±.	.±.	.±.	.±.	12.86±9.63
2003	.±.	.±.	.±.	.±.	2±3.34	.±.	.±.	.±.	.±.	12.95±9.64
2004	1.23±0.71	3.28±4.46	1±0	5±.	2.04±3.33	3.8±3.63	9.72±9.41	16.67±2.89	22.5±10.61	12.3±9.68
2005	1.45±1.91	2.96±4.63	3.14±5.33	3.09±4.63	2.55±4.52	6.17±6.73	15.21±10.14	16.78±9.56	17.26±11.59	11.63±9.58
2006	1.34±1.13	3.09±4.98	3.24±5.58	2.53±2.21	3.33±5.1	7.53±7.66	14.45±9.28	17.63±8.43	19.49±10.42	8.91±9.07
2007	1.47±1.59	4.15±5.87	3.96±6.68	2.71±3.95	.±.	9.93±9.15	14.15±9.98	18.39±8.41	17.26±10.39	.±.
2008	1.41±1.91	4.17±6.6	5.05±7.75	3.49±5.4	1±.	7.85±8.59	15.42±10.95	18.59±8.78	16.67±9.54	.±.
2009	1.51±2	4.93±7.76	9.78±12.91	4.96±7.78	.±.	8.62±9.8	15.96±11.73	18.95±8.68	17.02±11.04	.±.
2010	1.76±3.11	8.69±13.05	9.33±13.05	4.23±7.09	.±.	10.05±10.29	18.67±11.81	20.05±9.48	18.48±12.73	.±.
2011	1.7±2.74	8.16±10.2	10.86±13.07	3.81±6.44	.±.	10.32±10.25	18.15±11.65	19.86±9.52	15.45±11.58	.±.
2012	1.99±3.49	8.27±10.27	6.65±9.64	4.3±5.55	.±.	11.57±10.29	19.44±12.38	20.95±9.46	20.76±9.38	.±.
2013	2.19±4.45	7.27±10.07	4.76±7.37	3.45±5.23	.±.	11.11±9.88	19.05±11.58	17.21±11.21	18.67±10.04	.±.
2014	2.16±3.81	6.83±10.02	10.82±12.62	3.69±3.63	.±.	12.34±10.76	17.61±13.08	14.62±10.34	18.81±11.21	.±.
2015	2.07±3.25	5.96±7.72	5.58±7.97	4.89±6.49	.±.	11.29±10.28	15.7±11.82	13.99±9.39	15.21±11.3	.±.
2016	2.44±4.2	4.54±6.3	4.53±6.39	3.83±2.76	.±.	11.68±10.23	16.14±11.78	13.2±9.36	14.83±11.41	.±.
2004-2009	**1.44±1.74**	**3.75±6**	**4.84±8.28**	**3.26±4.97**	**2.17±3.65**	**7.74±8.26**	**14.88±10.2**	**18.11±8.77**	**17.6±10.65**	**12.01±9.66**
2011-2016	**2.09±3.71**	**6.86±9.34**	**7.04±10.02**	**4.04±5.36**	**.±.**	**11.43±10.3**	**17.5±12.11**	**16.79±10.29**	**17.6±10.95**	**.±.**
Change	↑	↑	↑	NSD		↑	↑	↓	NSD	

Table 3 (con't).

	Mean Total Soaktime (hrs)									
	E					W				
year	**00-20**	**20-35**	**35-50**	**>50**	**NRPT**	**00-20**	**20-35**	**35-50**	**>50**	**NRPT**
1997	.±.	.±.	.±.	.±.	27.93±31.44	.±.	.±.	.±.	.±.	21.88±24.68
1998	.±.	.±.	.±.	.±.	26.89±30.62	.±.	.±.	.±.	.±.	20.09±22.23
1999	.±.	.±.	.±.	.±.	25.82±27.84	.±.	.±.	.±.	.±.	23.64±24.59
2000	.±.	.±.	.±.	.±.	25.05±27.24	.±.	.±.	.±.	.±.	21.95±25.36
2001	.±.	.±.	.±.	.±.	25.96±26.53	.±.	.±.	.±.	.±.	22.57±24.72
2002	.±.	.±.	.±.	.±.	26.39±25.53	.±.	.±.	.±.	.±.	21.84±23.67
2003	.±.	.±.	.±.	.±.	26.58±27.44	.±.	.±.	.±.	.±.	23.46±24.13
2004	16.86±19.1	32.64±24.86	70±27.39	80±.	25.73±26	18.6±17.85	17.93±16.47	35.67±41.86	18±8.49	23.61±24.65
2005	17.62±18.86	35.53±28.67	48.09±33.22	41.56±35.22	27.63±25.45	11.06±10.61	25.6±25.79	33.43±31.44	42.44±36.81	24.06±23.33
2006	20.71±22.6	37.93±30.95	51.61±35.76	48.53±31.23	39.23±26.78	17.94±18.32	24.76±23.1	32.35±30.32	50.93±43.77	24.45±20.78
2007	26.82±28.55	42.44±33.26	53.56±33.84	51.38±37.77	.±.	27.18±23.48	36.11±31.68	58.56±34.22	80.25±54.69	.±.
2008	25.03±25.65	42.84±31.99	53.83±29.9	50.96±29.69	8±.	21.77±22.47	34.48±29.62	59.32±33.68	58.29±49.09	.±.
2009	30.95±31.4	46.58±36.22	58.91±33.48	42.43±31.6	.±.	14.74±19.55	30.8±28.03	56.93±29.95	61.25±52.78	.±.
2010	26.17±25.58	47.72±34.9	63.79±34.44	41.86±25.06	.±.	17.07±34	31.74±28.59	54.23±30.57	78.53±55.16	.±.
2011	24.08±24.78	48.03±31.64	64.36±31.06	69.13±41.43	.±.	12.78±15.98	26.79±24.14	55.43±37.74	60.14±52.25	.±.
2012	23.99±24.56	47.82±28.69	62.41±28.98	66.1±43.21	.±.	12.55±10.77	27.51±24.38	56.8±35.89	72.07±50.54	.±.
2013	24.58±24.66	50.95±31.68	64.56±34.22	37.42±35.13	.±.	13.24±13.81	26.37±21.48	47.84±34.73	64.07±46.07	.±.
2014	28.4±28.05	47.08±32.48	61.05±29.68	31.75±31.41	.±.	13.43±12.29	25.76±21.59	42.2±31.1	56.13±38.12	.±.
2015	29.93±30.55	44.35±29.77	61.11±36.18	43.31±47.74	.±.	13.09±14.17	24.27±21.46	44.69±29.24	45.15±37.58	.±.
2016	24.63±25.31	43.61±30.68	68.93±36.19	47.83±33.3	.±.	15.5±16.57	24.63±21.82	45.77±30.78	47.29±41.08	.±.
2004-2009	**24.93±26.79**	**40.53±32.31**	**52.88±33.53**	**47.38±33.79**	**26.44±26.02**	**17.53±19.19**	**28.91±27.24**	**47.7±34.07**	**57.6±48.89**	**23.74±24.22**
2011-2016	**26.09±26.65**	**46.96±30.91**	**64.2±33.02**	**49.99±42.31**	**.±.**	**13.57±14.25**	**25.74±22.45**	**49.21±33.95**	**58.77±45.93**	**.±.**
Change	↑	↑	↑	NSD		↓	↓	NSD	NSD	