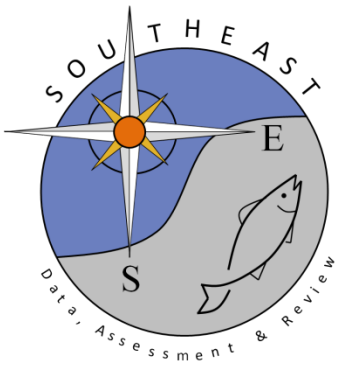
SEDAR31-AW04: The Effect of Hook Type on Red Snapper Catch

Steven Saul and John F. Walter

SEDAR41-RD64

1 December 2015



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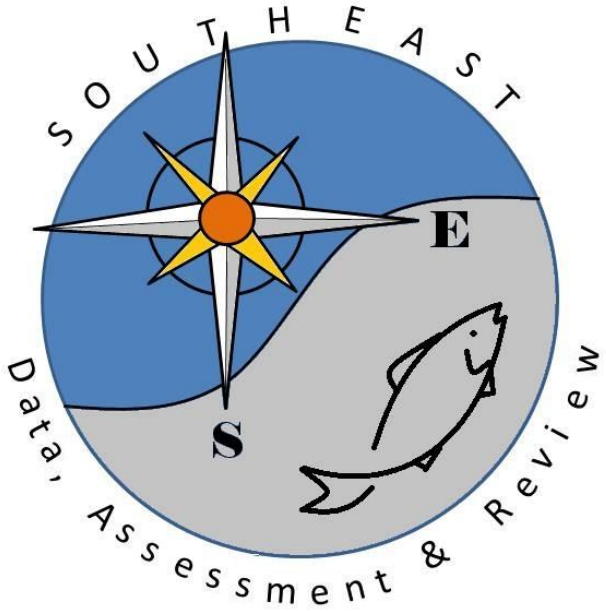
11 January 2013



Please cite as:

Saul, S. and J.F. Walter. 2013. The Effect of Hook Type on Red Snapper Catch. SEDAR31-AW04. SEDAR, North Charleston, SC. 13 pp.

The Effect of Hook Type on Red Snapper Catch

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Sustainable Fisheries Division Contribution Number: SFD-2013-003

Introduction

Changes to fishing regulations are important to properly account for in stock assessments. One of the primary inputs to stock assessment is an index of abundance. In many cases, the development of such indices is heavily reliant on fishery dependent data. The calculation of a continuous index of abundance across time requires that you assume that the catchability is constant across time. The implementation of regulatory actions in the middle of the time series, that cannot be accounted for though index standardization, may violate the assumption of constant catchability. Such a change could be calculated and thus accounted for using the fishery dependent data if the regulatory action were phased in across the fleet over time, such that some vessels operated under the older regulatory regime, while simultaneously, other vessels operated under the new regime. However, regulatory actions are often implemented in an overnight fashion in the middle of a time series. As a result, it is difficult for analysts to calculate how this regulatory change may have affected fisher behavior and possibly the indices of abundance calculated from fishery data.

One such regulatory change that was implemented in the Gulf of Mexico recreational reef fish fishery was the switch from J-hooks to circle hooks, which became effective June 1, 2008 as per Amendment 27 to the Gulf of Mexico Reef Fishery Management Plan (MFMC 2007). An abrupt switch such as this does not make it possible for the analyst to determine whether any change in catch rates estimated from the fishery dependent data is due to the gear switch or other factors which may change abundance (such as a change in the number fish over time, seasonal variations in abundance, etc.). As a result, scientists must resort to conducting experimental fishing studies using different gear types to explicitly calculate any difference in catchability and/or selectivity due to the new gear.

A number of studies have been done to evaluate the catchability and selectivity differences in hook type and hook size across various fisheries (Ralston 1990, Prince, Ortiz and Venizelos 2002, Cooke et al. 2005, Prince et al. 2007). In addition, many gear comparison studies have focused on calculating the release mortality of fish (Prince, Ortiz and Venizelos

2002, Burns and Froeschke 2012, Godin, Carlson, and Burgener 2012). Data from some of these studies may be able to also inform how gear changes may have affected catchability and selectivity. Although field studies such as those referenced here, and study used to collect the data analyzed in this paper are very useful for quantifying differences between gear selectivity and catchability, they are also costly and time consumptive to conduct. A simpler and more efficient way to provide analysts with similar information on how a regulatory change affects catchability and selectivity could be to phase in a regulation over the course of a year or two. In the absence of such a phased in approach, carefully designed studies that determine the differences in gear types will continue to be essential to properly inform stock assessments (Cass-Calay, Walter and Shirripa 2012).

For Gulf of Mexico reef fish, some work has been done to study the effect of circle hook size on the selection of various reef fish species, however the study did not compare circle and J hooks (Patterson, et al. 2012). New data however has recently become available to the National Marine Fisheries Service from a study done by the Dauphin Island Sea Lab that did compare the catches or reef fish from circle and J hooks in the Gulf of Mexico (Powers and Shipp, Personal Communication, 2013). In the study, recreational anglers fished for reef fish using circle and J hooks simultaneously during the same fishing event and on the same vessel across a number of years and spatial locations. This data was used in a negative binomial multiple regression to try and understand and quantify the effect that circle hooks may have had on catching red snapper. Ultimately, the goal of this work is to determine whether the switch from "J" to circle hooks in the red snapper recreational fishery affected catchability or selectivity of red snapper, and thus whether the indices of abundance need to be adjusted to account for the gear change, and if so, in what magnitude and direction.

Methods

The data collected during this study was used in a multiple regression using a negative binomial distribution in order to determine whether hook type had an effect on the number of red snapper caught during each fishing event. Catch, as numbers of fish, was modeled as the dependent variable while the natural log of fishing effort, calculated as the number of hooks fished times the minutes fished, was used as an offset in the regression. The negative binomial distribution was selected because the catch data (in numbers of fish) is essentially counts of successes and failures to catch fish in various size groups available at the sampling site. A poisson distribution was considered for use however the poisson model was overdispersed. Model selection was done in a stepwise fashion using Akaike's Information Criterion (AIC). The following factors and all one-way interactions were considered in the model:

Table 1: Factors considered in the negative binomial regression.

Factor	Number of Levels	Levels
Hook Type	2	J Hook and Circle Hook
Year	8	2003, 2004, 2005, 2006, 2007, 2008, 2009, 2012
Size Group	4	200mm, 300mm, 400mm, 500mm
Month	9	March, April, May, June, July, August, September, October, November

Results and Discussion

Descriptive statistics were calculated including the mean size of red snapper observed in the study, and the sample size for each gear and year (Table 2). First, a preliminary main effects only model was fit to the data (Table 3). Results from this initial model fit shows that the parameter for J hooks is statistically significant, initially suggesting that circle hooks have an effect on catchability. Then, a second, final model was fit which included all two-way interactions. Multiple regression results from the model with interactions show that the parameter for J hooks is no longer statistically significant, indicating that there is basically no circle hook effect for RS on the catch (Table 4). This is because in the model with interactions, the interaction between hook type and fish size group suggests that the effect that circle hooks are having on the catch is almost entirely dependent on the size of the fish available in the water at the location you are fishing. The two larger size groups are statistically significant indicating that circle hooks have more of an effect on larger fish than smaller fish. Also, the negative value of the coefficient for J hooks, and the fact that the value of the coefficient increases as the size of the fish increases, suggests that circle hooks are better at catching larger fish. In general, there tend to be fewer larger fish out there than smaller fish, as a result of natural and fishing mortality, which may be why circle hooks decrease the number of fish that are caught, and thus may have caused a drop in the recreational indices after 2008, when the regulation was implemented.

The hook effect in this study is also dependent on year as indicated by the interaction between hook type and year, where in some years there are more small fish than other years. This difference in the size of fish each year can be seen in the histogram plots of fish size for each year and gear in the Appendix. Thus, the hook effect is not unique but depends on the size of fish and on the year. This kind of effect is a selectivity issue, not catchability. As a result, the proper way to account for the switch to circle hooks is to do so in the stock assessment model by allowing for a selectivity change in the year of circle hook implementation, rather than post-hoc correcting the indices of abundance.

Acknowledgements

Thank you very much Dr. Bob Shipp, Dr. Sean Powers, and the recreational fishing community for collecting the multiple years of important data that was used in this analysis.

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Tables and Figures

Table 2: Average lengths of red snapper caught each year using each gear, and the sample sizes for each year and gear.

Year	Mean Size Circle Hook	Mean Size J Hook	Number Samples Circle Hook	Number Samples J-Hook
2003	356.91	341.80	241	289
2004	359.01	347.05	129	327
2005	352.37	333.37	183	207
2006	335.94	302.20	385	455
2007	327.50	333.37	242	468
2008	358.02	350.36	420	368
2009	416.24	372.41	235	169
2012	381.93	366.08	196	205

Table 3: Preliminary main effects only model.

Parameter	Estimate	Std. Error	Z Value	P Value	Upper CI	Lower CI
Intercept	-3.62	-18.67	0.19	0.00	-3.99	-3.24
Hook Type J	0.22	3.62	0.06	0.00	0.10	0.34
300mm Size Group	0.66	8.62	0.08	0.00	0.50	0.81
400mm Size Group	-0.54	-6.59	0.08	0.00	-0.71	-0.38
500mm Size Group	-1.81	-18.01	0.10	0.00	-2.01	-1.60
Year 2004	-0.07	-0.53	0.14	0.59	-0.34	0.19
Year 2005	-0.39	-2.83	0.14	0.00	-0.66	-0.11
Year 2006	0.31	2.51	0.12	0.01	0.07	0.56
Year 2007	0.89	6.31	0.14	0.00	0.61	1.16
Year 2008	0.87	6.33	0.14	0.00	0.60	1.14
Year 2009	1.52	10.97	0.14	0.00	1.24	1.80
Year 2012	0.19	1.34	0.14	0.18	-0.09	0.46
April	-0.36	-2.13	0.17	0.03	-0.69	-0.04
May	-0.67	-4.17	0.16	0.00	-0.99	-0.36
June	-0.30	-1.42	0.21	0.16	-0.71	0.11
July	-1.20	-6.82	0.18	0.00	-1.54	-0.86
August	-0.39	-2.09	0.19	0.04	-0.76	-0.02
September	-0.39	-2.37	0.16	0.02	-0.71	-0.07
October	-0.09	-0.51	0.18	0.61	-0.45	0.26
November	0.22	0.80	0.28	0.42	-0.31	0.76

Table 4: Model results from negative binomial fit of catch and hook type.

Parameter	Estimate	Std. Error	Z Value	P Value	Upper CI	Lower CI
Intercept	-3.81	0.25	-15.52	0.00	-4.29	-3.32
Hook Type J	0.24	0.19	1.21	0.23	-0.15	0.62
300mm Size Group	0.70	0.23	3.05	0.00	0.25	1.14
400mm Size Group	-0.28	0.25	-1.16	0.25	-0.77	0.20
500mm Size Group	-1.91	0.34	-5.68	0.00	-2.60	-1.27
Year 2004	-0.19	0.28	-0.68	0.49	-0.74	0.36
Year 2005	-0.67	0.26	-2.57	0.01	-1.18	-0.15
Year 2006	0.64	0.23	2.81	0.01	0.18	1.10
Year 2007	1.06	0.27	3.94	0.00	0.55	1.59
Year 2008	0.66	0.25	2.67	0.01	0.18	1.15
Year 2009	0.89	0.26	3.40	0.00	0.37	1.41
Year 2012	-0.58	0.28	-2.03	0.04	-1.13	-0.02
April	-0.16	0.17	-0.97	0.33	-0.49	0.16
May	-0.60	0.16	-3.74	0.00	-0.92	-0.28
June	-0.22	0.21	-1.06	0.29	-0.63	0.19
July	-0.99	0.17	-5.77	0.00	-1.33	-0.66
August	-0.16	0.18	-0.90	0.37	-0.53	0.20
September	-0.23	0.16	-1.41	0.16	-0.55	0.09
October	0.11	0.18	0.62	0.53	-0.25	0.46
November	0.38	0.27	1.41	0.16	-0.15	0.93
Hook Type J * 300mm Size Group	-0.12	0.15	-0.81	0.42	-0.41	0.17
Hook Type J * 400mm Size Group	-0.28	0.16	-1.72	0.09	-0.59	0.04
Hook Type J * 500mm Size Group	-0.48	0.21	-2.28	0.02	-0.90	-0.06
Hook Type J * Year 2004	0.19	0.26	0.74	0.46	-0.31	0.69
Hook Type J * Year 2005	0.54	0.25	2.19	0.03	0.05	1.03
Hook Type J * Year 2006	0.25	0.22	1.13	0.26	-0.19	0.69
Hook Type J * Year 2007	0.12	0.25	0.50	0.62	-0.37	0.62
Hook Type J * Year 2008	0.13	0.23	0.55	0.58	-0.32	0.58
Hook Type J * Year 2009	-0.37	0.24	-1.55	0.12	-0.84	0.10
Hook Type J * Year 2012	0.36	0.25	1.43	0.15	-0.13	0.86
300mm Size Group * Year 2004	-0.02	0.31	-0.05	0.96	-0.63	0.59
400mm Size Group * Year 2004	0.09	0.33	0.28	0.78	-0.56	0.75
500mm Size Group * Year 2004	0.03	0.47	0.06	0.95	-0.90	0.95
300mm Size Group * Year 2005	0.10	0.30	0.34	0.74	-0.49	0.70
400mm Size Group * Year 2005	0.00	0.33	0.00	1.00	-0.65	0.65
500mm Size Group * Year 2005	-0.31	0.50	-0.63	0.53	-1.34	0.66
300mm Size Group * Year 2006	-0.26	0.27	-0.99	0.32	-0.79	0.27
400mm Size Group * Year 2006	-1.27	0.30	-4.18	0.00	-1.88	-0.67
500mm Size Group * Year 2006	-0.93	0.43	-2.14	0.03	-1.79	-0.07
300mm Size Group * Year 2007	-0.14	0.30	-0.47	0.64	-0.73	0.45
400mm Size Group * Year 2007	-0.39	0.32	-1.20	0.23	-1.02	0.25
500mm Size Group * Year 2007	-0.90	0.49	-1.84	0.07	-1.87	0.05
300mm Size Group * Year 2008	0.18	0.29	0.62	0.54	-0.39	0.75
400mm Size Group * Year 2008	0.37	0.31	1.19	0.23	-0.24	0.97
500mm Size Group * Year 2008	0.51	0.41	1.25	0.21	-0.30	1.33
300mm Size Group * Year 2009	0.57	0.31	1.87	0.06	-0.03	1.18
400mm Size Group * Year 2009	0.40	0.33	1.20	0.23	-0.25	1.04
500mm Size Group * Year 2009	2.01	0.40	5.04	0.00	1.24	2.81
300mm Size Group * Year 2012	0.49	0.33	1.49	0.14	-0.15	1.13
400mm Size Group * Year 2012	0.75	0.35	2.14	0.03	0.07	1.43
500mm Size Group * Year 2012	1.38	0.44	3.12	0.00	0.53	2.26

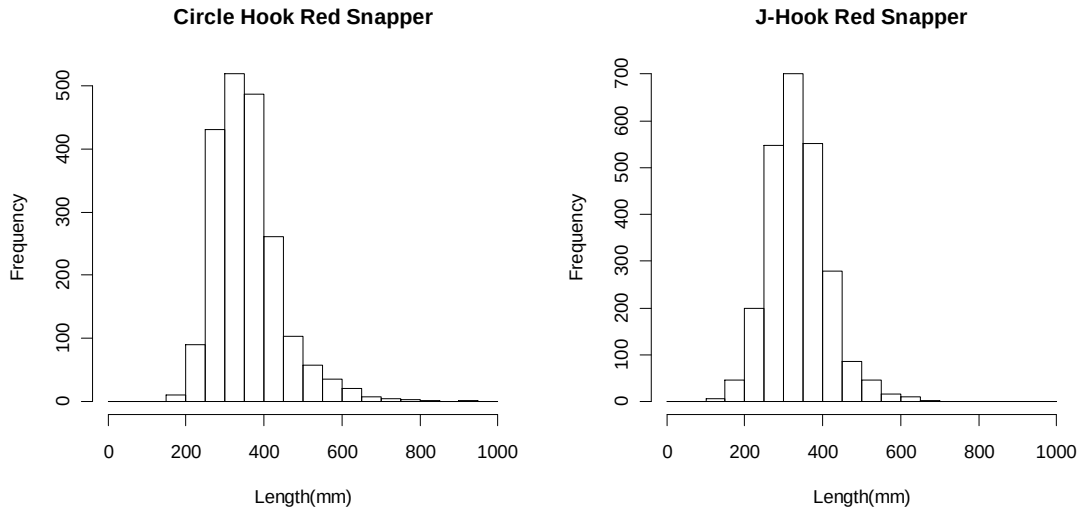
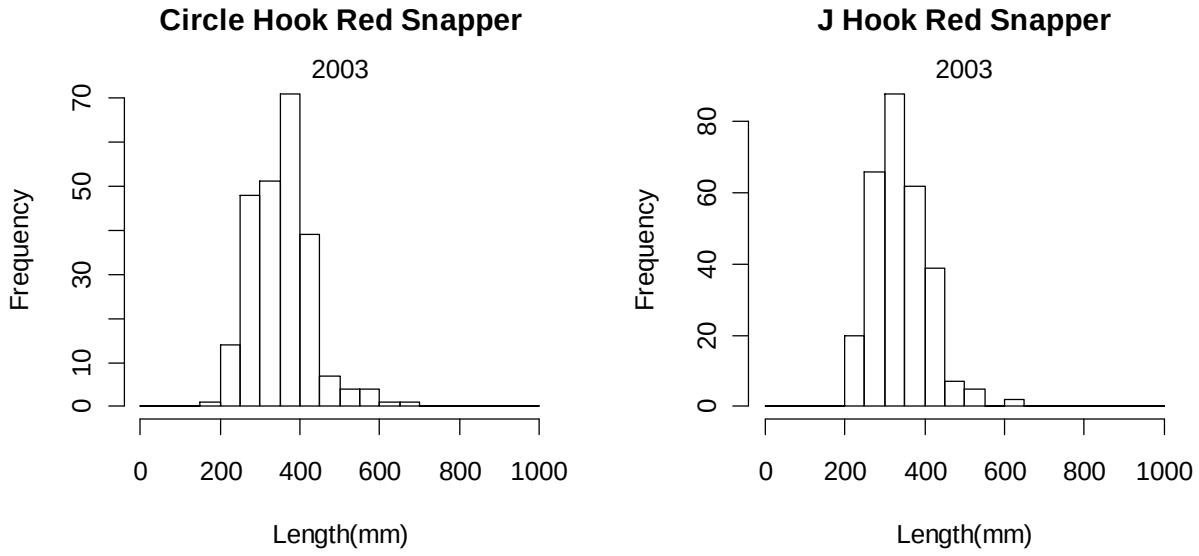
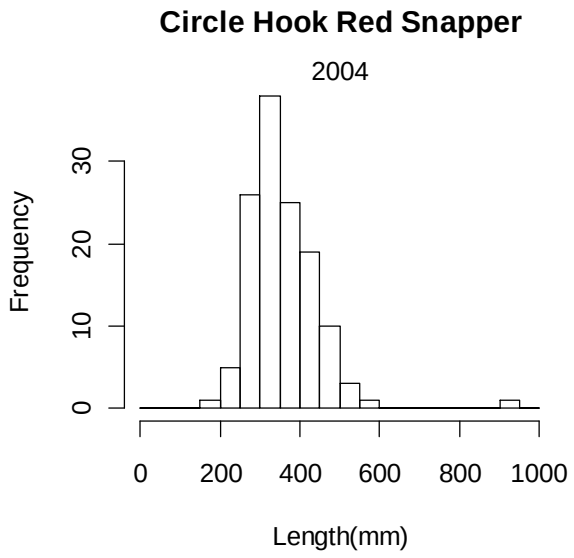


Figure 1: Comparison of red snapper lengths caught on circle and J hooks during the survey. When compared across years, there was a statistically significant difference in the size of fish caught using each gear type (t-test: t=8.4515, p <0.001).

Appendix: Plots of the size of fish caught each year by each gear

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Frequency
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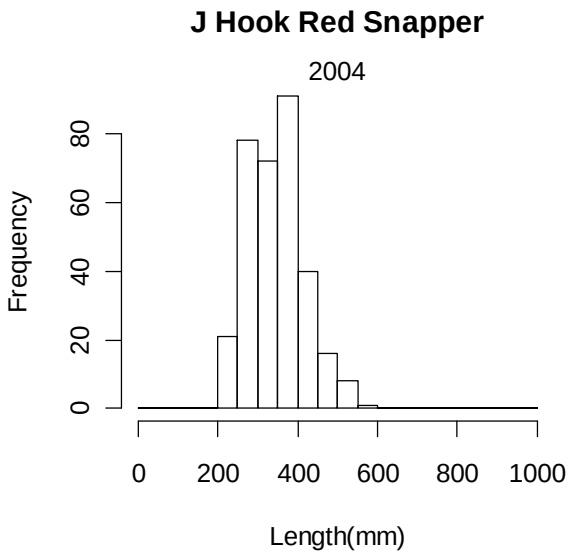
Length(mm)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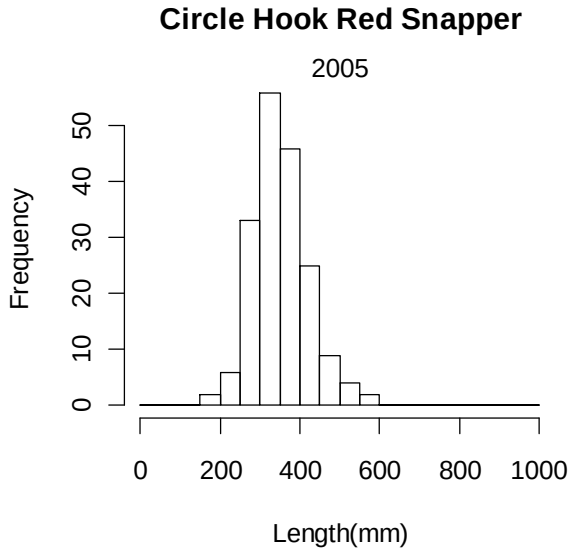
Length(mm)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Frequency
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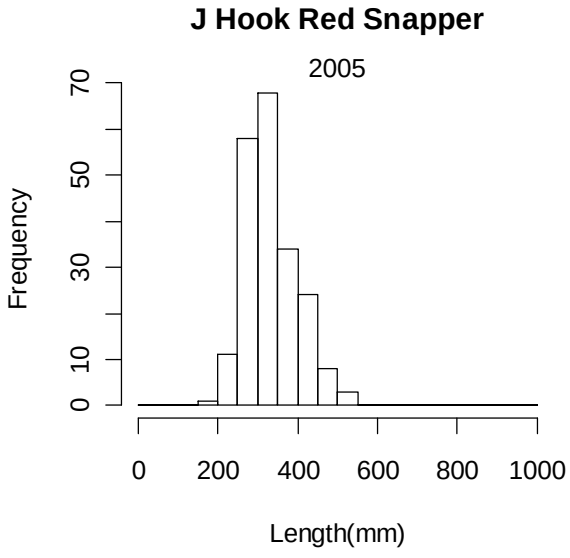
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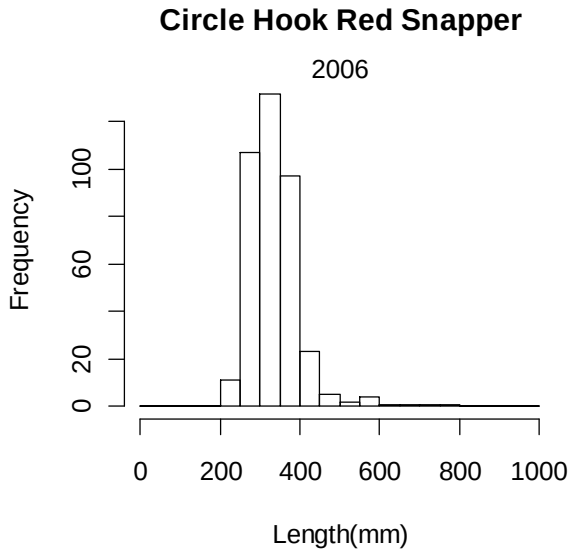
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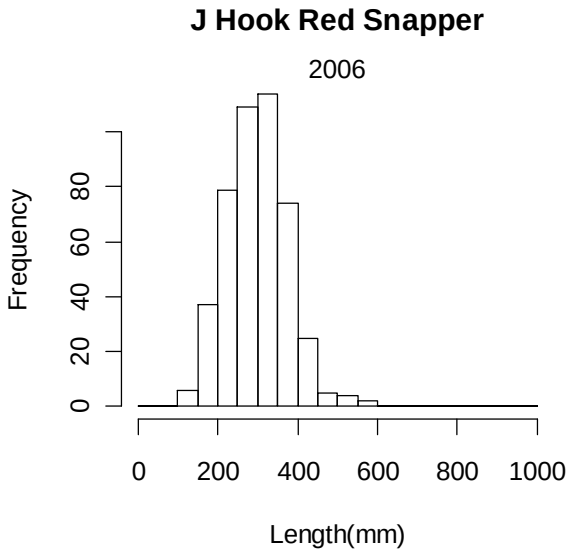
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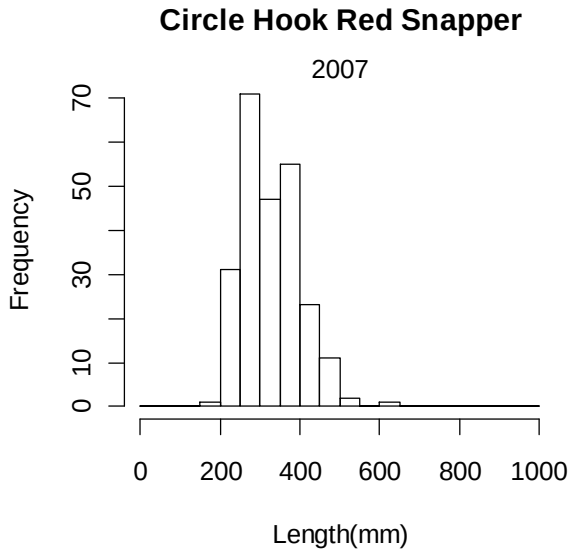
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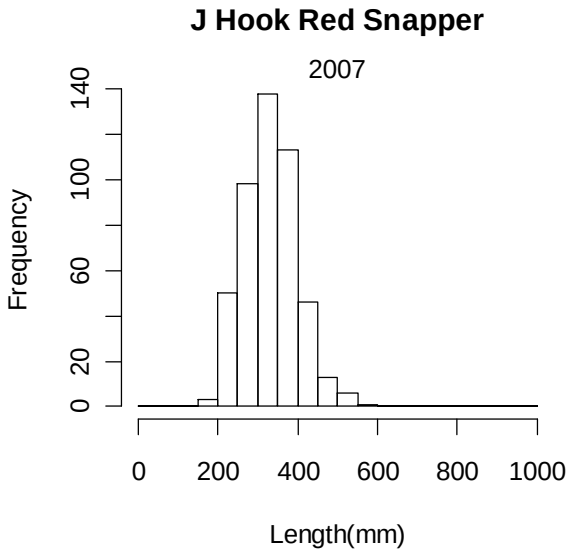
Length(mm)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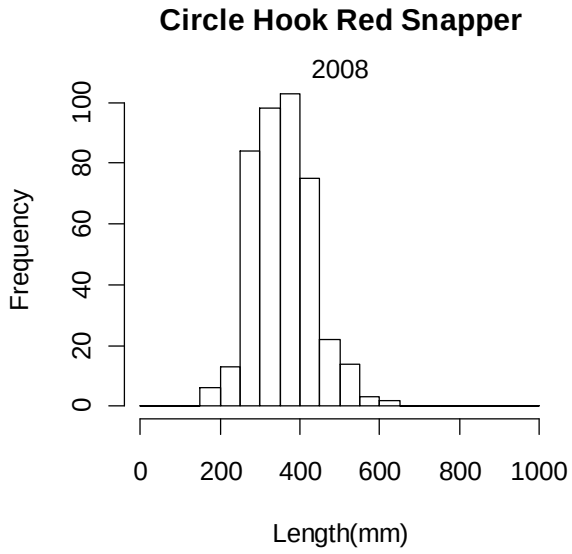
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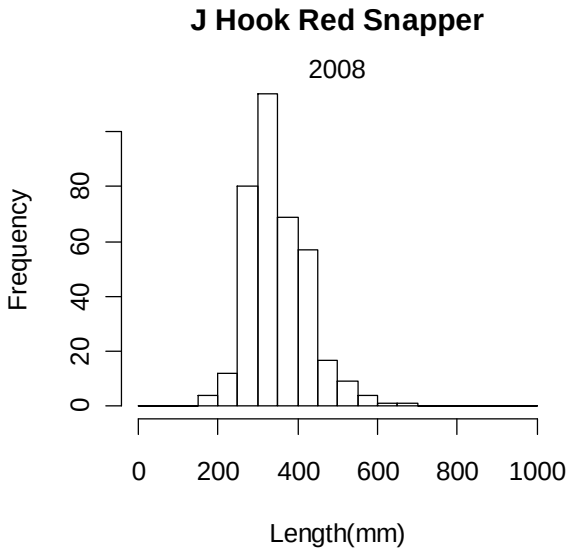
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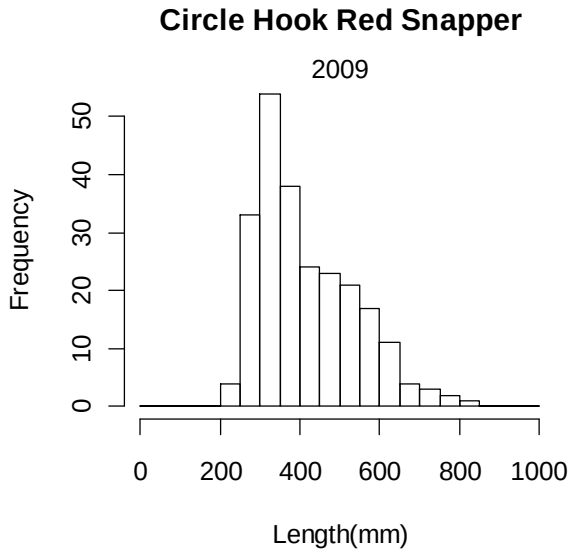
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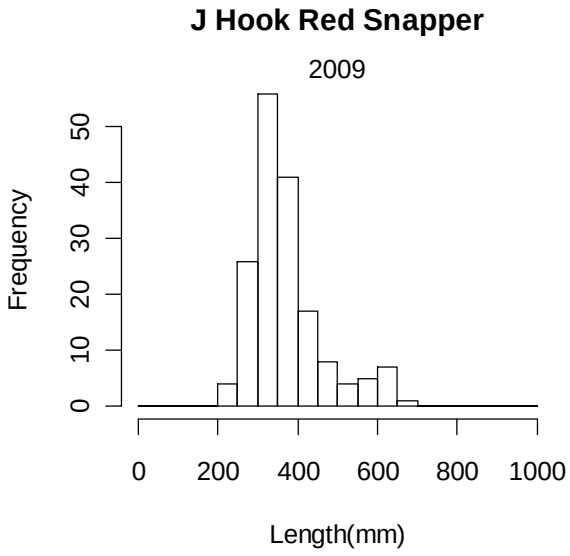
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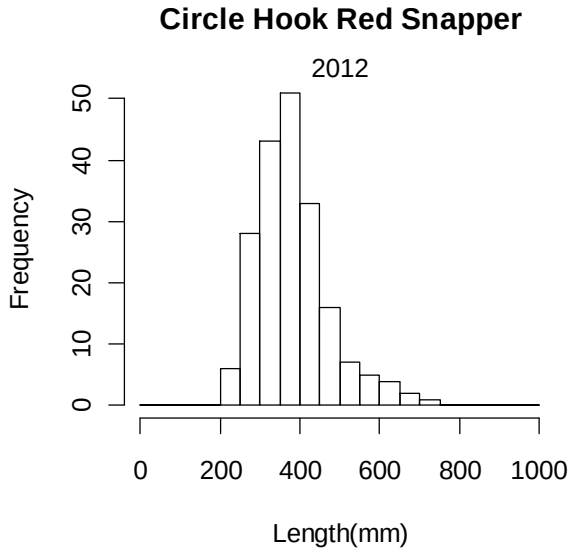
Circle Hook Red Snapper
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Frequency
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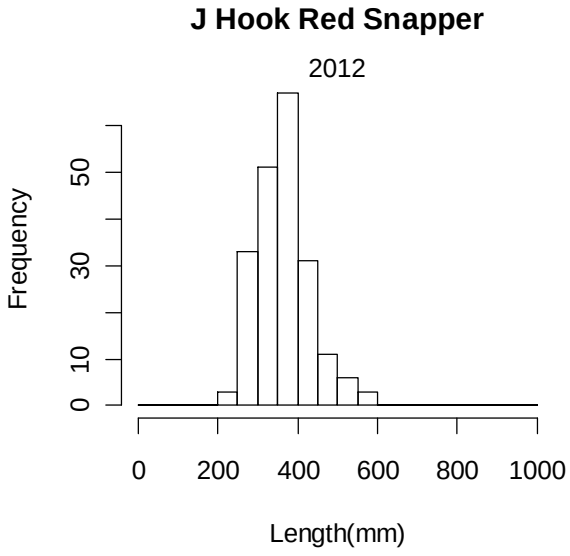
J Hook Red Snapper
2012
Frequency
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Length(mm)