SCIENTIFIC COMMITTEE
TENTH REGULAR SESSION

6-14 August 2014
Majuro -Marshall Islands

STANDARDIZATION OF BLUE SHARK CATCH PER UNIT EFFORT IN THE NORTH PACIFIC OCEAN BASED ON LONGLINE OBSERVER DATA FOR USE AS AN INDEX OF ABUNDANCE.

WCPFC-SC10-2014/ SA-IP-14

Joel Rice[1] and Shelton Harley[1]

[1] Oceanic Fisheries Programme, Secretariat of the Pacific Community (SPC-OFP), Noumea, New Caledonia.

STANDARDIZATION OF BLUE SHARK CATCH PER UNIT EFFORT IN THE NORTH PACIFIC OCEAN BASED ON LONGLINE OBSERVER DATA FOR USE AS AN INDEX OF ABUNDANCE.

Summary

This report presents a Catch Per Unit Effort (CPUE) series of blue shark (*Prionace glauca*) taken in longline fisheries in the North Pacific, based on observer data held by the Secretariat of the Pacific Community - Oceanic Fisheries Program (SPC-OFP). This is used to develop a candidate time series of standardised CPUE for use as an index of abundance in an updated stock assessment.

This specific analysis was motivated by: 1) the Scientific Committee concern that the primary index of abundance in the 2013 assessment was biased due to inadequate accounting of targeting practices documented in recent studies, and 2) the recent provision by the US of updated observer data for the Hawaiian fleet that filled data gaps in SPC holdings. Previous studies have analyzed observer data for blue shark CPUE in the North Pacific (Clarke et al. 2011a, Walsh and Teo 2012), however this is the first study to analyze the combination of the regional observer program dataset.

The sections of this report include a) a summary of the exploratory data analysis of blue shark (BSH) CPUE in the north Pacific ocean, b) a brief presentation of the method used to standardize the CPUE trend for blue sharks, c) model diagnostics, and d) a discussion of the quality of the available data and the relative strengths and weaknesses of the standardization procedures.

Initial data analysis based on boxplots and linear models indicated that SST, 5˚ latitudinal band and month were important factors in explaining the variation in observed CPUE. The standardized CPUE series for blue sharks in the north Pacific based on SPC held observer data covering the years 1993 - 2009. The negative binomial approach was used to standardize longline observer data. The step plot shows that the inclusion of *SST* had the most impact on the trajectory.

1 Introduction

This report presents a Catch Per Unit Effort (CPUE) series for blue shark (*Prionace glauca*) taken in longline fisheries in the North Pacific, based on observer data held by the Secretariat of the Pacific - Oceanic Fisheries Program (SPC-OFP). This is developed as a candidate index of abundance in an updated stock assessment.

Blue sharks are observed throughout the Pacific longline fishery, though this analysis focuses only on the north Pacific (Figure 1) to support an updated 2014 stock assessment. Preliminary genetic evidence suggests little genetic divergence throughout the Pacific though when tagging and fishery data are taken together, they suggest northern and southern stocks based on separate peak areas of abundance, life history patterns and based on seasonal reproduction (ISC SWG WCPFC-SC9-2013/ SA-WP-11a).

The framework for the analysis is to construct inputs for stock assessment based on an estimated catch and an index of abundance based on standardized catch per unit of effort (CPUE). The SPC longline observer database contains records from 1985 to recent years, however blue sharks were not routinely identified to species level until 1990, and in some fisheries later, hence the dataset used in this analysis spans the years 1993-2009. A comprehensive overview of the observer logsheet data and a characterization of the fisheries in which blue sharks are caught is presented in Kleiber et al. (2009) and Clarke et al. (2011a). That recent work by Clarke et al. (2011a) noted gaps in observer data in terms of time and space continuity, reporting rate, and identification with respect to sharks, as well as the targeting of blue sharks in the north Pacific ocean (Clarke et al. 2011b).

CPUE data for species such as sharks often have a large proportion of observations (or sets) with no catch, and also include observations with large catches when areas of higher densities are encountered; this is typical of bycatch species (Ward and Myers 2005). The signals from the nominal[2] CPUE data can be heavily influenced by factors other than abundance and therefore a procedure to standardize CPUE data for changes in factors (e.g. fishing technique, season, bait type) that do not reflect changes in abundance is usually recommended. Nominal CPUE data for bycatch species can be more variable than expected (i.e., overdispersed) with many outlying data points from uncommonly high catch rates. These outlying data points can sometimes be a function of shark targeting.

2 Methods

What follows is a summary of the methods used in this analysis.

2.1 Longline data preparation

The data were validated and trimmed (records with missing values for key explanatory variables removed) to include only relevant data. Environmental data about temperature, salinity, moon phase, and depth of the 27˚C isotherm downloaded from the GODAS database (2011) were matched to the observer data on set by set basis based on set coordinates and date. Latitude and longitude were truncated to the nearest 1˚; this location information was used to calculate the set specific association with a 5˚square (referred to hereinafter as cell). Date of set was used to calculate the

[2] The nominal CPUE is based on the observed catch and effort and calculated as catch/effort

year, month, quarter and trimester of the set. Set time was used to calculate the time category of the day in sixths starting at midnight. Details of the filtering rules applied are presented in Table 1.

2.2 CPUE methodology

CPUE is commonly used as an index of abundance for marine species. However, it is important that raw nominal catch rates be standardized to remove the effects of factors other than abundance. Further, catch data for non-target species (and sharks in particular) often contain large numbers of observed zeros as well as large catch values which need to be explicitly modelled (Bigelow et al. 2002; Campbell 2004, Ward and Myers 2005; Minami et al. 2007). Standardized CPUE series for the longline fishery were estimated where the measure of effort was number of hooks set (in thousands).

2.3 Overview of GLM Analyses

The filtered datasets were standardized using generalized linear models (McCullagh and Nelder 1989) using the software package R (www.r-project.org).

The negative binomial error structure (Lawless 1987) was used. This approach is typically more robust to issues of overdispersion (overdispersion can arise due to excess zeros, clustering of observations, or from correlations between observations) than the Poisson distribution (McCullagh and Nelder 1991), and is appropriate for count data (Ward and Myers 2005), but does not expressly relate covariates to the occurrence of excess zeros (Minami et al. 2007).

The model was fit to the data set independently and all variables used in the models were included as categorical factors except the response variables for catch and the effort (blue and BLUECPUE) and the offset variable (hook_est); these variables were included in the model as continuous variables (Table 2). Model selection began with piecewise ANOVA models (De'ath and Fabricius 2000, Zuur et al. 2009). The Akaike information criterion (AIC) was used as a metric to score the results and determine the final model.

Multiple methods of calculating the indices of abundance and confidence intervals exist depending on the model type (Shono 2008, Maunder and Punt 2004). In this study estimates were calculated by predicting results based on the fitted model and a training data set that included each year effect and the mean effect for each covariate (Zuur et al. 2009). Confidence intervals were calculated as ±1.96* SE, where SE is the standard error associated with the predicted year effect term.

3 Results

For brevity the model results for only the final model chosen are shown. A comparison of the proportion of non zero catch, and mean catch rate for blue shark is presented in Table 2 and 3 by latitude and longitude. Table 4 shows the comparison of the proportion of zeros, mean catch rate and the standardized CPUE for blue shark.

3.1 Initial Modeling Results

Initial analysis of the longline observer data suggested that SST, 5˚ latitudinal band (lat 5) and month (mm) were the main descriptive factors. Linear models and models were fit to the CPUE and various covariates, these along with plots of the nominal cpue and percent positive are in Figures 2-4.

3.2 CPUE Standardization Results –Negative Binomial

The standardized CPUE trend from fitting the data to the negative binomial (Figure 5) shows and increase in CPUE until 1999 and a subsequent decline. The diagnostic results from the negative model (Figures 6 & 7) do not show any significant trends in the plots of the residuals against the model covariates (Figure 7). Figure 6 shows the standard diagnostics of residuals vs. fitted, Pearson residuals vs. fitted, QQ plot and a histogram of the residuals. Comparison of model structure, residual deviance and residual degrees of freedom are listed in Table 5, the stepwise plot showing the component parts of the models is shown in Figure 8. The step plot shows that for the negative binomial model the inclusion of *SST* had the most impact on the trajectory.

4 Discussion

This paper has presented the standardized CPUE series for blue sharks in the north Pacific based on SPC held observer data covering the years 1993-2009. Although data exist for the years 2010 -2012 lack of coverage due to the majority of observers moving to purse seine vessels led to the exclusion of these data. The analyses described above treat the entire longline fleet as one fishery and make no account for any potential differences in the target species.

The overall trend is slightly smoother than the nominal, but shares the same trend of an increase from 1995 to the high point in 1998 and then a decline there after. The standardization models considered in this study only account for the relative catchability among vessels and make no account for any change in the absolute fishing power over time. Potential changes in vessel characteristics, equipment, crew or captain may alter the vessel effect through time. If a consistent trend in catchability is not accounted for the CPUE index could reflect a change in vessel characteristics, not abundance. Further research on better ways to model vessel catchability through time is recommended.

5 Figures

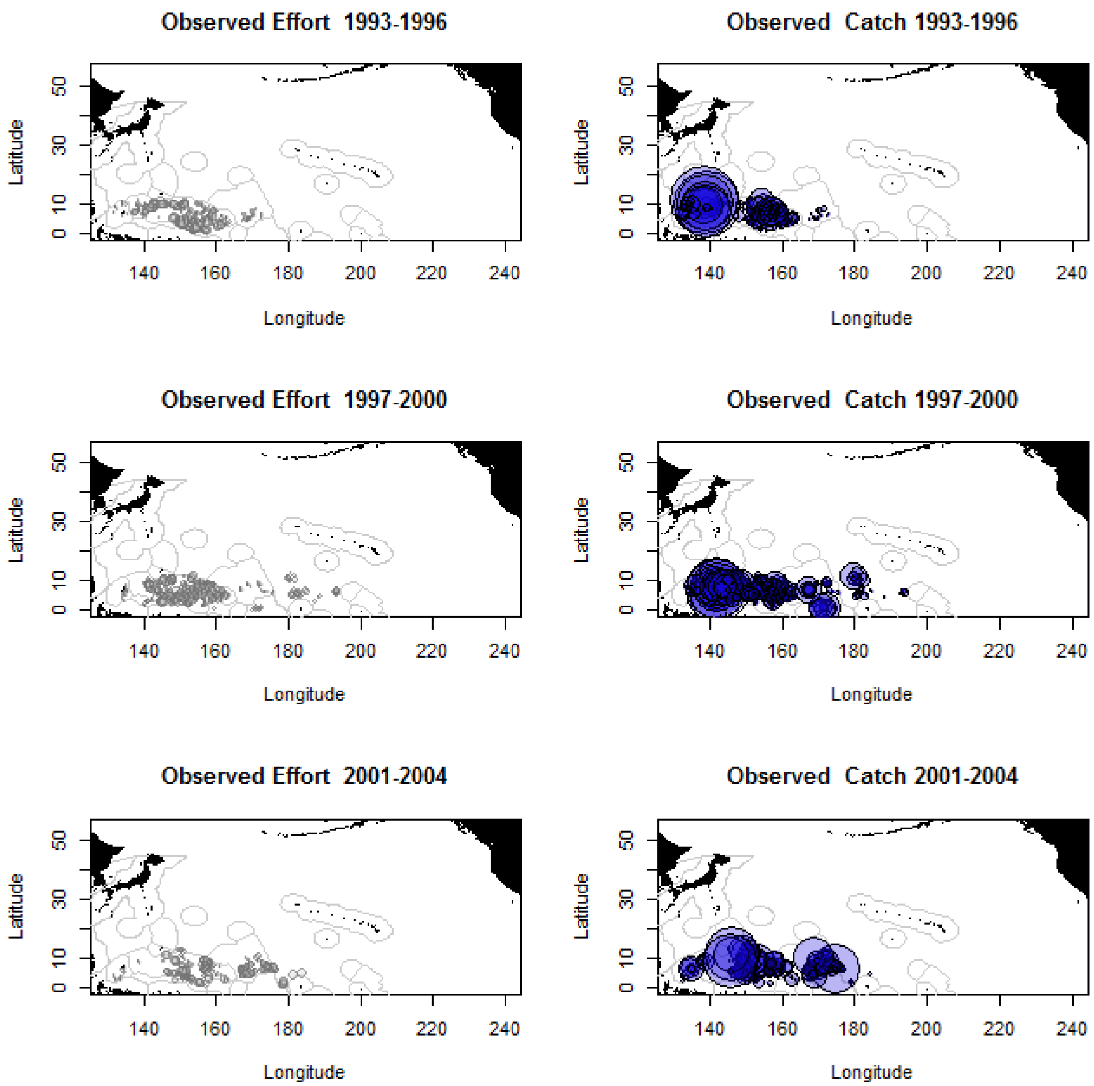

Figure 1: Observed effort (light grey circles) and catch (purple circles) of blue sharks in longline fisheries.

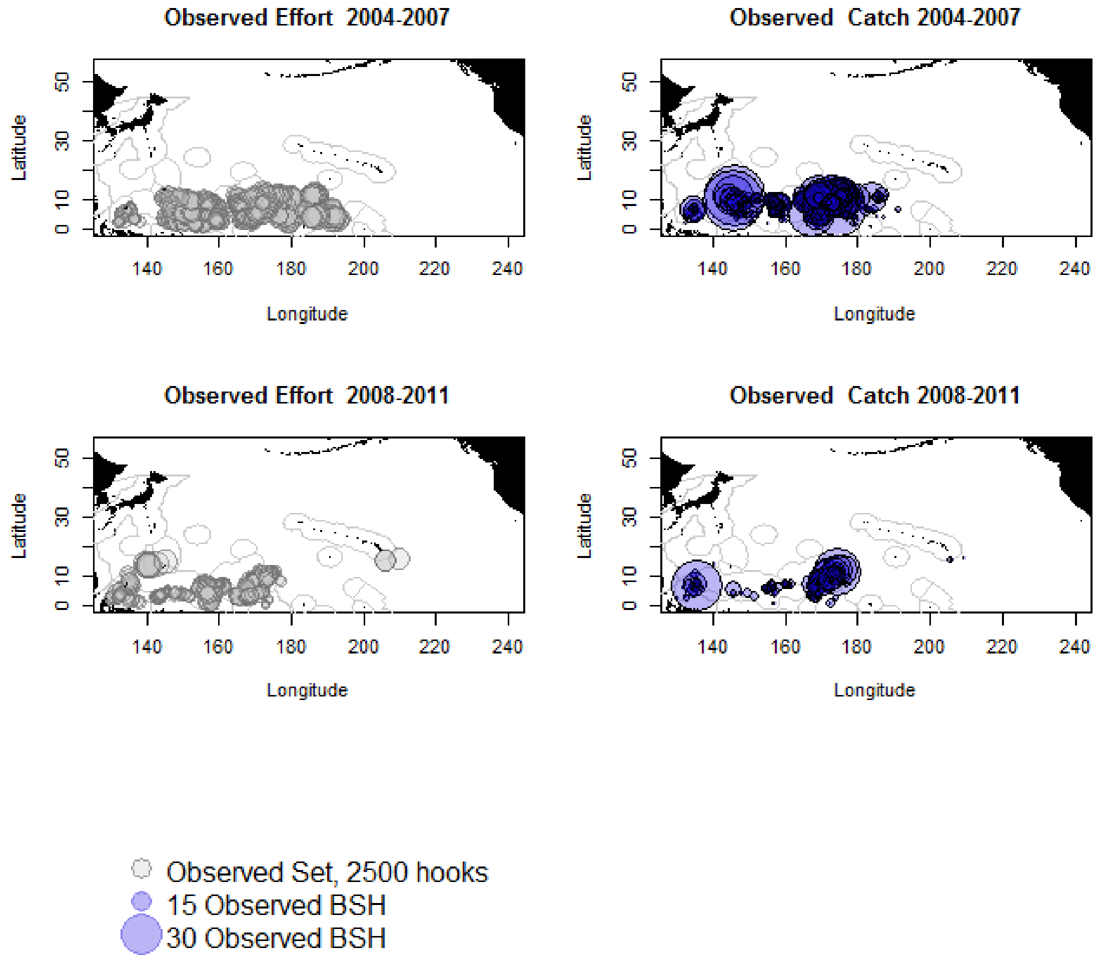

Figure 1 continued: Observed effort (light grey circles) and catch (purple circles) of blue sharks in longline fisheries.

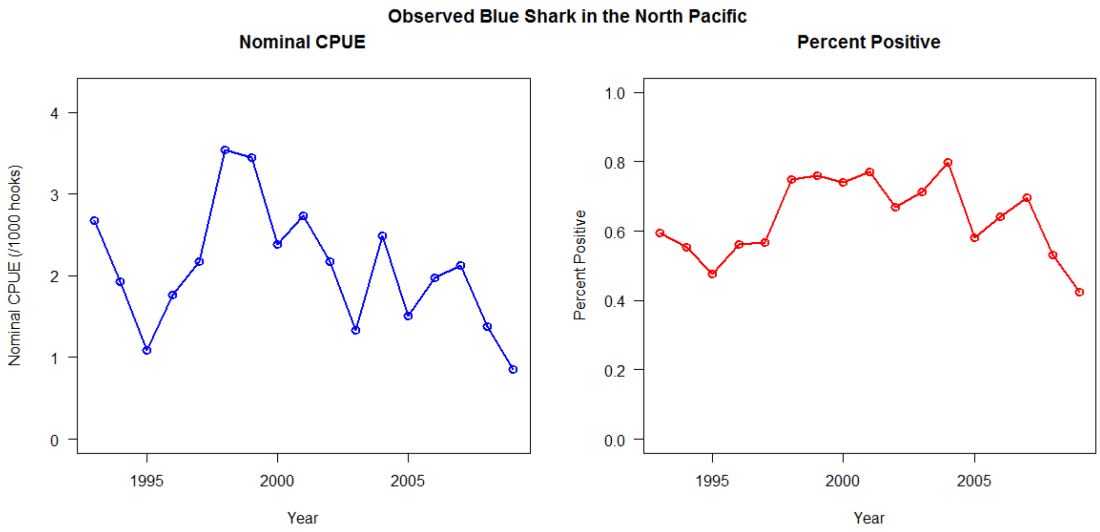

Figure 2: Nominal percent positive and average nominal CPUE.

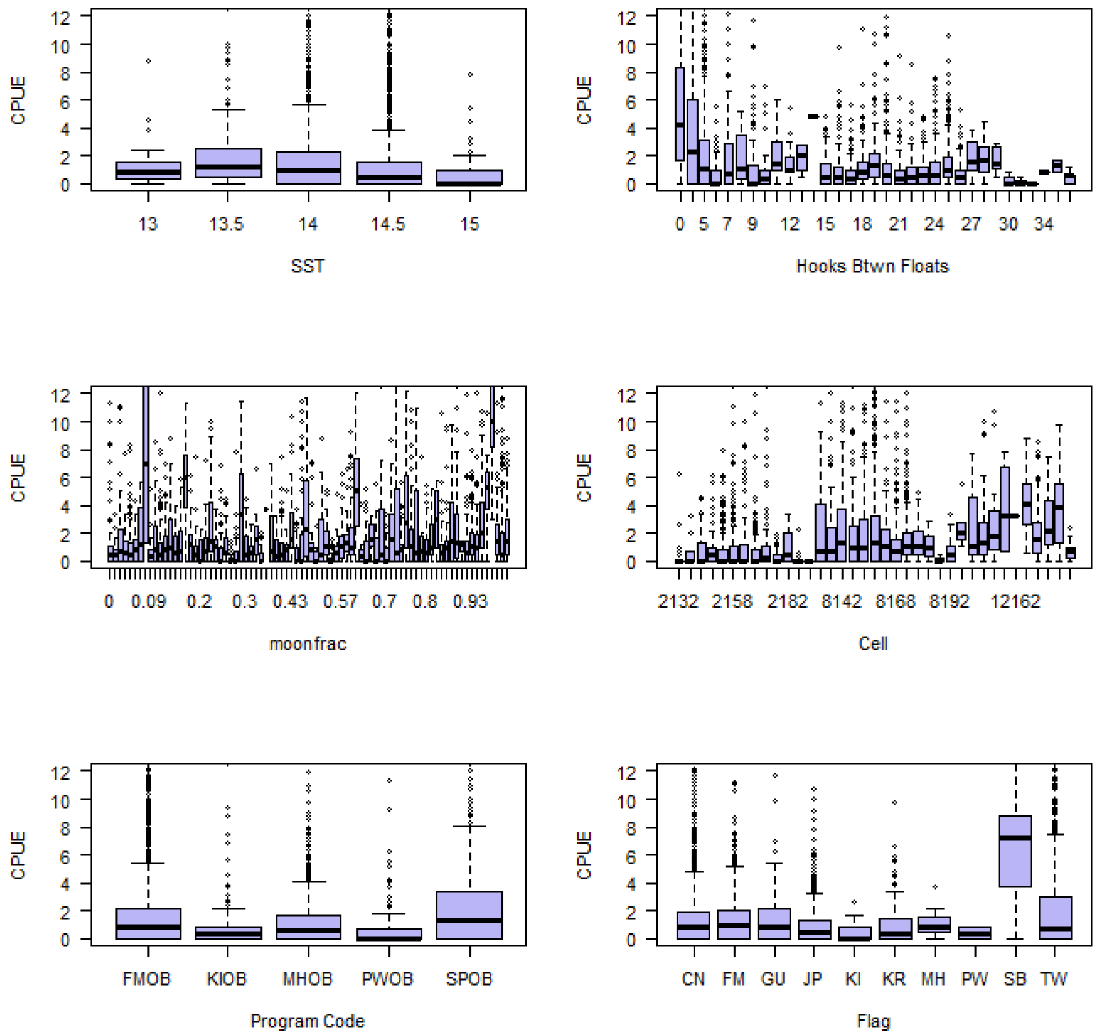

Figure 3: Boxplot of longline CPUE for blue sharks as a function of model variables.

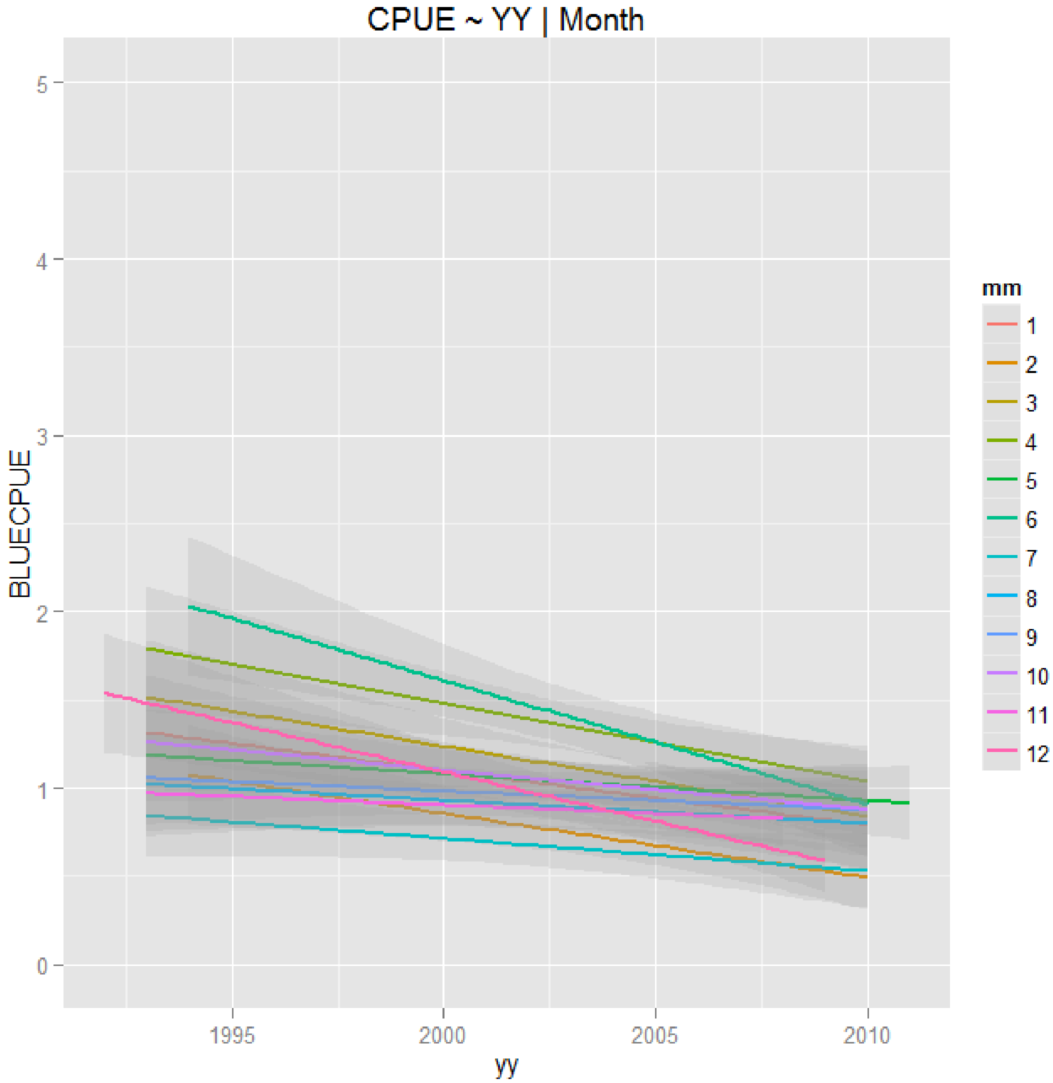

Figure 4: Linear models of blue shark CPUE as a function of year given month.

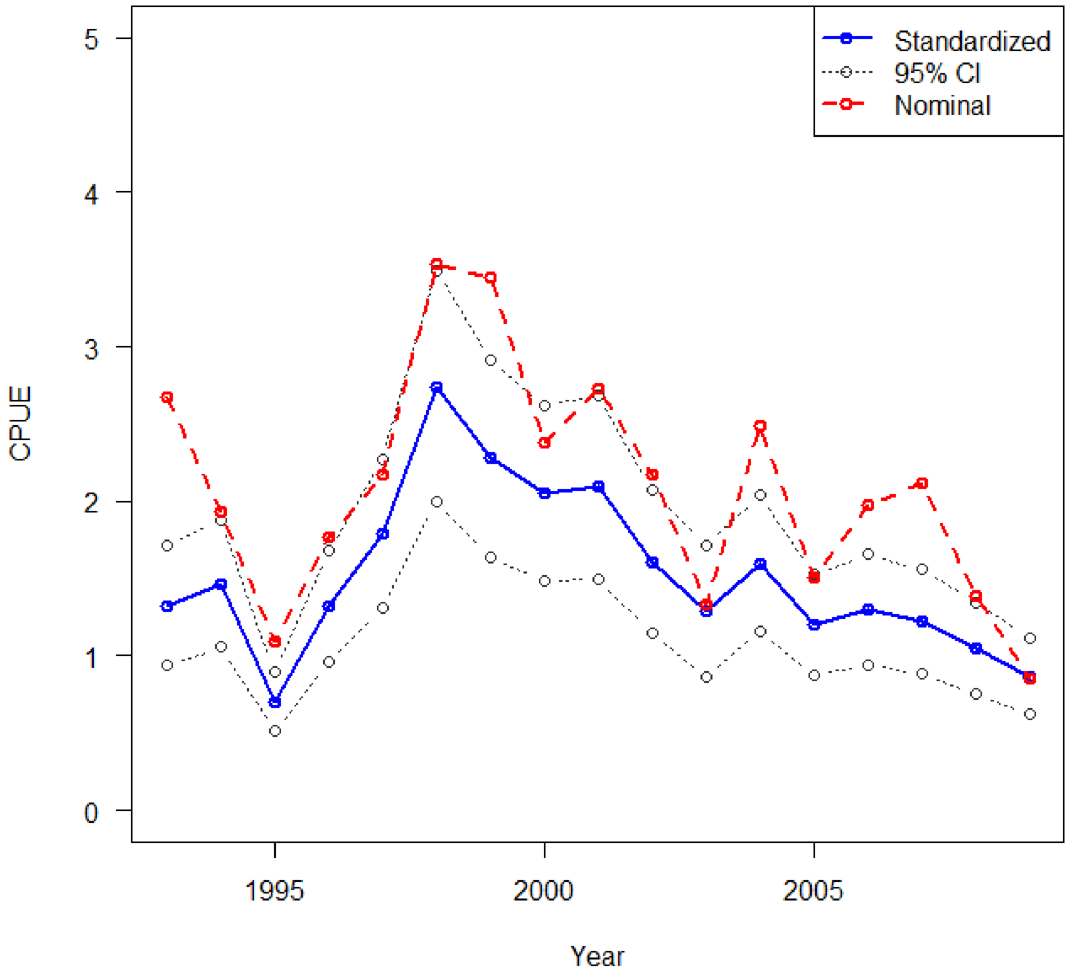

Figure 5: Results from the NB model: nominal CPUE (in red), the standardized CPUE time series (in blue), and 95% confidence intervals (in grey).

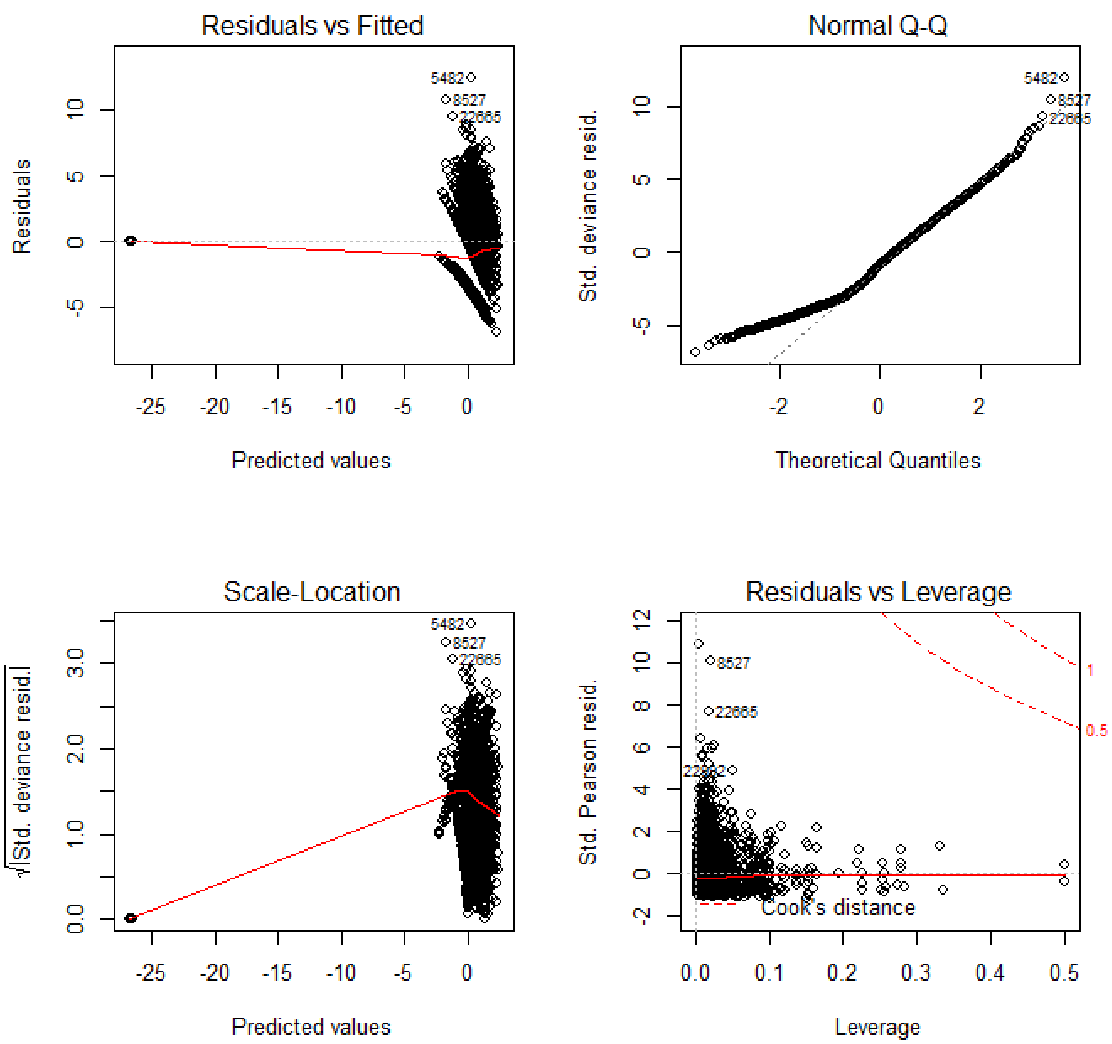

Figure 6: Diagnostic results from the NB model fit.

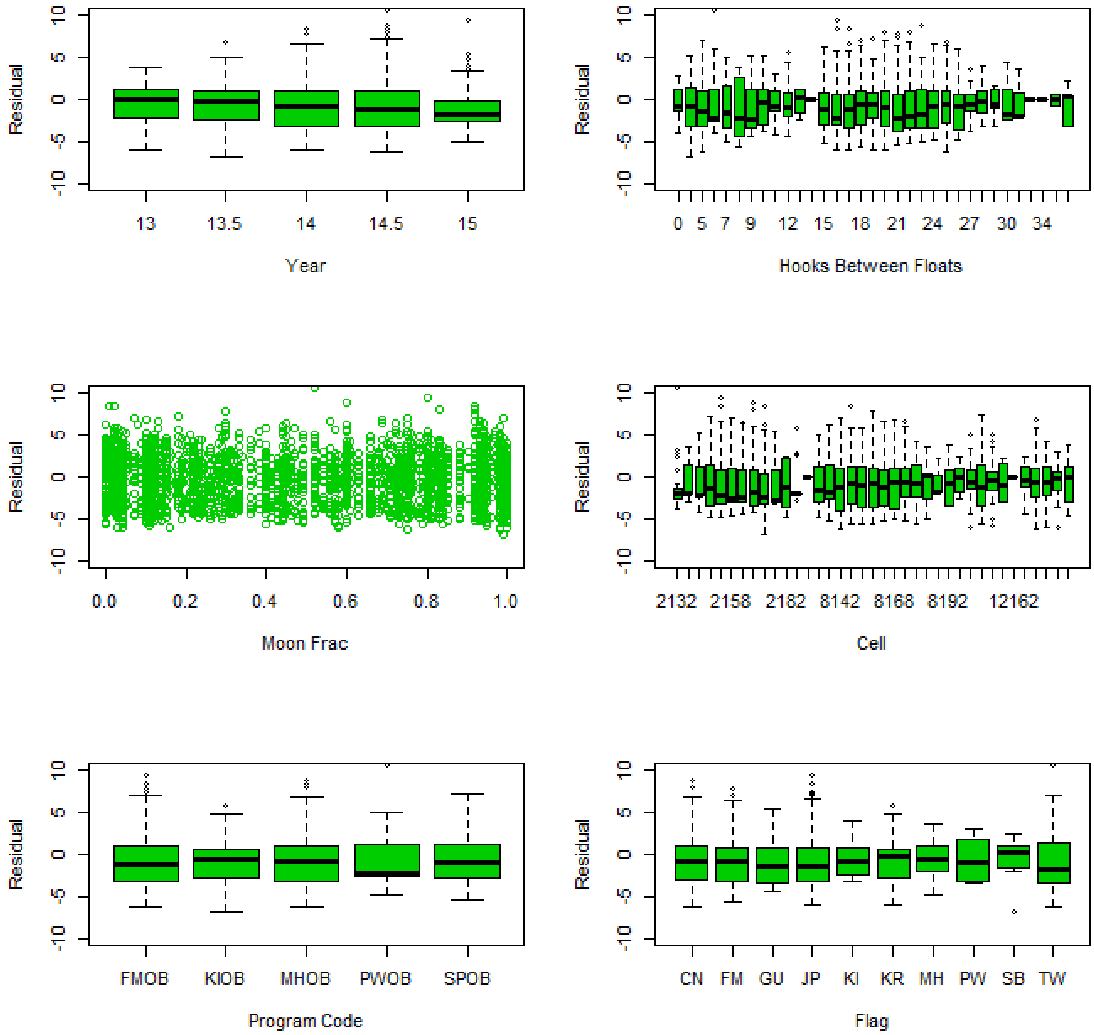

Figure 7: Diagnostic results from the NB model fit.

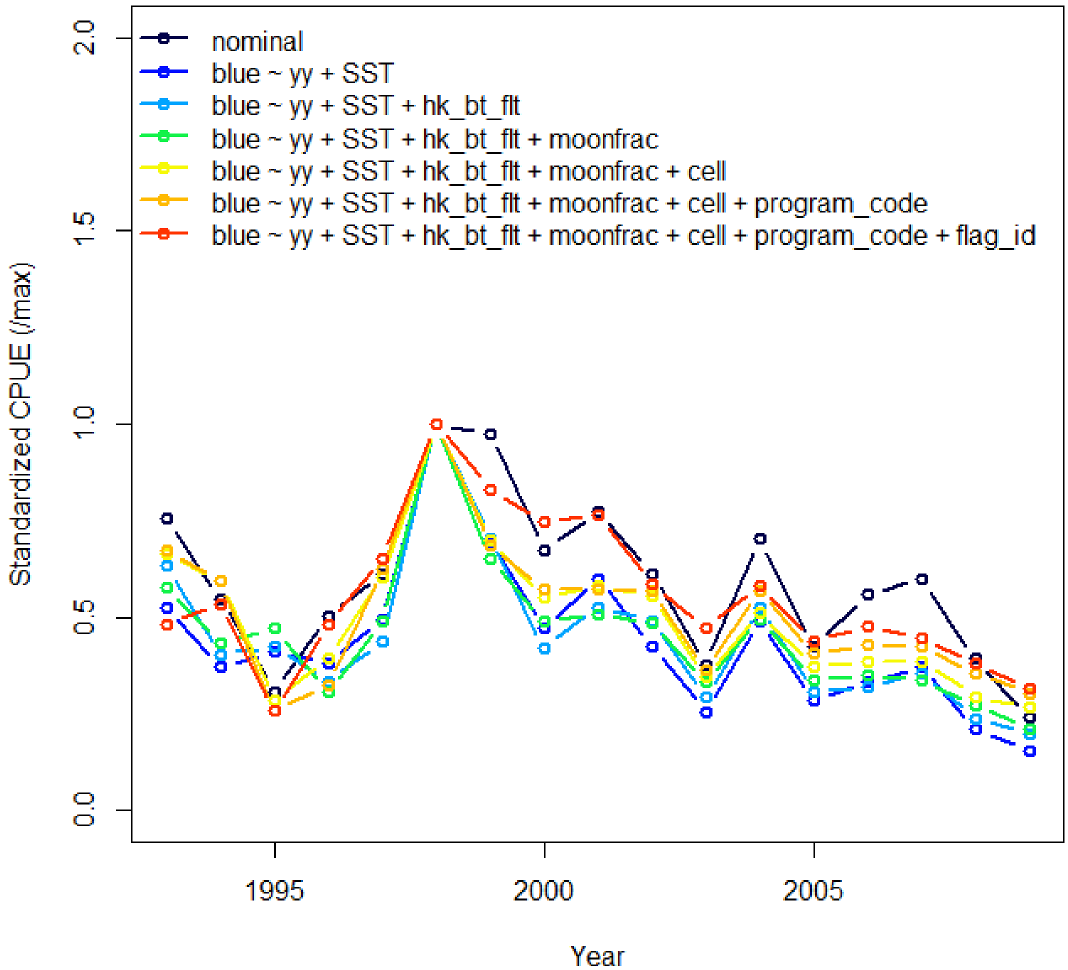

Figure 8: Step plots of model covariates upon catch rates from the NB model.

6 Tables

Table 1: Filtering Rules for the longline dataset on blue sharks

Filtering rules for the Bycatch Data	Number of Records	Number removed	Filtering Rule	Number of sets with blue shark catch
	57983		Initial data set	50473
	57703	280	Remove data east of 225 longitude	50205
	43108	18	Remove years outside 1993:2009 and latitude >35˚N.	36732
	4440	38668	Remove HWOB records	2843

Table 2: Average annual CPUE and Percent Positive Catch By Latitude.

	Average CPUE			Percent Positive		
	Latitude Band			Latitude Band		
Year	2.5	7.5	12.5	2.5	7.5	12.5
1993	0.586	3.775	NA	0.44	0.667	NaN
1994	1.249	2.69	NA	0.521	0.578	NaN
1995	0.372	1.705	6.635	0.276	0.507	0.882
1996	0.609	3.059	5.766	0.292	0.818	1
1997	1.148	3.108	1.445	0.431	0.661	0.4
1998	1.199	6.791	3.373	0.532	0.864	0.913
1999	2.384	3.846	2.206	0.605	0.854	1
2000	1.167	2.477	4.848	0.712	0.743	1
2001	0.7	3.086	15	0.5	0.886	NaN
2002	0.865	1.314	4.716	0.68	0.611	0.875
2003	NA	1.005	NA	NaN	0.714	NaN
2004	1.108	2.121	5.864	0.5	0.878	1
2005	0.386	1.011	1.82	0.415	0.735	0.767
2006	0.496	0.965	2.041	0.47	0.688	0.859
2007	0.396	1.2	2.208	0.407	0.772	0.966
2008	0.432	0.633	2.17	0.429	0.487	0.875
2009	0.271	0.669	1.231	0.319	0.494	0.818

Table 3: Average annual CPUE and Percent Positive Catch By Longitude.

Percent Positive

	Longitude Band									
	132.5	137.5	142.5	147.5	152.5	157.5	162.5	167.5	172.5	177.5
1993			0.526		0.25	1	0.667			
1994		0	0.727		0.574	0.537	0.5			
1995		0.909	0.614	0.75	0.429	0.417	0	0.3	0.379	
1996	1	1		0.222	0.528	0.452	0.667			
1997			0.786	0.483	0.739	0.413	0.333	0.706	0.647	0.75
1998	0.667	0.556	0.771	0.75	0.609	0.862	0.658			1
1999	1	0.938	0.95	0.721	0.588	0.909	0.455		0.9	
2000			0.786	0.774	0.673	0.771	0.724			
2001		1		1	1	0.803	0.5	1		
2002				0.941	0.574	0.867				0.333
2003						0.714				
2004	0.5	0		0.846	1	0.714		0.776	0.916	0.789
2005	0.286	0.333	0.5	0.727	0.351	1		0.571	0.621	0.545
2006			1	0.667	0.4	0.667	0.1	0.534	0.744	0.717
2007	0.24	0.458		0.667	0.786	0.639	0.676	0.63	0.856	0.915
2008	0.25	0.189		0.235	0.286	0.478	0.667	0.645	0.778	0.875
2009	0.75	0.478	0	0.8	0.167	0.294		0.5	0.561	

Nominal CPUE

	Longitude Band									
	132.5	137.5	142.5	147.5	152.5	157.5	162.5	167.5	172.5	177.5
1993			1.066		0.451	5.979	0.791			
1994		0	2.5		1.457	2.492	1.693			
1995		3.356	0.803	0.83	0.66	0.757	0	0.722	1.036	
1996	4.543	4.569		1.01	2.007	1.332	1.086			
1997			4.751	1.761	1.926	0.953	1.385	4.553	2.684	1.111
1998	0.597	1.296	2.618	4.066	1.407	4.813	2.744			4.457
1999	3.947	3.82	2.957	1.608	3.438	4.256	0.972		6.625	
2000			4.443	1.008	1.906	2.63	1.277			
2001		6.206		2.5	8.437	1.641	1.024	4.444		
2002				2.349	1.104	1.764				0.265
2003						1.005				
2004	2.973	0		2.204	0.525	1.569		1.418	2.413	0.792
2005	0.168	0.199	0.675	0.793	0.434	1.639		0.8	0.972	0.622
2006			6.422	1.269	0.245	0.896	0.16	0.632	1.293	1.608
2007	0.371	0.51		0.517	0.725	0.755	1.382	0.712	1.55	1.976
2008	0.254	0.23		0.452	0.284	0.383	0.722	0.818	1.694	1.802
2009	1.126	0.509	0	0.692	0.288	0.186		0.729	0.742	

Table 4: Comparison of the proportion of positive catch, mean catch and the standardized CPUE for blue shark.

	Filtered Data Set			Standardized CPUE		
Year	% Positive Catch	Mean Annual catch per set	Nominal CPUE SE	Negative Binomial Standardized CPUE	Negative Binomial Standardized CPUE (/max)	Negative Binomial SE
1993	59%	2.444	3.496	1.32	0.482	0.197
1994	55%	1.967	3.001	1.47	0.535	0.21
1995	48%	0.887	1.519	0.70	0.256	0.098
1996	56%	1.947	2.589	1.32	0.481	0.185
1997	57%	1.936	2.860	1.79	0.653	0.245
1998	75%	2.989	3.285	2.74	1	0.382
1999	76%	2.921	2.974	2.28	0.831	0.325
2000	74%	2.143	2.624	2.05	0.747	0.29
2001	77%	2.370	2.826	2.09	0.763	0.304
2002	67%	1.365	1.899	1.61	0.587	0.236
2003	71%	1.005	1.331	1.29	0.471	0.217
2004	80%	1.801	2.200	1.60	0.582	0.224
2005	58%	0.790	1.117	1.20	0.438	0.169
2006	64%	1.000	1.333	1.30	0.474	0.182
2007	70%	1.105	1.201	1.22	0.445	0.172
2008	53%	0.815	1.171	1.05	0.382	0.15
2009	42%	0.500	0.869	0.87	0.316	0.126

Table 5: Model comparison for blue shark CPUE standardization with the negative binomial.

	Df	Deviance	Resid. Df	Resid. Dev	P(>|Chi|)
NULL			4439	48341	
yy	16	2854.3	4423	45487	" < 2.2e-16"
SST	4	1545.1	4419	43942	" < 2.2e-16"
hk_bt_flt	32	2469.4	4387	41473	" < 2.2e-16"
moonfrac	1	295.6	4386	41177	" < 2.2e-16"
cell	36	5215.3	4350	35962	" < 2.2e-16"
program_code	4	180.7	4346	35781	" < 2.2e-16"
flag_id	9	716.6	4337	35064	" < 2.2e-16"

7 References

Bigelow K. A., Hampton J., & Miyabe N. (2002) Application of a habitat-based model to estimate effective longline fishing effort and relative abundance of Pacific bigeye tuna (*Thunnus obesus*). Fisheries Oceanography 11: 143-155.

Clarke, S. Harley, S. Hoyle, S. and Rice J. (2011) An Indicator-based Analysis of Key Shark Species based on Data held by SPC-OFP. http://www.wcpfc.int/doc/eb-wp-01/indicator-based-analysis-key-shark-species-based-data-held-spc-ofp

Clarke, S., Yokawa, K. Matsunaga, H., Nakano, H. (2011b) Analysis of North Pacific Shark Data from Japanese Commercial Longline and Research/Training Vessel Records. WCPFC-SC7-EB-WP-04. Accessed online at http://www.wcpfc.int/doc/eb-wp-02/analysis-north-pacific-shark-data-japanese-commercial-longline-and-researchtraining-ves

Campbell R. A. (2004) CPUE standardisation and the construction of indices of stock abundance in a spatially varying fishery using general linear models. Fisheries Research 70: 209-227.

De'ath G. & Fabricius K. E. (2000) Classification and regression trees: a powerful yet simple technique for ecological data analysis. Ecology 81: 3178-3192.

GODAS (2011) Data provided by the NOAA-ESRL Physical Sciences Division, Boulder Colorado from their Web site at http://www.esrl.noaa.gov/psd/, data accessed November 2011.

ISC SWG WCPFC-SC9-2013/ SA-WP-11a. 2013. Report of the shark working group workshops, May 2012, January and April 2013.

Kleiber, P., S. Clarke, K. Bigelow, H. Nakano, M. McAllister, and Y. Takeuchi. 2009. North Pacific blue shark stock assessment. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-PIFSC-17, 74 p

Lawless, J.F. (1987) Negative binomial and mixed Poisson regression. Can. J. Stat. 15, 209–225.

Maunder, M.N., Punt, A.E. (2004) Standardizing catch and effort data: a review of recent approaches. Fish.Res. 70, 141 -159.

McCullagh P. & Nelder J. A. (1989) Generalized Linear Models. Chapman & Hall.

Minami, M. Lennert-Cody, C.E., Gao, W. , Román-Verdesoto, M. (2007) Modeling shark bycatch: the zero-inflated negative binomial regression model with smoothing. Fisheries Research 84: 210-221.

Scientific Committee, Ninth Regular Session Summary Report. Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean. Scientific Committee. Regular Session (9th : 2013 : Pohnpei, Federated States of Micronesia) Ninth regular session, Pohnpei, Federated States of Micronesia, 6-14 August 2013 : summary report. – Kolonia, Pohnpei : Western and Central Pacific Fisheries Commission, 2013.

Shono H. (2008) Confidence interval estimation of CPUE year trend in delta-type two-step model. Fisheries Science 74: 712-717.

Walsh, W.A., Teo, S.L.H. 2012 Catch Statistics, Length Data and Standardized CPUE for Blue Shark Prionace glauca taken by Longline Fisheries based in Hawaii and California, ISC/12/SHARKWG-1/02.

Ward, P., Myers, R.A., (2005), Shifts in open –ocean fish communities coinciding with the commencement of commercial fishing. Ecology 86, 835-847.

Zurr, A.F., Ieno, E.N., Walker, N.J., Saveliev, A.A., Smith, Graham, M.S. (2009) Mixed effects models and extensions in ecology with R. Springer, NY, NY.

8 APPENDIX 2 Summary Output tables for the negative binomial model

```
Call:
glm.nb(formula = blue ~ yy + SST + hk_bt_flt + moonfrac + cell +  program_code + flag_id, data =
DataFile_T[DataFile_T$yy %in%  c(1993:2009), ], weights = offset(log(hook_est)), maxit = 2500,
   init.theta = 1.597510479, link = log)

Deviance Residuals:
   Min      1Q   Median      3Q     Max
-6.8987  -3.1451  -0.9443   1.0438  12.4345

Coefficients:
              Estimate Std. Error z value Pr(>|z|)
(Intercept)     -1.335e-02  2.336e-01  -0.057 0.954427
yy1994           1.033e-01  6.024e-02   1.715 0.086421 .
yy1995          -6.323e-01  6.479e-02  -9.759  < 2e-16 ***
yy1996          -1.992e-03  6.754e-02  -0.029 0.976467
yy1997           3.021e-01  6.217e-02   4.859 1.18e-06 ***
yy1998           7.289e-01  5.896e-02  12.362  < 2e-16 ***
yy1999           5.438e-01  5.809e-02   9.361  < 2e-16 ***
yy2000           4.373e-01  6.503e-02   6.725 1.75e-11 ***
yy2001           4.586e-01  6.490e-02   7.065 1.60e-12 ***
yy2002           1.967e-01  6.587e-02   2.986 0.002831 **
yy2003          -2.509e-02  1.138e-01  -0.221 0.825470
yy2004           1.880e-01  6.025e-02   3.120 0.001806 **
yy2005          -9.748e-02  6.291e-02  -1.549 0.121285
yy2006          -1.700e-02  6.228e-02  -0.273 0.784942
yy2007          -7.981e-02  5.932e-02  -1.346 0.178439
yy2008          -2.340e-01  6.902e-02  -3.390 0.000699 ***
yy2009          -4.228e-01  7.135e-02  -5.926 3.10e-09 ***
SST13.5         -1.295e-01  1.453e-01  -0.891 0.372810
SST14          -3.586e-01  1.453e-01  -2.467 0.013612 *
SST14.5         -5.359e-01  1.463e-01  -3.664 0.000248 ***
SST15          -1.328e+00  1.648e-01  -8.054 7.98e-16 ***
hk_bt_flt4      -5.839e-02  1.132e-01  -0.516 0.606079
hk_bt_flt5      -3.012e-01  1.078e-01  -2.793 0.005227 **
hk_bt_flt6      -7.090e-01  1.238e-01  -5.729 1.01e-08 ***
hk_bt_flt7      -4.049e-01  1.204e-01  -3.363 0.000770 ***
hk_bt_flt8       7.888e-02  1.522e-01   0.518 0.604316
hk_bt_flt9      -7.752e-01  1.253e-01  -6.188 6.11e-10 ***
hk_bt_flt10     -7.293e-01  1.410e-01  -5.172 2.32e-07 ***
hk_bt_flt11     -4.414e-01  1.655e-01  -2.667 0.007658 **
hk_bt_flt12     -3.290e-01  1.349e-01  -2.438 0.014756 *
hk_bt_flt13     -7.778e-02  2.333e-01  -0.333 0.738808
hk_bt_flt14      8.755e-01  3.655e-01   2.396 0.016595 *
hk_bt_flt15     -5.214e-01  1.223e-01  -4.263 2.02e-05 ***
hk_bt_flt16     -4.633e-01  1.209e-01  -3.832 0.000127 ***
hk_bt_flt17      3.533e-02  1.224e-01   0.289 0.772770
hk_bt_flt18      2.056e-01  1.162e-01   1.770 0.076686 .
hk_bt_flt19      1.822e-01  1.173e-01   1.553 0.120393
```

hk_bt_flt20	-3.058e-01	1.122e-01	-2.727	0.006399	**
hk_bt_flt21	-3.593e-01	1.193e-01	-3.013	0.002588	**
hk_bt_flt22	-4.428e-01	1.188e-01	-3.729	0.000193	***
hk_bt_flt23	-3.361e-01	1.162e-01	-2.892	0.003824	**
hk_bt_flt24	-3.198e-01	1.152e-01	-2.776	0.005501	**
hk_bt_flt25	-8.940e-02	1.136e-01	-0.787	0.431258	
hk_bt_flt26	-2.954e-01	1.192e-01	-2.479	0.013179	*
hk_bt_flt27	-1.986e-01	1.477e-01	-1.344	0.178904	
hk_bt_flt28	-8.798e-02	1.272e-01	-0.692	0.489115	
hk_bt_flt29	-1.395e-01	1.537e-01	-0.908	0.363984	
hk_bt_flt30	-8.023e-01	1.844e-01	-4.352	1.35e-05	***
hk_bt_flt31	-1.005e+00	3.970e-01	-2.533	0.011323	*
hk_bt_flt32	-2.663e+01	6.365e+04	0.000	0.999666	
hk_bt_flt34	-3.514e-01	3.978e-01	-0.883	0.377054	
hk_bt_flt35	6.699e-01	3.702e-01	1.809	0.070391	.
hk_bt_flt50	-1.480e-01	1.903e-01	-0.778	0.436741	
moonfrac	4.262e-01	3.336e-02	12.777	< 2e-16	***
cell2138	3.820e-01	1.901e-01	2.010	0.044451	*
cell2142	-4.758e-01	1.593e-01	-2.987	0.002818	**
cell2148	-5.391e-02	1.438e-01	-0.375	0.707819	
cell2152	-2.864e-01	1.414e-01	-2.025	0.042858	*
cell2158	1.157e-01	1.416e-01	0.817	0.413803	
cell2162	-1.156e-01	1.452e-01	-0.796	0.425764	
cell2168	3.956e-01	1.475e-01	2.682	0.007315	**
cell2172	2.140e-01	1.577e-01	1.357	0.174816	
cell2178	3.793e-02	1.636e-01	0.232	0.816663	
cell2182	4.061e-01	2.192e-01	1.852	0.063975	.
cell2188	-1.093e+00	2.441e-01	-4.476	7.62e-06	***
cell2192	-2.660e+01	3.543e+04	-0.001	0.999401	
cell8132	1.396e+00	1.346e-01	10.374	< 2e-16	***
cell8138	1.300e+00	1.324e-01	9.818	< 2e-16	***
cell8142	1.033e+00	1.424e-01	7.255	4.02e-13	***
cell8148	7.782e-01	1.416e-01	5.494	3.93e-08	***
cell8152	7.830e-01	1.403e-01	5.581	2.39e-08	***
cell8158	9.132e-01	1.384e-01	6.596	4.23e-11	***
cell8162	8.024e-01	1.439e-01	5.576	2.46e-08	***
cell8168	7.628e-01	1.466e-01	5.204	1.95e-07	***
cell8172	9.974e-01	1.457e-01	6.844	7.70e-12	***
cell8178	1.099e+00	1.505e-01	7.301	2.87e-13	***
cell8182	8.075e-01	1.816e-01	4.446	8.75e-06	***
cell8188	-1.304e+00	4.312e-01	-3.024	0.002491	**
cell8192	9.014e-02	1.939e-01	0.465	0.642071	
cell12132	1.763e+00	2.167e-01	8.138	4.01e-16	***
cell12142	1.111e+00	1.634e-01	6.802	1.03e-11	***
cell12148	1.245e+00	1.512e-01	8.238	< 2e-16	***
cell12152	9.943e-01	1.567e-01	6.345	2.22e-10	***
cell12158	1.141e+00	2.230e-01	5.117	3.11e-07	***
cell12162	1.983e+00	3.543e-01	5.598	2.17e-08	***
cell12168	2.216e+00	1.678e-01	13.207	< 2e-16	***
cell12172	1.499e+00	1.479e-01	10.133	< 2e-16	***
cell12178	1.831e+00	1.558e-01	11.755	< 2e-16	***

```
cell12182         1.832e+00  2.085e-01   8.786  < 2e-16 ***
cell12188         8.349e-01  2.291e-01   3.645 0.000267 ***
program_codeKIOB -2.863e-01  1.134e-01  -2.525 0.011566 *
program_codeMHOB  1.942e-01  5.826e-02   3.333 0.000859 ***
program_codePWOB -1.254e+00  8.284e-02 -15.140  < 2e-16 ***
program_codeSPOB  5.992e-02  3.837e-02   1.561 0.118435
flag_idFM         1.345e-01  2.446e-02   5.500 3.79e-08 ***
flag_idGU         9.077e-01  7.522e-02  12.067  < 2e-16 ***
flag_idJP         5.564e-01  3.839e-02  14.491  < 2e-16 ***
flag_idKI         3.754e-01  1.673e-01   2.244 0.024860 *
flag_idKR         7.847e-02  1.212e-01   0.647 0.517484
flag_idMH         5.230e-01  8.286e-02   6.311 2.77e-10 ***
flag_idPW         4.304e-01  1.450e-01   2.968 0.002993 **
flag_idSB         1.653e+00  1.676e-01   9.860  < 2e-16 ***
flag_idTW         7.328e-01  3.252e-02  22.531  < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for Negative Binomial(1.5975) family taken to be 1)

    Null deviance: 48341  on 4439  degrees of freedom
Residual deviance: 35064  on 4337  degrees of freedom
AIC: 115446

Number of Fisher Scoring iterations: 1


              Theta:  1.5975
          Std. Err.:  0.0269

 2 x log-likelihood:  -115238.3000
```