New England Fishery Management Council
50 WATER STREET | NEWBURYPORT, MASSACHUSETTS 01950 | PHONE 978 465 0492 | FAX 978 465 3116
E.F. “Terry” Stockwell III, *Chairman* | Thomas A. Nies, *Executive Director*

MEMORANDUM

DATE: September 5, 2014

TO: Whiting Oversight Committee (Committee)

FROM: Whiting Plan Development Team (PDT)

SUBJECT: **Advice on northern red hake overfishing**

In response to questions that the Committee directed to the PDT at is last meeting, the PDT undertook a series of analyses to address the potential for future overfishing of northern red hake, since the update assessment indicates that overfishing was occurring in 2013.

1. Are the current management measures and proposed specifications sufficient to prevent (i.e., keep the risk acceptably low) of future northern red hake overfishing?

2. If the measures are insufficient to prevent future northern red hake overfishing, can the PDT recommend adjustments or an approach to address this issue?

In addition, the PDT discovered a discrepancy in the benchmark and update assessment methods when the spring survey red hake biomass indices were calculated. This discrepancy caused a modest underestimate of the 2012-2014 ABC specifications presented to the Scientific and Statistical Committee on August 26th. This discrepancy is related to the choice of representative tows and the effects on the ABC, status determination, and accountability measures are explained below.

<u>Probability of northern red hake overfishing in 2015</u>

To answer question #1 above, the PDT developed a sensitivity analysis to forecast future northern red hake stock size and bracket the possible outcomes assuming that a) existing measures are effective and keeps catch at the 2013 level (361 mt) or b) measures do not restrain catch which would increase in proportion to the expected change in northern red hake biomass. In this sensitivity analysis, the PDT recognizes that the a lower value derived from the 2012 survey would be dropped and a new 2015 value would be added to the three-year moving average used to set ABC specifications.

The PDT advises that it can estimate the probability of overfishing under certain forecasted conditions, but it cannot advise when this estimate is unacceptably high, unless that estimate exceeds the legal limit of a 50% probability. Estimates of overfishing probabilities greater than the current risk (0%?) but less than 50% may or may not be acceptable depending on the Council's tolerance of overfishing risk. One caveat that the Council should consider in this sensitivity analysis is that, other than evaluating a range of potential survey values, there was no adjustment made to the existing estimates of scientific uncertainty to account for the additional uncertainty associated with projected stock size.

Some of the scenarios analyzed by the PDT exceeds the legal mandate of keeping the risk of overfishing below 50% (i.e. neutral risk). Others that assume an increase in catch that might occur if northern red hake biomass increases are associated with a high probability of overfishing (i.e. > 50%). It is difficult to predict how catch will change, but the direction of the change is clear. Therefore the Council may want to consider more restrictive management measures that could in the long run reduce cost and potentially improve income to the industry.

In this sensitivity analysis, the higher 2014 spring survey northern red hake biomass index becomes more influential than it is in the 2012-2014 moving average used for the proposed 2015-2017 specifications. As a result, there would be a lower probability that the current measures and proposed specifications would cause overfishing <u>if the commercial catch remains constant</u>.

There are actually two issues inherent in question #1. The first issue is whether the expected catch will exceed the 2015-2017 overfishing level (OFL) based on the 2012-2014 survey biomass index. This affects the triggering of accountability measures to prevent (or reduce) the likelihood of overfishing. The second issue is whether the existing measures have an unacceptable probability of causing overfishing, i.e., the exploitation rate (catch vs. actual stock biomass) is too high, which is the focus of this sensitivity analysis.

Bracketing the potential change in 2015 survey biomass to 2 standard deviations and assuming that the catch will remain at the 361 mt observed in fishing year 2013 results in probability of overfishing shown for runs 1 to 6 ??? in the table below. The probability estimates range from 2 to 99% for catches ranging from 361 mt (FY 2014 catch) to 807 mt (124% increase in catch) depending on the actual 2015 survey value (Table 1). Graphically, these scenarios are shown in Figure 1. The red shaded area represents high risk with the probability of overfishing above 50%.

Alternatively, analyses 7 and 8 (Table 1) estimate the survey biomass index by increasing the biomass of the 2014 spring survey red hake to account for growth and natural mortality. This procedure estimates that stock biomass would decrease from 3.02 kg/tow to 5.95 kg/tow (Table 1), but because a low 2012 value would be dropped from the three-year moving average, the basis for the ABC calculation would increase from 2.03 kg/tow to 3.23 kg/tow and ABC would increase by 64%. Assuming that catch remains the same as it was in FY 2013 (361 mt), then the probability of overfishing is estimated to be <1%. If however the catch increases in proportion to the change in biomass forecasted by the projection (increasing to 669 mt), the probability of overfishing increases to 99% relative to the revised OFL of 542 mt. A risk-neutral catch that has a 50% probability of overfishing would of course be near the OFL, or 543 mt (Figure 2).

Table 1. Sensitivity analysis results

Sens. Analysi	Parameters	Biomass index	3-yr avg biomas	Catch	OFL	ABC	ABC/2014 AB	ABC/OFL	ACL	Catch/ABC	Overfishing probability at AB	Overfishing probability at assumed catch
		(kg/tow)	(thousand mt)	(thousand mt)	(thousand mt)	(thousand mt)			(thousand mt)	(% ABC)	Pr (F > FMSY) @ ABC	Pr (F > FMSY)
Null	2014 Assessment Update	3.020	2.033	0.361	0.331	**0.287**	0%	87%	0.273	26%	6%	**82%**
1	Spr. SV. 2015 = **Spr. SV. 2014 + 2s.d.** FY 2014 Catch = FY 2013 Catch	3.399	2.591	0.361	0.422	**0.368**	28%	87%	0.350	-2%	2%	2%
2	Spr. SV. 2015 = **Spr. SV. 2014 + 2s.d.** FY 2014 Catch > FY 2013 Catch (~10%)	3.399	2.591	0.397	0.422	**0.368**	28%	87%	0.350	8%	2%	19%
3	Spr. SV. 2015 = **Spr. SV. 2014 + 2s.d.** FY 2014 Catch > FY 2013 Catch (~25%)	3.399	2.591	0.451	0.422	**0.368**	28%	87%	0.350	23%	2%	**80%**
4	Spr. SV. 2015 = **Spr. SV. 2014 + 2s.d.** FY 2014 Catch > FY 2013 Catch (~50%)	3.399	2.591	0.542	0.422	**0.368**	28%	87%	0.350	47%	2%	**99%**
5	Spr. SV. 2015 = **Spr. SV. 2014 + 2s.d.** FY 2014 Catch > 2 X FY 2013 Catch (~124%)	3.399	2.591	0.807	0.422	**0.368**	28%	87%	0.350	119%	2%	**99%**
6	Spr. SV. 2015 = **Spr. SV. 2014 - 2s.d.** FY 2014 Catch = FY 2013 Catch	2.641	2.338	0.361	0.381	**0.331**	15%	87%	0.314	9%	4%	25%
7	2015 Biomass Forecast based on long term growth and M = 0.2	2.474	2.282	0.361	0.542	**0.472**	64%	87%	0.448	-24%	<1%	<1%
8	2015 Biomass Forecast based on long term growth and M = 0.2	5.595	3.232	0.669	0.542	**0.472**	64%	87%	0.448	42%	<1%	**99%**

Figure 1. Probability of overfishing at various 2015 spring survey biomass levels and a range of 2015 catch from the proposed ABC, constant catch at FY 2014 levels, and with a 25% increase in catch.

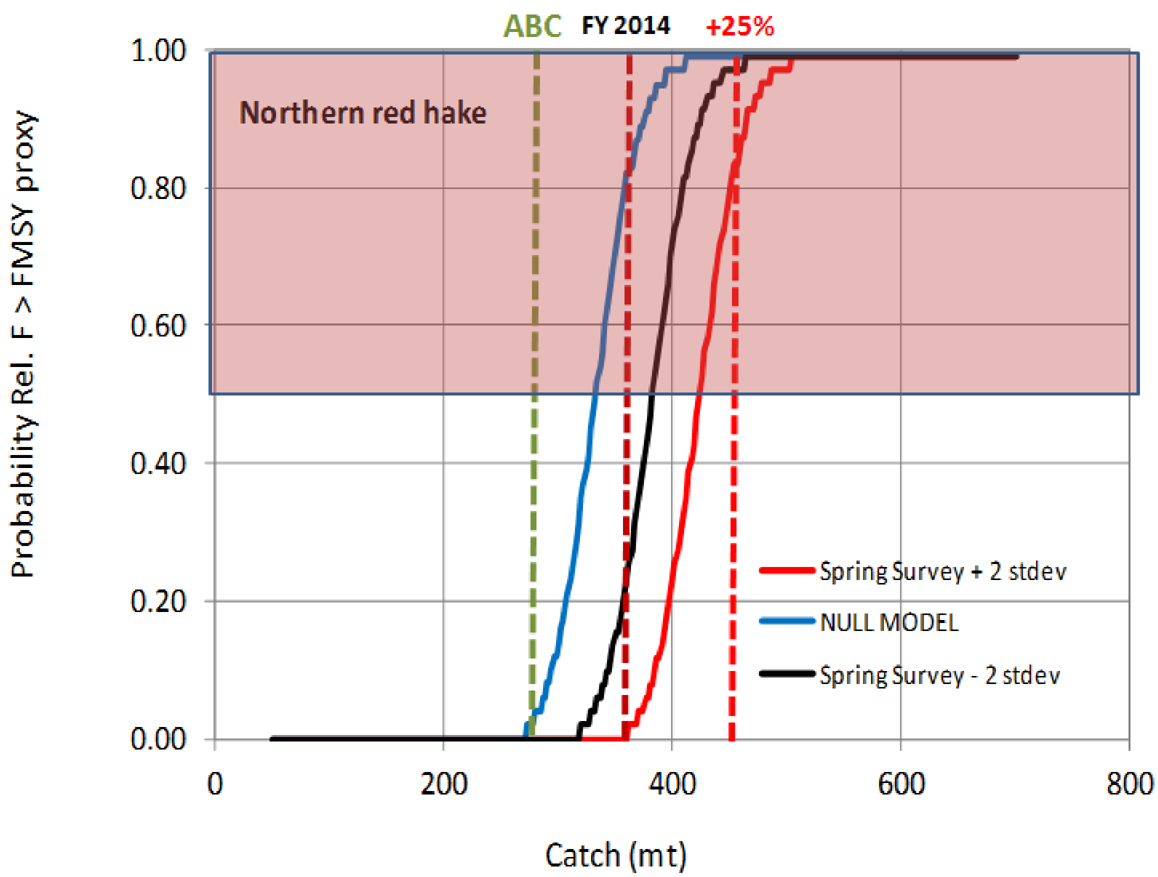
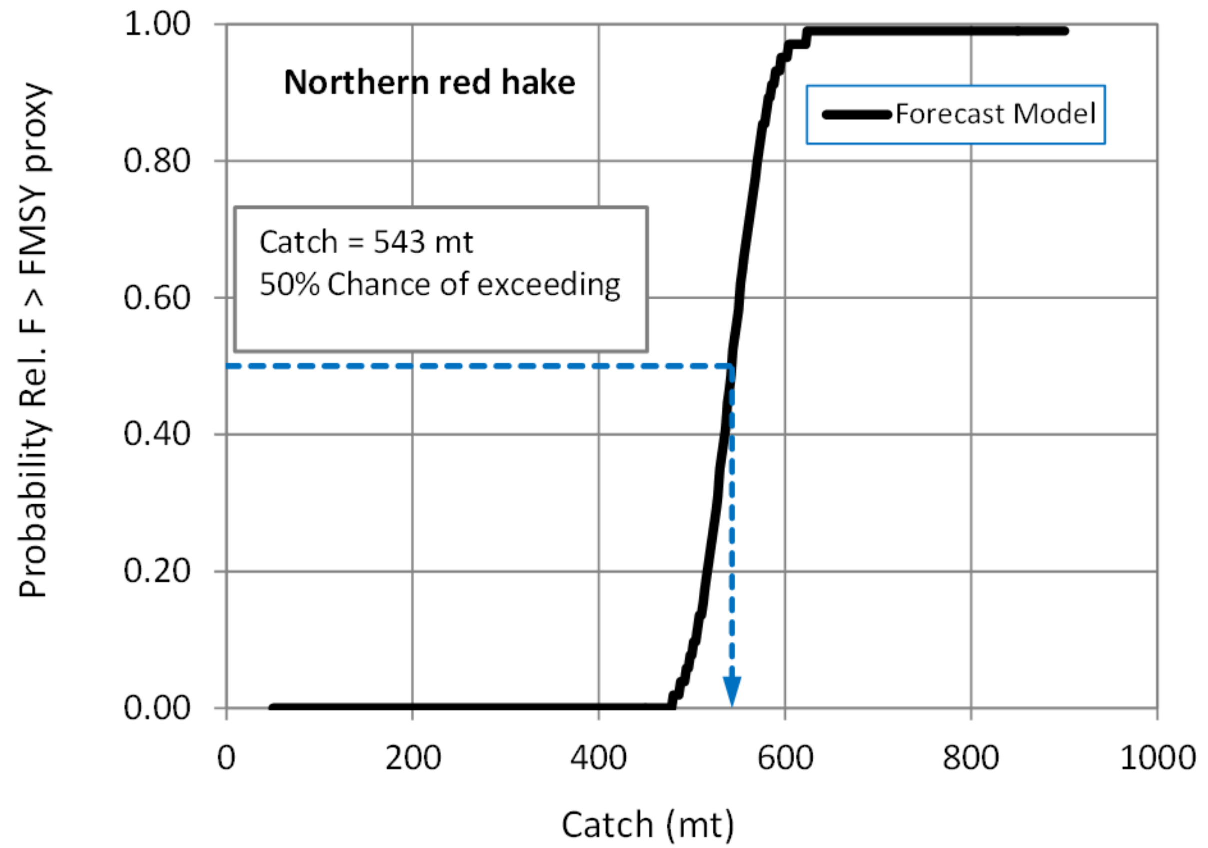


Figure 2. Catch that is estimated to have a 50% probability of overfishing with a forecast change in 2015 biomass from the observed size frequency distribution in the 2014 spring trawl survey.



Overfishing Sensitivity Analysis

Methods and results to be added

Potential measures to reduce the risk of northern red hake overfishing

As you know, small-mesh fishing in the northern stock area and Gulf of Maine is highly regulated by mesh restrictions, gear restrictions, possession limits, and seasonal area restrictions (Table 1). The net and seasonal area restrictions specify where and when and with what gear vessels may use small-mesh to minimize interactions with large mesh groundfish. In most cases, these interactions had not been analyzed for many years, often since the action that originally created one of the exemption areas. Yet since that time, many observed trips using small-mesh trawls have been recorded and not analyzed in this regard. The Whiting PDT began analyzing these data to include in the 2015 SAFE Report, an effort that is ongoing and will become a chapter in the final report.

Table 2. Summary of seasons when small-mesh fishing for whiting may occur by exemption area.

	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Cultivator		June 15 – October 31								
GOM[*] Grate			July 1 – November 30							
Small I			July 15 – November 30							
Small II	– June 30								January 1 –	
Cape Cod					Sept 1 – Nov 20					
RFT[†]					September 1 – December 31					

After the last Whiting Oversight Committee meeting, this analysis was extended to include red hake catch rates in the six exemption areas to determine whether there were conditions where red hake catches are significantly higher than they are at other times and conditions. It is unsufficient to simply summarize the catch rates between months, for example because a) the differences may be due to the influence of another cofactor (such as year) on trips that by coincidence had been observed and b) differences may not be significant due to small sample size.

The analysis of red hake catches focused on the following covariates as explanatory variables: month, year, exemption area, net type, and mesh size. A multifactor general linear model was performed assuming a negative binomial error structure due to overdispersion of catch rate data. A model with all variables was included and, if appropriate, reduced to the most influential variables. The final alternative model was compared to the fully saturated model and to a null model with no covariates to determine whether the model fit the data better than the alternatives.

The final, best-fit model was one that included only exemption area as the explanatory variable. Month was not a significant explanatory variable once the differences caused by area fished were taken into account. Areas where red hake catch rates were significantly higher included Raised Footrope Area 1, Small Mesh Area 1, and the Cultivator Shoals Area (Figure 2**).**

Lacking sufficient data to answer these questions (i.e. significant differences in observed red hake catch rates), the advisors and fishermen may be able to shed light on whether there are there gears which tend to reduce red hake catch, are there specific areas or seasons which small mesh fishing should be curtailed to keep northern red hake catch below the ACL and prevent overfishing.

The PDT also attempted to analyze the effects of net type and mesh size on red hake catch rates on observed small mesh trawl trips in exemption areas. Due to the wide variety of net descriptions in the data, trawls were reclassified as either “raised footrope trawls” or “other trawls”. Due to small sample size and unbalanced design, this model failed to converge on a solution, even when the two variables were considered and analyzed independent of each other.

Analysis of red hake catch rates

One type of analysis focused on catches by the small-mesh fishery within the exemption areas. No attempt was made to analyze the catches from various types of nets and configurations because the sample size was too small to analyze the various (and sometimes ambiguous) net types and configurations. Main effects considered were exemption area, month, year, plus a month*year interaction term. The model was fit to catch/kept-all ratios for the following species or species groups: cod, multispecies roundfish, multispecies flatfish, and red hake.

Catch to Kept-all ratios were and typically are highly skewed or even overdispersed with large numbers of observations at low values and a few number of high valued catch rates. This condition presents challenges and often invalidates parametric General Linear Models. To properly handle the skewed distribution, the GENMOD procedure (see http://support.sas.com/documentation/cdl/en/statug/63033/HTML/default/viewer.htm#genmod_toc.htm) was applied assuming a negative binomial distribution of the data.

For each species group, an attempt to fit the catch/kept-all data was made using a fully-saturated model including all main effects plus a year*month interaction term. If the model converged on a solution and the year*month interaction term was not significant, then a 'best-fit' model was attempted using only the significant explanatory variables. Both models were also compared to a null model having only an intercept term to determine whether the fully-saturated model or the 'best-fit' model were better based on comparison of the full log-liklihood and AIC values. In some cases, the null or fully-saturated models did not converge on a solution and were therefore not used in the comparison.

Red hake in the small-mesh fishery

Neither the null model (Table 1) nor the saturated model (Table 2) for red hake converged. Despite this, the analysis determined that exemption area was the only statistically significant variable. A 'best-fit' model with only exemption area as the explanatory variable (Table 3) was significant. An alternative model with exemption area and month was attempted but did not converge on a solution.

Taking into account the main effects, there appear to be a difference in red hake catch rates between areas, but incorporation of month did not improve the model fit (which in fact failed to converge on a solution). The mean and confidence intervals of observed red hake catch rates by exemption area is shown in Figure 1. The Cultivator Shoals area had the highest red hake catch rates, followed by Raised Footrope Trawl Area 1 and Small mesh Area 1.

Figure 3. Mean and confidence intervals of observed red hake catch rates in the small mesh fishery from 2008-2013, by exemption area.

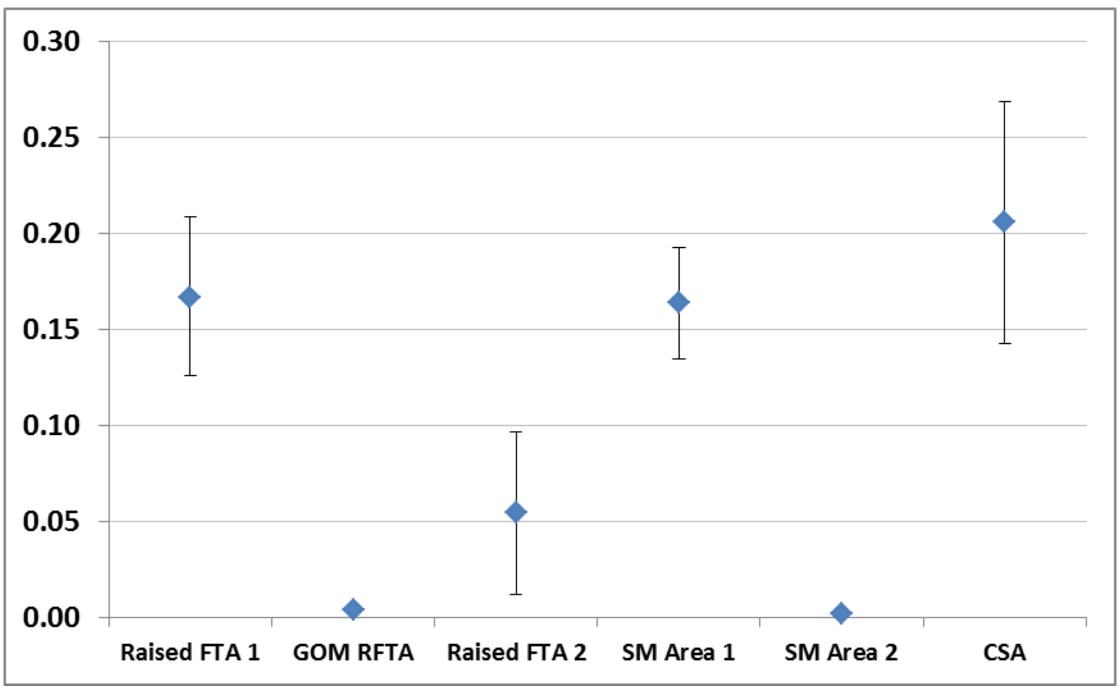


Table 3 – Fully-saturated model fit to red hake catch in the small mesh fishery during 2008-2013. 'Objectid_1' represents the various exemption areas.

The SAS System

The GENMOD Procedure

Model Information		
Data Set	DAVE.SM_MESH	
Distribution	Negative Binomial	
Link Function	Log	
Dependent Variable	red_hake_catch	RED_HAKE_CATCH

Number of Observations Read	785
Number of Observations Used	785

Criteria For Assessing Goodness Of Fit			
Criterion	DF	Value	Value/DF
Deviance	780	237.0006	0.3038
Scaled Deviance	780	237.0006	0.3038
Pearson Chi-Square	780	382.2103	0.4900
Scaled Pearson X2	780	382.2103	0.4900
Log Likelihood		-316.4840	
Full Log Likelihood		-298.0980	
AIC (smaller is better)		608.1960	
AICC (smaller is better)		608.3040	
BIC (smaller is better)		636.1901	

WARNING: The relative Hessian convergence criterion of 2.3610923562 is greater than the limit of 0.0001. The convergence is questionable.

Analysis Of Maximum Likelihood Parameter Estimates							
Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	Pr > ChiSq
Intercept	1	279.5219	337.3697	-381.711	940.7544	0.69	0.4074
month_obs	1	-23.1633	41.0916	-103.701	57.3747	0.32	0.5730
objectid_1	1	0.1367	0.0525	0.0337	0.2396	6.77	0.0093
year_obs	1	-0.1409	0.1678	-0.4698	0.1880	0.70	0.4012
month_obs*year_obs	1	0.0116	0.0204	-0.0285	0.0517	0.32	0.5704
Dispersion	0	0.0000	0.0000	0.0000	0.0000		

Table 4 - Null model (no main effects) fit to red hake catch in the small mesh fishery during 2008-2013. 'Objectid_1' represents the various exemption areas.

The SAS System

The GENMOD Procedure

Model Information		
Data Set	DAVE.SM_MESH	
Distribution	Negative Binomial	
Link Function	Log	
Dependent Variable	red_hake_catch	RED_HAKE_CATCH

Number of Observations Read	785
Number of Observations Used	785

Criteria For Assessing Goodness Of Fit			
Criterion	DF	Value	Value/DF
Deviance	784	266.7824	0.3403
Scaled Deviance	784	266.7824	0.3403
Pearson Chi-Square	784	483.3000	0.6165
Scaled Pearson X2	784	483.3000	0.6165
Log Likelihood		-331.3748	
Full Log Likelihood		-312.9889	
AIC (smaller is better)		629.9778	
AICC (smaller is better)		629.9931	
BIC (smaller is better)		639.3091	

WARNING: The relative Hessian convergence criterion of 1.5859051456 is greater than the limit of 0.0001. The convergence is questionable.

Analysis Of Maximum Likelihood Parameter Estimates							
Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	Pr > ChiSq
Intercept	1	-1.9413	0.0942	-2.1259	-1.7566	424.58	<.0001
Dispersion	0	0.0000	0.0000	0.0000	0.0000		

Table 5 – 'Best fit' model fit to red hake catch in the small mesh fishery during 2008-2013. 'Objectid_1' represents the various exemption areas.

The SAS System

The GENMOD Procedure

Model Information		
Data Set	DAVE.SM_MESH	
Distribution	Negative Binomial	
Link Function	Log	
Dependent Variable	red_hake_catch	RED_HAKE_CATCH

Number of Observations Read	785
Number of Observations Used	785

Criteria For Assessing Goodness Of Fit			
Criterion	DF	Value	Value/DF
Deviance	783	261.6966	0.3342
Scaled Deviance	783	261.6966	0.3342
Pearson Chi-Square	783	441.3020	0.5636
Scaled Pearson X2	783	441.3020	0.5636
Log Likelihood		-328.8320	
Full Log Likelihood		-310.4460	
AIC (smaller is better)		626.8920	
AICC (smaller is better)		626.9227	
BIC (smaller is better)		640.8890	

Algorithm converged.

Analysis Of Maximum Likelihood Parameter Estimates							
Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	Pr > ChiSq
Intercept	1	-2.4348	0.2505	-2.9257	-1.9439	94.49	<.0001
objectid_1	1	0.1257	0.0565	0.0149	0.2366	4.95	0.0262
Dispersion	1	0.0000	0.0003	.	.		

The SAS System

The MEANS Procedure

Analysis Variable : red_hake_catch RED_HAKE_CATCH						
NETTYPELIST	**N Obs**	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**
2-Seam Trawl	45	45	0.2510498	0.4061545	0	1.6591376
4-Seam Trawl	25	25	0.2846743	0.4831556	0	2.1092885
Balloon Trawl, 2-Seam	4	4	0.000776398	0.0015528	0	0.0031056
Box Trawl, 4-Seam	71	71	0.1914390	0.4306843	0	2.9611902
Flatfish Trawl, 2-Seam	22	22	0.0045376	0.0119096	0	0.0552677
Flatfish Trawl, 4-Seam	1	1	0	.	0	0
Flynet, 2-Seam	5	5	0.0473339	0.0348306	0.0153846	0.0911854
Groundfish Trawl	1	1	0	.	0	0
Groundfsh Trawl,2-Seam	63	63	0.0469350	0.1107337	0	0.5832349
Groundfsh Trawl,4-Seam	24	24	0.2240200	0.3154184	0	1.1736175
Hadd Separator, 2-Seam	12	12	0.000127136	0.000246899	0	0.000741021
Other (Comment)	23	23	0.3662927	0.7885106	0	2.6474747
Raised Footrope Trawl	65	65	0.2288301	0.2007776	0	0.6859584
Raised Footrope,2-Seam	158	158	0.1863977	0.2269479	0	1.2500000
Raised Footrope,4-Seam	49	49	0.1937929	0.3050958	0	1.8357143
Shrimp Trawl	18	18	0.0053028	0.0150516	0	0.0555556
Shrimp Trawl, 2-Seam	163	163	0.0201669	0.0990570	0	0.8109195
Shrimp Trawl, 4-Seam	4	4	0.0110000	0.0128062	0	0.0240000
Unknown	32	32	0.1972111	0.2708772	0	0.9408805

Re-estimation of 2012-2014 red hake ABCs

When the final update assessment was performed and 2015-2017 ABCs, the NEFSC discovered that there was a discrepancy with the 2012-2014 ABC specifications. A bit of forensic work revealed that some representative tows had been omitted from the estimation procedure, which underestimated the northern red hake ABC by 12%, or 39 mt, and the southern red hake ABC by 14%, or 552 mt. The discrepancy has **NO EFFECT** on the 2015-2017 ABCs proposed to the SSC nor on the existing or proposed ABCs for northern and southern silver hake. The corrections also had no effect on red hake status determination. Overfishing of northern red hake was occurring in 2013 even after the modest correction to the benchmark assessment had been made.

The Whiting PDT discussed the ramifications of this correction and determined that it has no effect on the fishery in the southern management area, because red hake catches in 2012, 2013, and most likely 2014 are a small fraction of the ABC. Conversely, the northern red hake catches in 2012 and 2013 were over the ABC and OFL, but with the correction, they were not over as much as previously estimated. Originally, the 2012 overage was estimated at 45% and the 2013 overage was 36%. Given the corrected annual catch limit (ACL), the overages were 27.5% and 19%, respectively.

The regulations at 648.90(b)(5) require the Regional Administrator to reduce the specified in-season possession limit trigger by the same percentage by which a given ACL was exceeded. In fishing year 2012, the northern red hake ACL was exceeded by 45 %. For the beginning of the 2014 fishing year, the in-season possession limit was reduced to 45% (the original 90% – the 45% overage), and the in-season possession limit reduction was implemented when 45% of the total allowable landings were projected to have been harvested. In fishing year 2013, the northern red hake ACL was exceeded by 36 %. Because the 36% overage is within the reduction implemented for 2014, a further reduction in FY 2015 may not be necessary. If, in FY 2014, catch again exceeds the ACL, thereby indicating that the 45% trigger was insufficient, reductions for 2016 may be necessary.

Taking the ABC corrections into account, the northern red hake ABC should have been 12% higher than it had been set. Therefore the overage was only 27.5% instead of 45.2% and the AM trigger would have been set in 2014 at 62.5% (90% - 27.5%) instead of 45% (90% - 45%).

Details of the effects of the corrected survey data on ABC specifications and AMs are given below.

To be added

Recommendations

The Committee and Council should consider this corrected information in the context of setting appropriate management measures for the 2015 fishing year. That is, the Council could potentially reset the possession limit trigger to something higher than the current 45%, and may choose to set it commensurate with the actual overage of 27%. However, the Council should consider these potential changes in combination with other measures that are intended to ensure that the northern red hake ACL is not exceeded.