Darkblotched Rockfish
Stock Assessment Review (STAR) Panel Report

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Overview

A draft assessment of the coastwide darkblotched rockfish (*Sebastes crameri*) off the U.S. west coast using data through 2012 was reviewed by the STAR panel during May 13-17, 2013. This assessment used the Stock Synthesis platform version 3.24o. Fisheries are grouped into two fleets: the domestic trawlers and "bycatch" fleet (foreign POP fishery, and at-sea hake fishery). The draft assessment incorporated a variety of data sources into the candidate base model, including landings, length- and age-compositions from the retained commercial catch, discard ratios, length- and age-compositions as well as mean individual body weight of the discards. Also, data from four National Marine Fisheries Service (NMFS) bottom trawl surveys are used to estimate indices of relative stock abundance and generate length and age frequency distributions for each survey. The Northwest Fisheries Science Center (NWFSC) shelf-slope survey covers the period between 2003 and 2012 and provides information on the current trend of the stock. Three other surveys (which are discontinued) include the NWFSC slope survey (1999- 2002), the AFSC slope survey (1997-2001), and the AFSC shelf triennial survey (1980-2004).

The last full assessment of darkblotched rockfish was conducted in 2007. The 2007 full assessment was subsequently updated in 2009 and 2011. Significant changes made in this assessment comparing to the 2007 assessment include:

1. Updated Washington historical landings and used the recently reconstructed Oregon and California landings conducted by SWFSC and ODFW in collaboration with NWFSC.
2. Changed the structure of fishing fleets and divided fishery removals between two fisheries instead of combining all removals into one fleet as in the last assessment.
3. Used the newest GLMM software to construct survey abundance indices
4. Changes in both fecundity and maturity parameters/functions, such as considering atresia in maturity function.
5. Estimated male natural mortality (M) while fixing female M=0.05.
6. Used a fixed value for steepness (*h*=0.779) which is the mean of the prior from Thorson et al 2013.

Multiple model runs were conducted and reviewed to examine model assumptions and structure, and to identify uncertainties in the assessment. Panel discussion focused on the model selection criteria for the survey abundance and the implication of the new fecundity and maturity parameters. The recommended base case model after discussion with the STAT is includes updated maturity and fecundity functions, sex specific M with female M fixed at 0.05 and male M estimated, steepness of *h*=0.779.

Darkblotched rockfish stock status – the terminal year depletion rate (SSB_{2013}/SSB_0) from the final base model is 36%. Natural mortality is used to bracket the uncertainty in the states of nature in the decision table.

The STAR panel concluded that the darkblotched rockfish assessment was based on the best available data, and that this new assessment constitutes the best available information on darkblotched rockfish off the U.S. west coast. The STAR panel thanks the STAT team for their willingness to respond to panel requests and their dedication in finding possible solutions to difficult assessment problems.

Discussion and Additional Analyses Requested by the STAR Panel

1. *Request*:

a. Plot the estimated GLMM vessel effect coefficients over time from the two sides (presence-absence, positive catch rate) of the NWCOMBO model. Specifically, plot the posterior modes from each year from each vessel with a reference line at zero.

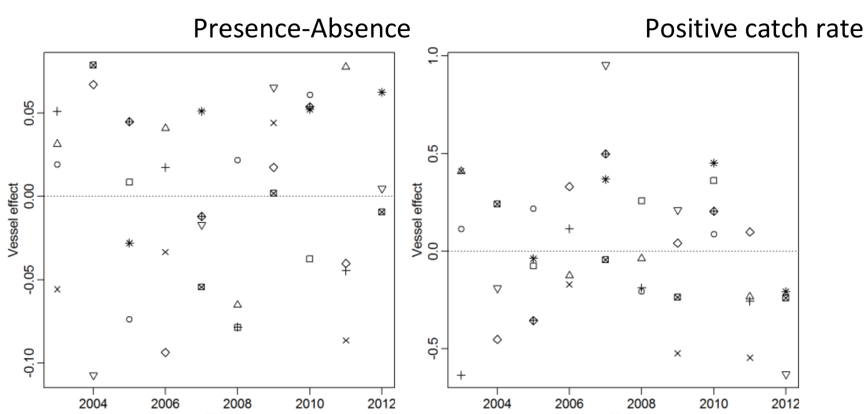
b. Plot the mean of the log catches vs. the SD of the log catches, for each year and strata combination on one plot.

c. Plot a comparison of the design-based index series, the GLMM-based result, and the GLMM with the ECE-based result for the NWCOMBO survey.

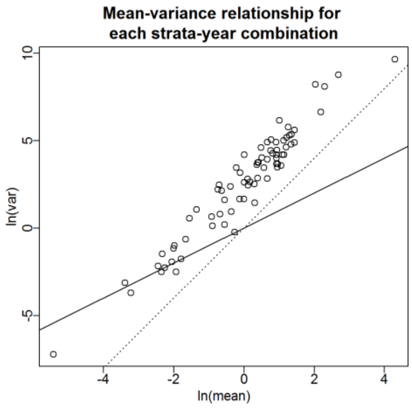
<u>*Rationale*</u>: Request "a" could reveal potential confounding between random vessel effects and actual trends in the surveyed stock over time. Request "b" will illustrate the need for adding the ECE implementation to the standard GLMM. Request "c" will indicate the sensitivity of the resulting index to the method employed.

<u>Results</u>:

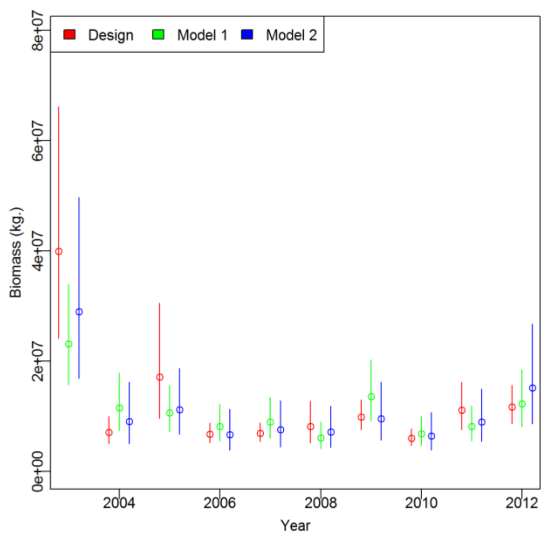
a. Vessel effects were small in the presence:absence of darkblotched (creating a relatively noisy survey), but larger for positive catch rates; however, there were some trends in the time series of vessel effects for positive catches (e.g. 2010-2012) which indicated the possibility of confounding with year effects. One reason for this "vessel effect" could be the random draw of survey sites or stations that may or may not have darkblotched. Therefore, there may not be a vessel effect on darkblotched catching efficiency; this may be more of a random station effect.



b. No apparent need for ECE.



c. Year 2003 was the extreme catch event year and all models showed this catch event that year, although the model with ECEs less so. The design-based model had consistently smaller confidence intervals for the lowest index values. However, the plot did not indicate significant model sensitivity to an ECE treatment.



Model 1 – GLMM with ECE

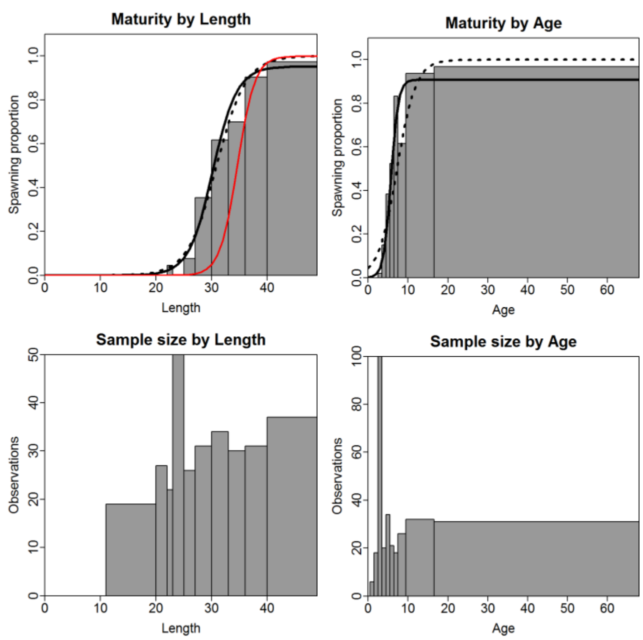
Model 2 – GLMM

There were further discussions about model selection criteria. The darkblotched STAT chose between the ECE-based gamma and lognormal error distributions based on goodness-of-fit and matching the variance in the error distribution using Q-Q plots. A design-based model was summarily rejected since it does not include a random vessel effect. Model strata were chosen a priori. The panel recommended further exploration of ECE treatment in GLMM estimates with different criteria for model selection. This evaluation and the summary of the results used for assessment needs to be species specific.

2. **Plot the newly collected maturity data binned both by age and by size. On the age-plot, add the model fit. Overlay the 2011 maturity-at-size model on the size-plot.**

Rationale: These are new unpublished data and, despite model constraints, it is important to establish that the logistic model is fitting the data adequately and to evaluate how the new relationship compares with that from the previous assessment.

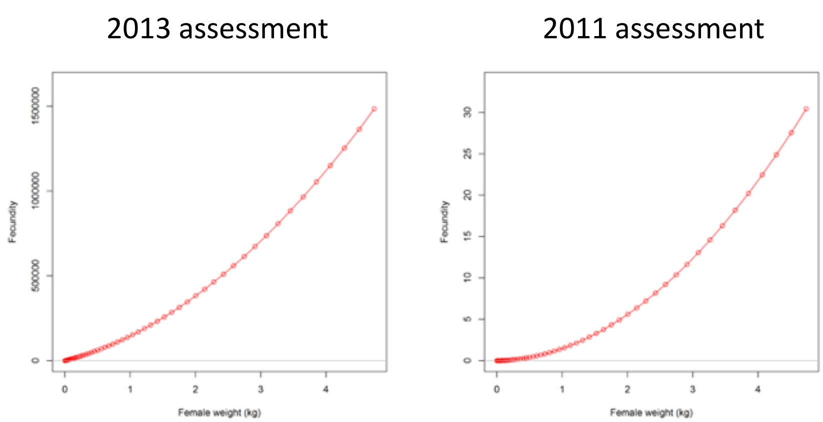
Results: Maturity as a function of length looks smooth and is the preferred approach compared to modeling maturity as a function of age. However, asymptotic proportion mature appears to be less than one. Atresia has been observed in mature darkblotched females. It is not possible to account for atresia in the current version of SS3 when maturity is a function of length. Therefore, maturity by age was modeled in this assessment. There was a substantial change in the maturity ogive compared to the 2011 assessment update, with the maturity shift at the peak of the stock's yield curve. The previous maturity ogive was based on an earlier study (circa 1990) in which maturity was determined histologically but was limited to one part of the OR coast. The newer maturity information shows a significantly higher maturity at younger ages and the presence of some atresia at older ages. The new maturity parameters were used in the proposed base model because it provides samples from a broader range of the species' distribution.

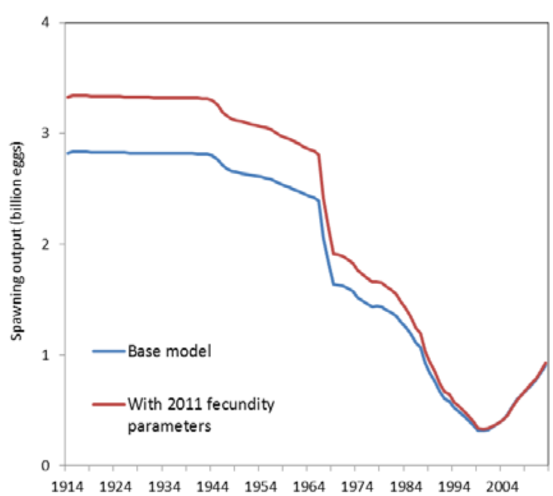


3. **Plot the 2011 fecundity relationship with the newer curve used this year; also show sensitivity of model output to this change if this was not reflected in the tabled sensitivity results.**

Rationale: The sensitivity in Table 14 appears to use fecundity proportional to spawning biomass and not the 2011 fecundity relationship, which differs from the curve used in this assessment.

Results: There was more curvature in the 2011 fecundity-weight relationship; the 2013 assessment used the relationship provided by E.J. Dick in his dissertation. The STAT also plotted the spawning output time series varying only the fecundity-weight relationship from the 2011 assessment and that of the 2013 assessment. The big change was in the equilibrium, unfished spawning output; it was lower using the new fecundity-weight relationship which resulted in a lower depletion ratio. Clarification provided by the STAT indicated that the newer fecundity relationship included the data from which the older values had been derived in addition to several other sources. Exploring the darkblotched fecundity relationship is a research recommendation.





Model	Base	With 2011 fecundity parameters
Negative log-likelihood		
Total	1400.71	1400.91
Indices	-12.34	-12.40
Length frequencies	445.05	445.24
Age frequencies	1004.82	1004.80
Selected parameters		
$\mathrm{Ln}(R_0)$	7.67	7.67
Steepness (*h*)	0.779	0.779
Female *M*	0.05	0.05
Male *M*	0.05	0.05
Female L at A_{min}	2.27	2.27
Female L at A_{max}	42.72	42.72
Male L at A_{min}	2.27	2.27
Male L at A_{min}	37.97	37.97
Female von Bert *K*	0.198	0.198
Male von Bert *K*	0.239	0.239
Management quantities		
Equilibrium spawning output (million eggs)	2,821	3,327
2013 Spawning depletion	32%	28%

4. **Run an alternate model with sex-specific M; specifically, estimate the value for males holding the value for females at 0.05. Compare this with the base case.**

Rationale: Dimorphic growth is often accompanied by different rates of natural mortality. Although the data are insufficient to estimate M for both males and females, if female M is fixed then the compositional data should be informative about the difference in M between the sexes. Estimating at least one sex would capture more of the uncertainty in the model results. The anticipation is that the male natural mortality is likely to be greater than that for females.

Results: Male M was estimated to be 0.67, which is higher than female M (0.05) as expected. The total negative log likelihood was lower and the model converged well. The STAT recommended this model change. SSB depletion for this model is 35%.

5. **Report tuning results by fleet and data source; specifically, input vs. harmonic mean effective sample sizes, input σs vs. RMSE for surveys, mean body weights, and discard ratios.**

Rationale: There is a need to see the results of the methods that were documented and applied.

Results: The AFSC slope survey tuning exhibited the biggest change of fit. However, since that survey only had 4 data points and was a flat fit, it had little effect on model results. Discard ratios had a big tuning difference since the years were time blocked (for the retention curve asymptote) to approximate the WCGOP annual total mortality estimates of darkblotched discards.

6. **Add to the table listing parameter estimates, the error distributions assumed for each data source.**

Rationale: The data summary figure (Figure 7 in the draft assessment) is helpful, but a tabular summary would help specify the specific approach used in this stock assessment.

Results:

Data sources used	Error distribution assumption
Catch	Assumed to be known without error (uncertainty explored via sensitivity analysis)
Abundance	Lognormal
Length composition	Multinomial
Age composition	Multinomial
Mean body weight	Normal
Discard	Normal

7. **Run an alternate sensitivity assuming a single CV young parameter for both sexes. Then, in a second run, try estimating the CV for old fish freely, but only one parameter for both sexes. If time permits, (and the second run was successful) estimate the CV for old fish for each sex separately, and consider adjusting Amax.**

Rationale: The CV for length at age is often an important parameter in defining equilibrium unfished biomass levels. Estimating the CV for young (Age-0) males seems redundant. SS can be configured to use the same value for females, even when parameters are directly estimated for each sex. This may improve the estimability of the CVs for old fish, especially if Amax is reduced from -999 to something within the range of the data.

Results: The STAT concluded that there was not enough conditional age data to reliably estimate the CV for older females and males either separately, or as a single parameter. Estimating CVs for all life stages caused an implausible growth gradient. Also, the estimated values for CV old were very close to those estimated outside the model and fixed in the base case.

The new proposed base model would fix the CV old for both sexes at the value estimated outside the model, and estimate CV young for males and females as a single parameter (female CV young is estimated and male CV young is set to be equal to estimated value of female CV young). Including more of the historical age data (particularly from California) via a reconfiguration of the fleet structure and/or ageing of additional historical samples may solve this problem and allow free estimation of CVs for young and old fish in future assessments. A new base case would also include a slight change in setting of A1 and A2 (ages associated with L1 and L2 in the von Bertalanffy growth model used in the model).

Model	Base	CVyoung the same for both sexes	Female CVold estimated	CVold estimated for both sexes	With 2011 A_1 andA_2 settings
Negative log-likelihood					
Total	1400.71	1401.56	1400.14	1399.74	1391.31
Indices	-12.34	-12.35	-12.37	-12.39	-12.50
Length frequencies	445.05	444.92	450.53	449.48	452.53
Age frequencies	1004.82	1005.80	998.93	999.64	987.75
Selected parameters					
Ln(R_0)	7.67	7.67	7.66	7.66	7.66
Steepness (*h*)	0.779	0.779	0.779	0.779	0.779
Female *M*	0.05	0.05	0.05	0.05	0.05
Male *M*	0.05	0.05	0.05	0.05	0.05
Female L at A_{min}	2.27	2.24	2.26	2.25	2.27
Female L at A_{max}	42.72	42.71	42.82	42.76	42.72
Male L at A_{min}	0.00	0.00	0.00	0.00	0.00
Male L at A_{min}	37.97	37.98	38.02	38.03	37.97
Female CV young	0.127	0.132	0.137	0.137	0.112
Male CV young	0.139	0.000	0.000	0.000	0.000
Female CV old	0.046	0.046	0.042	0.044	0.045
Male CV old	0.046	0.046	0.000	0.041	0.041
Female von Bert *K*	0.198	0.198	0.197	0.198	0.198
Male von Bert *K*	0.239	0.239	0.238	0.238	0.239
Management quantities					
Equilibrium spawning output (million eggs)	2,821	2,819	2,803	2,803	2,821
2013 Spawning depletion	32%	32%	31%	31%	32%

8. Plot the Pearson residuals for conditional age-at-length for NWCOMBO survey ages.

Rationale: If fixed CVs for old fish are causing lack of fit, it should be evident in the residuals.

Results: There were some large residuals, especially for male age-at-length samples in some years which indicates noisy data. The error assumption may not be particularly robust which can be addressed with the previous research recommendation to supplement the ageing samples by ageing older and larger fish.

9. If time permits, plot the at-sea hake bycatch age-distributions.

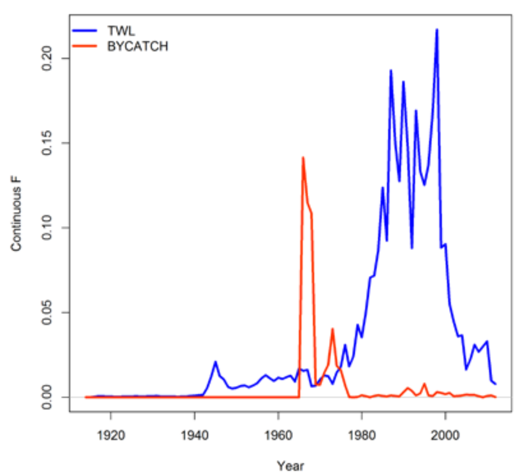
Rationale: These data might provide information on the degree of dome-shape for the trawl fishery.

Results: Sample sizes are small, yet the annual patterns did not appear to be significantly different that for bottom trawl. The patterns and comparisons did not provide compelling evidence of dome-shaped fishery selectivity. It is recognized that the age data are limited in this model reinforcing the recommendation to enhance the ageing of historical samples.

10. Plot the fishing mortality rates (fully selected F, or sum of Fs) by fleet.

Rationale: To assist in understanding the length and age composition time series.

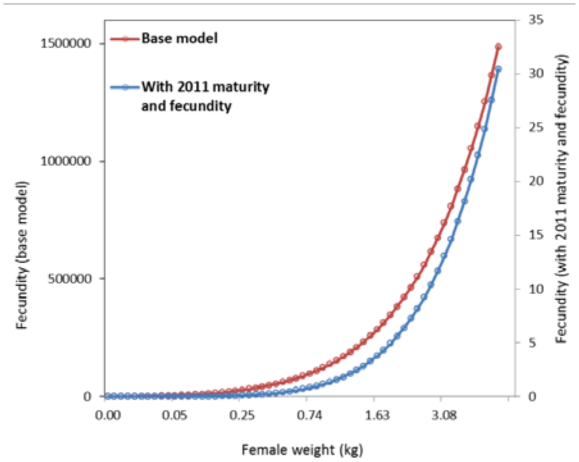
Results:

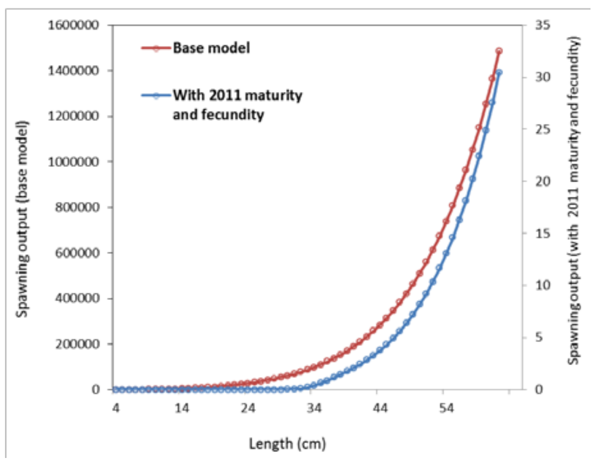


11. **Plot the fecundity at weight relationship used in this assessment and the relationship used in 2011 in the same units (slide 6 of STAT day 1 response- combine the two plots into 1 panel). Make a second plot which adds the spawning output at length based on the 2011 base case model fecundity and maturity parameters to the data plotted in figure 46 (in the draft document), again using equivalent units.**

Rationale: It would be helpful to be able to make a direct comparison of the changes that have been made between the two models.

Results: The STAT confirmed the Nichols 1990 study was part of E.J.'s maturation analysis of darkblotched. It wasn't clear that the maturity comparison was done appropriately. ***This will be double checked for the post-STAR draft of the assessment.*** The apparent change in maturity shows a significantly earlier age at maturation than modeled in the past assessment.





12. **Present a comprehensive set of results and diagnostics (fit to data and residuals) for the revised base case model reflecting changes made as a result of the Day 1 analyses.**

Rationale: In order to review the revisions, the STAR panel needs to see a reasonably complete set of results.

Results: The negative log likelihoods (NLLs) for the new base case indicated improved fits to all data with a total NLL improvement of about 20 units. The changes in the modeling of growth parameters did not change the von Bertalanffy growth functions for males and females but did improve the fits, which is a good outcome. The STAT team reported that convergence diagnostics also looked better for the revised approach.

13. **Re-create the sensitivity analyses corresponding to levels proposed by the STAT for the axes of uncertainty for the decision table using the revised base case model.**

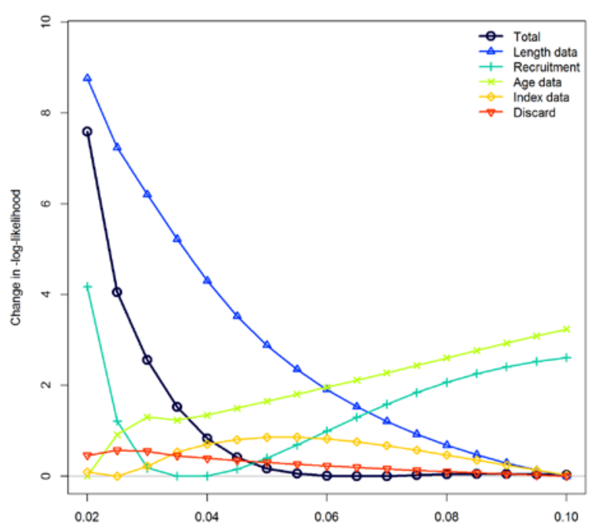
Rationale: This will be helpful in selecting the final format for the decision table.

Results: The STAT varied female M, which is the major axis of uncertainty, to determine spawning output that corresponded to the 12.5% and 87.5% quantiles of 2013 spawning output confidence intervals found in the 'new' base run. These values of female M are 0.045 and 0.06 (base case of 0.05). The STAT proposed these values as the high and low states of nature for the decision table. The STAR Panel rejected these bounds because they did not properly account for uncertainty due to M. This is because the spawning output confidence intervals found in the 'new' base run, which were proposed to generate a range of female M's for the decision table, were based on a fixed female M=0.05. Alternate methods for determining the appropriate quantiles were provided by the STAT and discussed.

14. Re-create the natural mortality and steepness likelihood profiles using the revised base case model.

Rationale: This will provide background for potential decision table levels for these parameters.

Results: The profile on M showed a reasonable pattern. However, the length data seem to be driving the model towards high M. The M profile is appreciably flatter with male M being estimated (i.e., model improvement). The logical inconsistency is high M does not comport with a long-lived species like darkblotched. Fixing female M may have created some other mis-specification in the model that has not been discovered. The additional (early) age data could provide information for the model to estimate natural mortality. It was recommended that future research could ascertain whether additional otoliths exist and whether they could be aged using current ageing methods.



15. Find the lower and upper states of nature for natural mortality that are approximately half as likely as the base case based on the methods presented. Use the likelihood profile for the lower M bound and the prior distribution for the upper M bound). This is a proxy for actually running a model with estimated natural mortality using the

informative prior. Run and summarize the sensitivity analyses (high and low) for each of these.

Rationale: These runs will serve as the basis for the decision table.

Results: The female natural mortalities used to bracket low and high states of nature were 0.036 and 0.082, respectively. The rationale for selecting these values is provided in the section "Description of base model and alternative models used to bracket uncertainty". It was clear that the range of the states of nature shown as depletion is wide given the proposed low and high states. The next assessment should focus on an informed M and h priors for darkblotched. A more representative age sample over time may also assist in directly estimating M.

16. Present the decision table results for at least one catch stream, for all three states of nature.

Rationale: This will allow a final look at the range of results coming from the states of nature, leaving additional catch alternatives for the STAT to identify in consultation with the GMT, council, etc.

Results:

			State of nature					
			Low *Female M=0.036*		Base case Female M=0.05		High *Female M=0.082*	
Management decision	Year	Catch (mt)	Spawning output (million eggs)	Depletion	Spawning output (million eggs)	Depletion	Spawning output (million eggs)	Depletion
Catch calculated using SPR of 71.9% applied to the base model	2013	223	607	18%	1,214	36%	3,606	82%
	2014	240	648	19%	1,294	39%	3,770	85%
	2015	252	688	20%	1,374	41%	3,922	89%
	2016	260	722	21%	1,441	43%	4,032	91%
	2017	266	751	22%	1,496	45%	4,101	93%
	2018	271	776	23%	1,541	46%	4,135	94%
	2019	276	798	23%	1,578	47%	4,147	94%
	2020	280	821	24%	1,613	48%	4,150	94%
	2021	285	844	25%	1,646	49%	4,149	94%
	2022	289	867	25%	1,678	50%	4,146	94%
	2023	293	891	26%	1,709	51%	4,140	94%
	2024	297	915	27%	1,739	52%	4,133	94%
Catch calculated using current rebuilding SPR of 64.9% applied to the base model	2013	302	607	18%	1,214	36%	3,606	82%
	2014	323	641	19%	1,288	38%	3,764	85%
	2015	339	674	20%	1,360	41%	3,909	88%
	2016	347	701	20%	1,420	42%	4,011	91%
	2017	353	722	21%	1,467	44%	4,073	92%
	2018	358	738	21%	1,504	45%	4,101	93%
	2019	363	752	22%	1,533	46%	4,106	93%
	2020	368	766	22%	1,560	46%	4,102	93%
	2021	372	780	23%	1,586	47%	4,096	93%
	2022	377	796	23%	1,611	48%	4,087	93%
	2023	381	811	24%	1,635	49%	4,076	92%
	2024	385	826	24%	1,657	49%	4,064	92%
2014 ACL catch assumed for years between 2015 and 2024	2013	317	607	18%	1,214	36%	3,606	82%
	2014	330	640	19%	1,287	38%	3,762	85%
	2015	330	672	20%	1,358	40%	3,907	88%
	2016	330	699	20%	1,418	42%	4,010	91%
	2017	330	722	21%	1,467	44%	4,073	92%
	2018	330	740	22%	1,506	45%	4,103	93%
	2019	330	756	22%	1,538	46%	4,111	93%
	2020	330	773	23%	1,567	47%	4,110	93%
	2021	330	791	23%	1,597	48%	4,106	93%
	2022	330	811	24%	1,626	48%	4,101	93%
	2023	330	830	24%	1,654	49%	4,094	93%
	2024	330	850	25%	1,681	50%	4,085	92%

Description of the Base Model and Alternative Models Used to Bracket Uncertainty

The darkblotched rockfish stock base model covered the portion of the population occurring off the U.S. west coast. The model included historical catches from both foreign and domestic fleets, and incorporated time-varying retention to allow for changes in the recent fishery. The fishery data used in the assessment include landings, length and age compositions from the retained commercial catch and in recent years discard ratios are incorporated, including their length and age compositions as well as mean individual body weight of the discards. Data from four National Marine Fisheries Service (NMFS) bottom trawl surveys provided fishery-independent indices of relative abundance, and length- and age-frequency distributions. The assessment model is sex-specific to account for dimorphic growth, using the von Bertalanffy growth equation and estimating most of the associated parameters, although fixing the CV of length-at-maximum-age. Externally estimated life history parameters, including the weight-length relationship, female fecundity and maturity schedule, have been substantially revised since the last assessment. Recruitment dynamics are assumed to follow the Beverton-Holt stock-recruit function, with steepness fixed at a value of 0.78. Because fecundity is estimated to differ from female body-weight, spawning output is reported in millions of eggs. Natural mortality for female darkblotched rockfish is fixed at the value of 0.05/yr, while the corresponding value for males is freely estimated.

Summary:
Start year of the model =1915; one area; two genders; two fishery fleets (domestic trawl and foreign bycatch), discard estimated within the model for the domestic trawl fleet, no discard is assumed for foreign bycatch fleet.

Biology:
Natural mortality (M) is fixed at 0.05 for females and estimated for males;
Von Bertalanffy growth model, length at $A_1 = 2$ and CV young are assumed the same for both genders (estimated for females, set equal to females for males), CV old age ($A_2 = 30$) fixed for both genders, all other growth parameters estimated within the model for females and males separately; and
Beverton-Holt stock-recruitment model, *h* is fixed at 0.779 (based on this year's prior), recruitment deviations estimated.

Selectivity:
Asymptotic length-based selectivity for fisheries; and
Dome-shaped length-based for surveys.

Abundance indices:
AFSC triennial trawl survey (1980-2004), divided into two time series;
AFSC slope bottom trawl survey (1997, 1999-2001);
NWFSC slope bottom trawl survey (1999-2002); and
NWFSC shelf-slope bottom trawl survey (2003-2012).

Length frequencies:
Domestic trawl;
AFSC triennial trawl survey;
AFSC slope bottom trawl survey;
NWFSC slope bottom trawl survey; and
NWFSC shelf-slope bottom trawl survey.

Age frequencies:
Domestic trawl;
AFSC triennial trawl survey;
AFSC slope bottom trawl survey;
NWFSC slope bottom trawl survey; and
NWFSC shelf-slope bottom trawl survey.

The current assessment estimates a similar relative stock trend to recent updates, and the 2007 assessment, indicating that the stock declined rapidly during the 1960s through the 1990s, and has been increasing in recent years. The base case model estimate for 2013 spawning depletion is 36%. Uncertainty about this estimate is characterized via both the likelihood profile and the prior distribution for female natural mortality. The choice to use both sources of information for this fixed parameter was motivated by the observation that the assessment data showed strong information against extremely low values of natural mortality, but was relatively uninformative (i.e. flat profile) for large values. In the absence of a fully integrated posterior distribution, the prior distribution based on maximum age was used as a proxy for the upper end of the range. The primary axis of uncertainty for the decision table was therefore based on female natural mortality values of 0.036 and 0.082, both approximately half as likely as the base case value of M=0.05. The lower value of natural mortality corresponded to a 2013 depletion estimate of 18% and the higher value of natural mortality corresponded to a depletion estimate of 82% illustrating the marked sensitivity of the assessment results to a very poorly informed parameter. Both the fixed value for steepness, and the magnitude of historical catch were identified as large sources of additional uncertainty not captured in the decision table.

Comments on the Technical Merits of the Assessment

This stock assessment was carried out in a highly competent and professional manner. The draft document was well written and distributed to the Panel two weeks in advance of the meeting. The panel appreciated the Executive Summary, and particular the section *Unresolved problems and major uncertainties*. The suite of sensitivity analyses provided in advance to the Panel greatly simplified the review process. A detailed description of changes since the last full assessment of this stock (i.e. 2007) was provided, and included the impacts on model results. Again this greatly simplified the review process.

Panel discussion and requests focused on better understanding of model selection criteria for survey indices, implication of new maturity and fecundity parameters, and the sensitivity of model outputs to natural mortality values. The STAT responded to several Panel requests for additional analyses and always provided results the next day. Any potential discrepancies were quickly resolved. This resulted in an improved stock assessment for darkblotched rockfish and the Panel concluded that the stock assessment was based on the best available data, the new assessment estimates constitute the best available information on stock status, and are suitable to serve as the basis for fishery management decisions.

Areas of Disagreement

There were no major areas of disagreement between the STAT and the STAR Panel.

Unsolved Problems and Major Uncertainties

Problems unresolved at the end of the meeting form the basis for some of the research recommendations, below. Many of the research recommendations address detailed aspects of the fishery and survey data; the biology and vital rates; and nuances of the modeling. However, clearly the assessment is sensitive to the treatment of natural mortality (M) as evidenced by the decision table analyses. Because M was fixed at 0.05 for females, and results are sensitive to this assumption, probability intervals for spawning output and depletion do not reflect the real uncertainty about these 'states of nature'.

Uncertainty about the catch history was explored in the draft document, but not quantified or incorporated into the final assessment model or decision table. This may be a substantial source of uncertainty, and could require investigation of catch reconstructions with regard to uncertainty in order to better understand the plausible range for historical estimates.

Concerns Raised by the GMT and GAP Advisors During the Meeting

There were no major concerns raised by either the GMT or GAP advisors.

Prioritized Research Recommendations

1) The base model does not use commercial age composition data for years that lacked coast wide samples. The additional age data could provide information necessary for the model to estimate such parameters as the CVs defining the distribution of lengths at older ages and natural mortality. Future research could ascertain whether additional otoliths exist for these years, and whether they could be aged using current ageing methods. Also, alternative fleet structures (with state specific fisheries) could be explored to take use of as much currently available age data as possible.

2) There is a large quantity of age data from California that is currently being excluded from the model (<2002, and from other states >2008). Work should be continued to try to incorporate these data into the model, potentially by restructuring the fleets, reading additional historical ages, or other means. This would help to reconcile and make consistent the treatment of length data and age data over time and space. Additional ages may help to allow estimation of the CV parameters for male and female growth and perhaps explore alternate approaches to the growth parameters themselves.

3) Use a prior for female M in the next assessment – the current likelihood profile indicates that it may be estimable given a reasonably informative prior.

4) The base model uses newly available information of female maturity collected within the NWFSC shelf-slope survey. This new information includes data on mass atresia (a form of skipped spawning), not previously available for the assessment. At present, Stock Synthesis allows incorporation of this information only when maturity is expressed as a function of age. Effort should be devoted to expand maturity options in Stock Synthesis to allow expression of maturity information (with mass atresia) as a function of female length.

5) Continued collection of maturity samples would allow future researchers to explore differences in maturity at age, either spatially or over time.

6) Additional research would be important to explore whether other life history parameters, such as growth and fecundity vary spatially or change over time as well. This information will help in defining spatial structure of future models.

7) Given that the population range extends north to the border with Canada, it is important that future research would evaluate the impact of not accounting for any Canadian portion of population abundance. Such an analysis would require evaluation of movement of darkblotched (including larvae) along the coast, which information is currently lacking.

8) Future research could also improve existing meta-analyses for natural mortality and steepness, which both contribute to the implied yield curve. Directions for improvements include (1) explaining variability between methods in natural mortality estimates, included in the Hamel natural mortality method and (2) developing a larger database of species for estimating steepness, perhaps by including species from other regions, e.g., Canada and Alaska.

9) As a diagnostic, a natural mortality value, as indicated by the likelihood profile, that is very different value than that used in the model indicates some model misspecification. Additional effort should be made to determine what features (such as the CV of length at age for old fish, selectivity, steepness, or other model structure) might be creating this pattern.

10) Continue to pursue making this assessment fully Bayesian. This will allow for probabilistic interpretation of the results, as well as far more efficient reporting and treatment of uncertainty in terms of the decision table, use of priors, etc.

11) General recommendations for all species:
    a. Recommend that STAT teams to present a sensitivity analysis (Tables and Figures) in the draft document for any axis of uncertainty that is likely to be considered for the decision table. This would facilitate efficient discussions during the meeting.

b. It would be helpful to routinely include a time-series of species-specific Canadian (B.C.) landings for comparison with U.S. landings and trends.

c. The specific treatment and results of model tuning procedures should be reported in the document including all input/output sample sizes, effective sample sizes, sigmas, RMSEs (including recruitment deviations), that are applicable.

d. For survey GLMM analyses, the STAT teams need to report a standard summary of the raw data, and fitting of the model including both results and diagnostics. Additional research should attempt to identify (and perhaps simulation test) a method for model selection including the error distribution, the treatment of random vs. fixed effects and the inclusion of ECE mixture distributions that can be reliably applied across all species.

e. General recommendation to identify where and when E.J. Dicks fecundity relationships are better than existing data for a given species.