6. Assessment of the Rex Sole Stock in the Gulf of Alaska

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Executive Summary

Rex sole (*Glyptocephalus zachirus)* are assessed on a biennial stock assessment schedule to coincide with the availability of new survey data. For Gulf of Alaska rex sole in alternate (even) years we present an executive summary to recommend harvest levels for the next two years. Please refer to last year's full stock assessment report for further information regarding the assessment model (McGilliard et al. 2015), available online at http://www.afsc.noaa.gov/REFM/Docs/2015/GOArex.pdf). A full stock assessment document with updated assessment and projection model results will be presented in next year's SAFE report.

GOA rex sole is currently managed as a Tier 5 species because reliable estimates of $F_{35\%}$ and $F_{40\%}$ (required for Tier 3 management) are not available for this stock. However, rather than using biomass estimates from the NMFS bottom trawl survey to calculate ABC and OFL in the standard Tier 5 calculations, the assessment uses a Tier 3-type age-structured assessment model and projection model to estimate total adult biomass for use in the Tier 5 calculations. The single species projection model was run using parameter values from the accepted 2015 assessment model (McGilliard et al. 2015), together with updated catch information for 2015 - 2016, to predict stock status for rex sole in 2017 and 2018 and to make ABC recommendations for those years.

Summary of Changes in Assessment Inputs

There were no changes made to the assessment model inputs since this was an off-cycle year. New data added to the projection model included an updated 2015 catch and new estimated catches for 2016 and 2017. As for the 2015 assessment, apportionments were computed based on the random effects model predictions of survey biomass in each area.

Summary of Results

New information available this year to update the projection model consists of the total catch for 2015 (1,957 t) and the current catch for 2016 (1,533 t as of October 8, 2016). The projection model was run to generate estimates of total (age 3+) biomass for 2017-2018. In order to do this, estimates for the total catches to be taken in 2017 and 2018 are required (the 2016 fishery was still underway when this analysis was performed). The final catch for 2016 was estimated by taking the average tons caught between October 8 and December 31 over the previous 5 years (2011-2015) and adding this average amount to the catch-to-date as of October 8 for 2016. The estimated final catch for 2016 was 1,771 t. The 2017 catch was estimated as the average of the total catch in each of the last 5 years (2011-2015). The estimated catch for 2017 was 2,912 t. The resulting estimates of total biomass in 2017 and 2018 from the projection model were then converted to adult biomass (as a proxy for exploitable biomass) using a conversion factor determined from the 2015 assessment model, because numbers-at-age for 2017 and 2018 were not available from the projection model. The OFLs and maximum permissible ABCs for 2017 (updated from last year's assessment) and 2018 (new this year) were then calculated based on Tier 5 specifications for F_{OFL} (=M) and *max* F_{ABC} (=0.75M) using the estimates of adult biomass at the start of each year, M=0.17, and the Baranov catch equation. The maximum permissible ABCs for 2017 (updated) and 2018 (new) are 8,311 t and 8,421 t, respectively, and the OFLs are 10,860 t for 2017 and 11,004 t for 2018. The maximum permissible ABC and OFL values for 2017 proposed last year for 2017 and 2018 were 7,507 t and 9,810 t, respectively. Recommended OFL and ABC values as recommended this year are higher than

those recommended in 2015 because estimated catch for 2016 was much lower (1,771 t) than the estimate for 2016 catch in the 2015 projections (3,188 t). In addition, the 2015 projections assumed a catch estimate for 2017 equal to the 2016 ABC value as recommended in 2014 (8,979 t), while the estimate of 2017 catch in this year's projections was 2,912 t (the average of the 2011-2015 yearly catches).

Although it is not possible to use a Tier 3 approach to make harvest recommendations for rex sole because estimates of $F_{35\%}$ and $F_{40\%}$ are not considered reliable, the SSC has decided that it is possible to use a Tier 3 approach for determining overfished status because the estimate of $B_{35\%}$ (i.e., 35% of the unfished spawning stock biomass) is considered reliable (it does not depend on the fishery selectivity), as is the estimate of current (2016) spawning stock biomass. Because the estimated spawning stock biomass for 2016 (43,731 t) is greater than $B_{35\%}$ (19,896 t), the stock is not considered overfished. Because the 2015 catch was less than the 2015 ABC (i.e. 1,957 t < 9,150 t), overfishing is not occurring.

Because the stock appears to be healthy and is only lightly exploited, the author's recommended ABCs for 2017 and 2018 are the maximum permissible ones. The principal reference values for this update and from last year's assessment are summarized in the following table:

Quantity	As estimated or *recommended this* year for:		As estimated or *recommended this* year for:	
	2016	2017	2017*	2018*
M (natural mortality rate)	0.17	0.17	0.17	0.17
Tier	5	5	5	5
Projected total (3+) biomass (t)	67,941	68,074	75,359	76,356
Female spawning biomass (t)	43,808	46,292	47,008	49,317
$B_{100\%}$	56,845	56,845	56,845	56,845
$B_{40\%}$	22,738	22,738	22,738	22,738
$B_{35\%}$	19,896	19,896	19,896	19,896
$F_{OFL}=M$	0.170	0.170	0.17	0.17
$maxF_{ABC}=0.75*M$	0.128	0.128	0.128	0.128
F_{ABC}	0.128	0.128	0.128	0.128
OFL (t)	9,791	9,810	10,860	11,004
maxABC (t)	7,493	7,507	8,311	8,421
ABC (t)	7,493	7,507	8,311	8,421
Status	As determined in 2015 for:		As determined in 2016 for:	
	2014	2015	2015	2016
Overfishing	no	n/a	no	n/a
Overfished	n/a	no	n/a	no

* Projections are based on the final catch from 2015 of 1,957 t and estimated catches for 2016 and 2017 of 1,771 t and 2,912 t that were used in place of maximum permissible ABC for 2016 and 2017. The 2016 projected catch was calculated as the current catch of GOA rex sole as of October 8, 2016 added to the average October 8 – December

31 GOA rex sole catches over the 5 previous years. The 2017 projected catch was calculated as the average catch from 2011-2015. The 2018 projected F was set equal to the average F from 2012-2016. Projected total (3+) biomass for GOA rex sole is currently defined as numbers-at-age multiplied by maturity-at-age (as a proxy for fishery selectivity) and weight-at-age, summed over males and females, as for previous assessments.

Area Apportionment

The table below shows apportionment of the 2017 and 2018 ABCs and among areas, based on random effects model predictions of survey biomass in each area for 2017-2018.

Quantity	Western	Central	West Yakutat	Southeast	Total
Area Apportionment	17.55%	59.32%	10.22%	12.90%	100.00%
2017 ABC (t)	1,459	4,930	850	1,072	8,311
2018 ABC (t)	1,478	4,995	861	1,087	8,421

Responses to SSC and Plan Team Comments on Assessments in General

SSC, December 2015: The SSC reminds the authors and PTs to follow the model numbering scheme adopted at the December 2014 meeting.
The author will follow the new numbering scheme in the next full assessment.

SSC, December 2015: Many assessments are currently exploring ways to improve model performance by re-weighting historic survey data. The SSC encourages the authors and PTs to refer to the forthcoming CAPAM data-weighting workshop report.
Two data-weighting methods that were discussed at the CAPAM data-weighting workshop have been applied to GOA rex sole previously: the Francis data-weighting method (Francis 2011) and the McAllister and Ianelli method (McAllister and Ianelli 1997). Developers of Stock Synthesis are working on adding additional distributions for age- and length-composition likelihood components that may better address data-weighting. The author will follow future developments and apply best available practices for future assessments.

Responses to SSC and Plan Team Comments Specific to this Assessment

SSC, December 2015 and GOA Plan Team, November 2015: The SSC agrees with the PT recommendation to examine rex sole age, growth, and maturity information and updating the growth data used in the model.
The next full assessment of GOA rex sole will include updated estimates of growth and, if possible, updated estimates of maturity. An updated analysis of ageing error will also be done.

The SSC concurs with the PT and author recommendation that more information should be collected on fishery size and age compositions to inform selectivity parameters and potentially improve estimates of harvest rates.
The age and growth lab has been ageing a backlog of GOA rex sole otoliths from the fishery. Ageing of fishery otoliths is expected to be completed in time to be included in analyses for the September Plan Team meeting in 2017.

The SSC concurs that further research on genetics and growth should be conducted to explore these two growth patterns seen on the otoliths.
The age and growth lab has noticed two distinct growth patterns on GOA rex sole otoliths and the author has discussed the possibility of a future collaborative research project with age and growth personnel to explore these patterns further.

Data Gaps and Research Priorities

The rex sole fishery is primarily a bycatch fishery that takes mainly older, larger fish. Current estimates of optimum harvest levels based on Tier 3 calculations (e.g., at $F_{40\%}$ harvest rates) are very large but highly uncertain. The rex sole fishery should continue to be monitored to assess whether a directed rex sole fishery has developed; quantities such as $F_{40\%}$ (=F_{ABC} in Tier 3a) will be sensitive to the characteristics of the resulting fishery selectivity curves. Otoliths from the fishery are currently being aged and the resulting age data will be included in future analyses to explore whether these data help to better inform selectivity parameters and improve estimates of harvest rates. Additionally, the assessment would benefit from updated estimates of growth and maturity and an exploration of ways to better account for scientific uncertainty, especially uncertainty associated with parameters that are currently fixed in the model.

Literature Cited

Francis, R. I. C. C. (2011). Data weighting in statistical fisheries stock assessment models. *Canadian Journal of Fisheries and Aquatic Sciences, 68*, 1124-1138.

McAllister, M.K. and Ianelli, J.N. 1997. Bayesian stock assessment using catch-age data and the sampling –importance resampling algorithm. Can. J. Fish. Aquat. Sci. 54: 284-300.

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