Stock Assessment Review (STAR) Panel Report for Kelp Greenling

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Overview

The STAR panel reviewed a new full assessment for kelp greenling (*Hexagrammos decagrammus*) off Oregon during a five-day meeting in Newport, OR. The stock assessment team (STAT) prepared a new benchmark assessment using the most recent Stock Synthesis 3 software, with a thorough reconsideration of the data and model structure, and including investigations of historical and recent landings and discards, length and age data and fleet structures. The last assessment was conducted in 2005.

The STAR Panel recommends that the new assessment for kelp greenling off Oregon constitutes the best available scientific information on the current status of the stock and that it provides a suitable basis for management decisions.

Summary of Data and Assessment Models

Kelp greenling data

<u>*Stock definition*</u>

Kelp greenling range from southern California, north to the Aleutian Islands, Alaska, but are rarely found south of Point Conception, California. The main population range and fisheries activities are from central California (including the Channel Islands) north through Oregon. They are most prevalent nearshore and intertidally in depths <50m. There is little direct information on the stock structure of kelp greenling off the U.S. west coast. Little is also known of kelp greenling movement patterns, but given their nearshore distribution and the territorial behavior of adults, they are not believed to migrate great distances. The effect of a potential wider spawning stock contributing to the stock within the defined boundaries is unknown at present. The current assessment is confined to the Oregon coast.

Kelp greenling live to at least 17 years of age, with clear sexual dimorphism after maturity. Females batch spawn into nests where males fertilize the eggs and subsequently guard them against predation and help and oxygenate the eggs by fanning. Larvae are planktonic for about 6-12 months before settlement. Their preferred habitat is inshore, where they are accessible to shore-based or small vessel recreational fishermen.

As well as estimates of stock biomass from the assessment model, biomass was also estimated very approximately from habitat area and density measurements, which, depending on the area included, suggested total biomass was in the order of 500-1500 mt within 3 miles of the coastline, and 4000-5000 mt if the area was extended to the 100 fathom line. This information could be used for comparison with stock biomass estimates from the stock assessment model.

<u>*Catches*</u>

There has been a recreational fishery on kelp greenling since records began, but since the 1990s a commercial fishery has been landing to a market for live fish. Kelp greenling is predominantly caught using hook-and-line gear by recreational fishermen and by hook-and-line or longline gear by commercial fishermen. Combined landings peaked in 2002, but management limits have stabilized commercial fishery catches since 2004.

Commercial landings of kelp greenling were available from the Pacific Fisheries Information Network (PacFIN; 1988 – 2014). Commercial landings before 1988 are believed to be negligible.

Recreational catch data begin in 1973 for the ocean-boat fishing mode and in 1981 for the estuary boat and shore fishing modes. Unlike the shore and estuary modes, the ocean-boat recreational fleet rarely targets kelp greenling, but lands some incidental catches. For years 1915-1980 and for recent years (2005 – 2014), no direct information was available to estimate catch from the estuary-boat and shore based fishing modes, so a catch series was derived from fishing license sales (pre-1980) or from catches during surrounding years (2005-2014).

Uncertainty in the historical catch was examined for the pre-STAR base by doubling historical (1915-1980) and recent (2006-2014) catch from the estuary-boat and shore-based recreational fisheries, and by beginning the catch series in 1940. Neither of these scenarios greatly affected current relative biomass depletion levels.

Indices

Four abundance indices were developed from fisheries catch and effort data. Although some potential fishery independent indices were considered, none were identified as suitable as indices of abundance for this species. For the commercial fishery, the Oregon Commercial Logbook data provided information for 2004-2012. Recreational catch and effort data come from the Marine Recreational Fishery Statistics Survey (MRFSS, 1981-2002) and the Oregon Ocean Recreational Boat Survey (ORBS, 2001-2014) data collection programs, and the Recreation Onboard Observer Survey (2001-2014). The MRFSS and ORBS programs cover all types of fishing trips, so those trips that target greenling, among other species, were selected based on landed species composition using the Stephens-MacCall logistic regression technique. The observer program reported fishing locations, so only fishing on habitat likely to catch greenling was used in this case. All catch-per-unit-effort (CPUE) indices were standardized using delta-generalized linear models, with binomial and lognormal or gamma likelihoods for the presence/absence and positive trip components respectively.

The STAT provided a comparison plot in their presentations that showed that there is no apparent long-term abundance trend and some inconsistencies in trends shown by multiple indices in the most recent period since 2003. There appears to be a good correspondence of trends in the onboard observer and ORBS dockside index, with the logbook index standing out as being dissimilar.

Time was taken during the meeting to examine the filtering applied to the logbook index – particularly the application of a requirement that vessels must have fished (or held permits) for 10 years in the fishery. The vessel filter removed nearly 70% of the associated catch for filtered records which was considered to be too aggressive. A filter based on the requirement that vessels fished for at least 3 years removed only about 10% of the associated catch. The STAR Panel believed that this might improve the balance between increased noise produced by a smaller data set and consistency over the time series. It was also noted that the purpose of the GLM was to improve consistency over the time series so that less filtering might be required.

The meeting spent considerable time exploring the MRFSS index and also associated biological data. There was uncertainty in how the MRFSS dockside index was aggregated to trip level, so this index was removed from the base model.

Age and length compositions

Length compositions were compiled from data collected by the ORBS and MRFFS programs for recreational ocean-boat (1980-2014), estuary-boat (1980-2013), and shore (1980-2005) fishing modes. Commercial length compositions by sex for hook-and-line fisheries (1988 - 2014) are collected by port biologists following a stratified, multistage sampling design.

Age compositions were available from the Ocean-boat mode recreational fishery and commercial fishery. With regard to age-compositional data for kelp greenling, the reliability of age-readings is unknown. The length of the initial larval stage and early life history are uncertain and early growth appears rapid. It is generally assumed kelp greenling hatch in winter and settle from the plankton during the following summer. Surface reads work well on young fish, and errors on ageing 0-2 rings are likely to be negligible, but thereafter errors should increase significantly. Because ageing error for kelp greenling had not been estimated (no double-reads), a proxy was required.

Cabezon (*Scorpaenichthys marmoratus*) was identified as the most appropriate proxy for estimating ageing error. Lingcod (*Ophiodon elongatus*), which had originally provided ageing error information for the kelp greenling assessment model, is aged using fin-rays and therefore seemed an inappropriate proxy. The kelp greenling otoliths are probably most similar to Atka mackerel in structure, and the Bering Sea Atka mackerel fishery does have estimates of ageing error. However, kelp greenling has a crystalline structure, making them more difficult to age. So, errors in age-reads for kelp greenling may be higher than those estimated for Atka mackerel.

There was a lack of data for young 0-1 year old fish, when growth was most rapid. An approach was found to augment the age-at-length data for these young fish using ODFW "special projects" data, which had deliberately done target sampling to obtain small fish for age and length measurements. These data were only suitable for the growth model as they had not been sampled randomly.

Substantial exploration of the MRFFS data, both biological and catch-effort, revealed that there were fundamental uncertainties in the aggregation methods for 'trip' delineation and for the sampling of lengths and weights over time. The STAT was unable to resolve the issue of whether the data currently available for CPUE analysis accurately represented individual trips, and therefore the MRFSS index of abundance was removed from the base case model configuration. The STAT was able to identify a dataset of length information that was thought to represent actual measured lengths (as opposed to lengths derived from weight measurements), and these data were included in the revised base case. Mean weight data were removed from the model, as they represented sampling of the same fish for which lengths had been collected. The MRFSS data will remain a source of major uncertainty until the properties of the basic data can be resolved.

Kelp greenling Assessment model

This assessment used Stock Synthesis version 3.24u and was structured as a single, two-sex population spanning Oregon coastal waters, with an annual time step covering the period 1915 to 2014. Fleets were specified for the recreational ocean-boat, estuary-boat, and fishing from shore fleets and one commercial fleet, which included a combination of hook-and-line and longline gear types. Data used in the assessment includes time-series of commercial and recreational landings, four abundance indices (CPUE), length compositional data for each fleet, and age compositional data from the recreational ocean-boat fleet. Observations of conditional age at length were included to inform estimation of growth. Discard and discard-mortality rates were also used for each fleet to expand total landings to total catch.

Selectivity was assumed to be asymptotic for the recreational ocean fleet, and dome shaped for the commercial and recreational estuary and shore fleets.

Evidence for model convergence was based on a low value for the final gradient, parameters not hitting bounds and jittering starting values for estimated parameters. While likelihood profiles were not very smooth, they also provided additional evidence for convergence. The Panel agreed that acceptable evidence of convergence was provided.

There were insufficient data in the original base case model to estimate growth parameters, and the values of these parameters had a substantial effect on the model results. There were clear patterns in the residuals of the fits to smaller fish when parameters were fixed to externally estimated values. The STAR and STAT opted to include conditional age at length data from "special projects" of age-1 fish (without an associated length composition sample), in order to allow the estimation of a simplified growth curve (only L_{Amax} estimated separately for males and females, and only one parameter describing the spread of length at age for all ages/sizes).

Currently, ages in SS are recorded as whole numbers only. In this case, higher precision might help estimate growth more accurately for the faster growing younger fish. There also may have been a problem with recording of age as 0 given the date of collection and the length of the larval period. Age-0 fish were therefore removed, and, with the “special project” data in the conditional age-at-length, a reasonable fit was obtained.

Conditional age-at-length observations can be informative for the age structure of the population if corresponding length compositional data are also available. In the case of kelp greenling, growth is very rapid and most catches were taken close to the asymptotic size, so age and recruitment events may be largely obscured by growth variability. Marginal age- and length-compositional data were included to improve estimates of the population age structure.

The prior probability on the natural mortality coefficient is extremely important, but very problematic for kelp greenling. It represents an extrapolation to younger maximum ages than the species for which the relationship was developed. This means that the prediction interval, even though it is very wide, is still an underestimate of the uncertainty.

Final model results indicate that while the stock size is small compared to most fisheries, it appears to have been only lightly exploited with current spawning biomass at near unfished levels. Stock assessments are generally improved when contrast becomes evident in the input data, which will likely only happen should this stock become more heavily fished.

The major source of uncertainty explored and suggested by the STAT and agreed by the Panel for inclusion as an axis of uncertainty for management recommendations was natural mortality.

Treatment of uncertainty

Uncertainty was assessed using sensitivity runs, a retrospective analysis, and likelihood profiles on key parameters as well as reporting the asymptotic standard errors on all parameters. No MCMC integration was carried out.

Sensitivity analysis was the major method used to explore uncertainty in the model. Each sensitivity run was based on changing one component (data source or structural assumption) relative to the base model. The four types of sensitivity were (1) removal of an index of abundance time series, (2) removal of length- or age-compositional data, (3) evaluation of structural (parameterization) assumptions, and (4) alternative assumptions about the estuary and shore catch time series. Eighteen sensitivity runs were completed before the STAR review, and a further four during the review to identify a suitable axis for uncertainty in the decision table. Original sensitivity runs may not be accurate because the new base model had a significant change in the growth model. In general, the depletion ratio (SB_{2014}/SB_0) was less sensitive, ranging from 75% to 90% across credible sensitivity scenarios. However, absolute biomass varied enormously and was very sensitive to the value used for the natural mortality coefficient.

Retrospective analysis was conducted by sequentially removing 1 through 5 years of data from the base model starting with 2014 and working backwards. The retrospective did not indicate any great systematic bias outside the estimated range of uncertainty or a significant problem for any management advice.

Likelihood profiles were performed across three parameters that have significant effect on stock productivity: natural mortality (M), steepness (h), and unexploited recruitment (R_0). Likelihood profiles were used to indicate the contribution for each data source. Likelihood profiles indicated that R_0 was reasonably estimated, but the likelihood was fairly flat suggesting a wide confidence range. Steepness probably could not be reliably estimated, with the final estimate dependent on the input prior. Natural mortality is a major source of uncertainty informed by length and age composition data, and dependent on the growth model. There was some evidence for higher rates of natural mortality for females than males.

Requests by the STAR Panel and Responses by the STAT

Request 1.1: Provide a summary of the raw count of age-length samples informing growth. Include the samples used to externally estimate growth.

Rationale: Help us understand how SS is dealing with growth.

Response: The STAT team provided a summary table similar to those in the document (Tables 11-12).

Request 1.2: Verify the Q-Q plot for the commercial logbook index.

Rationale: The Q-Q plot displayed seemed erroneous.

Response: The displayed Q-Q plot was in fact correct when the gamma distribution was used for the positive catch sub-model. When the filtering criteria for the number of years required to have fished (>= 1 set) was relaxed (to 3 years in this case), model diagnostics improved with more data. A revised logbook index was constructed that applied this 3-year filtering rule.

Request 1.3: Provide a summary of indices used in the assessment with rankings on expectation of how informative they may be as indices of abundance.

Rationale: Assist in gauging the a priori importance of the indices.

Response: The STAT provided the following table.

ID	Fleet	Years	Name	Fishery independent	Filtering	Method	Rank	Method endorsed
1	6	2004-2013	Commercial Logbook	No	Logbook complete, 10 years in fishery (also 3, 5)	delta-GLM (bin-gamma)	2	-
2	7	2001-2014	Onboard Observer CPFV	No	Positive drifts	delta-GLM (bin-lognormal)	1	Nearshore Workshop
1	8	2002-2014	ORBS dockside	No	Stephens-MacCall	delta-GLM (bin-lognormal)	2	SSC
2	9	1981-2002	MRFSS dockside	No	Stephens-MacCall	delta-GLM (bin-lognormal)	3	SSC

Request 1.4: Improve estimates of L at Amin. Try Amin <2. Fix the parameters for young males and females to be the same. Include 0 and 1 yr. old otoliths.

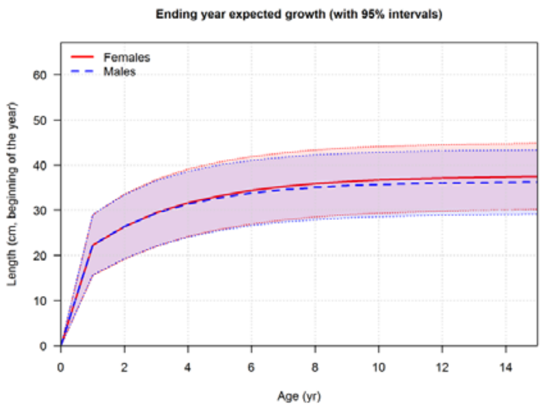
Rationale: Growth directly affects scale.

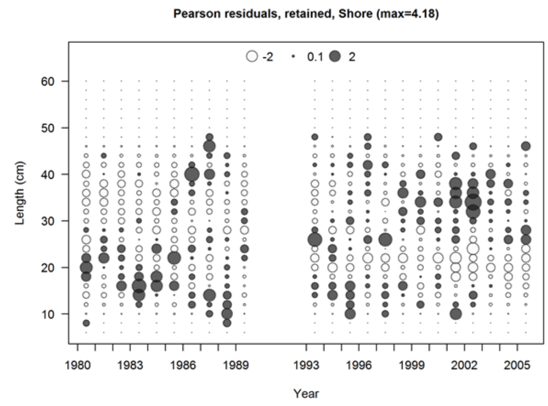
Response: This was part of the Panel investigation of improvement of growth fits by the model to alleviate existing composition residual patterns and apparent bias in fits to length at Amin. The STAT added age information from special research project data for the years 2012-2014, when information on 0 and 1 year old fish was collected (N=72 for age-0 fish; N=14 for age-1 fish). The STAT explored many model runs that set Amin to 0.5 and 1 while fixing and/or estimating growth parameters. A more reasonable growth curve could be estimated by fixing the parameters for young males and females to be the same at a reasonable level according to available data. The CV-young parameter value was estimated but the CV-old parameter value was fixed at 0.1.

Request 2.1: *Top priority*: For developing growth curves, set the population bin structure to start at 0. Fix the ageing error for ages 0 and 1 to be equal to 0. Then estimate male to be equal to female parameters for the CV young and Amin. If further work is required, then look at length selection for ages 0 and 1, drop all age 1 data, lambda >1 for the special project collection of young ages, all special ages assume age 0, assume all special project ages are age 1.

Rationale: Growth, which directly affects the scale of the model results, needs to be better specified, preferably without resorting to using fixed parameters.

Response:	The STAT provided many model runs exploring each of these scenarios, which helped to formulate an approach for estimating growth. Starting the population bin structure at length bin 0 helped to constrain the growth pattern to reasonably fit the size of young fish (see below).





Request 2.2:	Provide initial sample sizes for recreational compositional data as the number of trips or number of anglers rather than as the number of sampled fish.

Rationale:	The fish in each sample are not independent. Using the number of fish sampled as the Input-N overstates the precision of the compositional observations.

Response:	The STAT provided a table (below) showing the raw and trip-based sample sizes for length composition data.

	Trips			Raw			Percent		
Year	Shore	Estuary	Ocean	Shore	Estuary	Ocean	Shore	Estuary	Ocean
1980	175	32	31	529	71	46	25%	31%	40%
1981	115	19	20	274	46	46	30%	29%	30%
1982	125	19	39	239	52	72	34%	27%	35%
1983	80	15	11	211	47	16	27%	24%	41%
1984	118	35	48	240	144	71	33%	20%	40%
1985	256	32	63	470	84	71	35%	28%	47%
1986	207	48	47	353	122	55	37%	28%	46%
1987	147	55	36	332	253	58	31%	18%	38%
1988	89	38	65	232	139	83	28%	21%	44%
1989	63	10	40	155	22	60	29%	31%	40%
1993	222	20	71	530	72	135	30%	22%	34%
1994	138	27	101	299	60	162	32%	31%	38%
1995	122	17	49	246	59	75	33%	22%	40%
1996	146	27	62	309	109	87	32%	20%	42%
1997	134	25	112	316	85	163	30%	23%	41%
1998	49	14	104	93	61	156	35%	19%	40%
1999	76	27	199	138	83	298	36%	25%	40%
2000	97	9	101	262	31	165	27%	23%	38%
2001	65	30		153	106		30%	22%	
2002	108	26		300	109		26%	19%	

Request 2.3:	Confirm the MRFSS/ORBS dockside index is trip-based.

Rationale:	The raw data from MRFSS are interview-based and require processing and aggregation to convert then to trip-based observations.

Response: To the best of the STATs knowledge, the available data was trip-based. However, the STAT acknowledged that the aggregation of data going from raw data to trip-based data seemed excessive.

Request 2.4: Explore the recommendations from the Nearshore Assessment Workshop and confirm they have been properly addressed.

Rationale: The STAT is responsible for addressing the Workshop recommendations.

Response: The STAT presented a list of items pertaining to Kelp Greenling that were recommendations from the Nearshore Assessment Workshop. Each item was addressed to some degree in the assessment document.

Request 2.5: If there are length observations corresponding to the mean weights, remove the mean weights. For what is left, confirm the CV of mean weight is a SE (i.e., is the number of fish factored into a weight sample?).

Rationale: It is good practice to avoid double-use of any data.

Response: Removal of the mean weight data was completed; this change made no difference to point estimates.

Request 2.6: Check the CVs on the onboard CPFV index to confirm that input logSEs are correct.

Rationale: Some of the input logSE values seemed inconsistent with information provided in the assessment document.

Response: The input logSE values in the model were correct. The STAT decided to reformat abundance index tables in the document to improve clarity.

Request 2.7: Determine how much MRFSS data there are (total trips and trips w/ kelp greenling) for the (1) private boats sampled in estuaries, (2) shore-based beach/bank, and (3) shore-based man-made.

Rationale: The STAR Panel wants to better understand whether the model has a reasonable balance of data from the different sources.

Response: The STAT produced the table below (estuarine data) and noted that there is potential for the development of a MRFSS estuarine index. This cannot be accomplished during the STAR; it will need to be future research.

Mode	INLAND	INLAND with Kelp Greenling
Man Made	4612	1372
Beach/Bank	3757	611
Charter	366	2
Private/Rental	4784	659

Requests 3.1 to 3.6 below inform a new base model:

Request 3.1: Drop the MRFSS index.

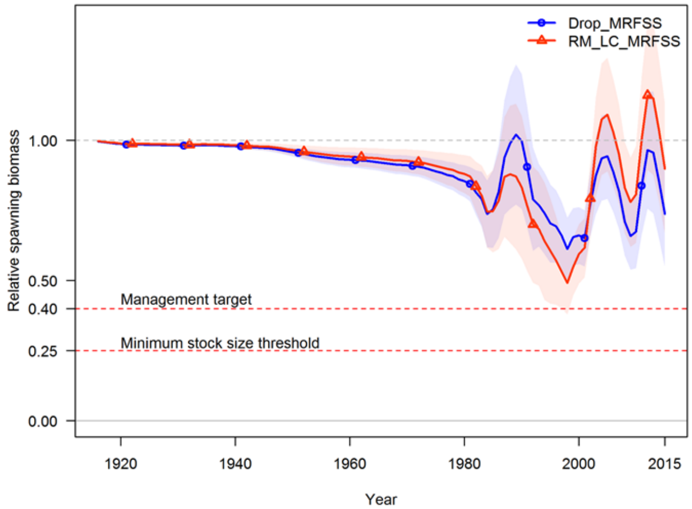
Rationale: MRFSS catch and effort data appear to be incorrectly aggregated at the trip level.

Response: The STAT agreed that given this uncertainty the index should be dropped.

Request 3.2: If this can be done expeditiously tonight, remove the MRFSS length compositional data that are calculated from mean weights (assuming non-integer values indicate this); otherwise, this is a recommendation for future research.

Rationale: The observed data should be observations, not derived quantities.

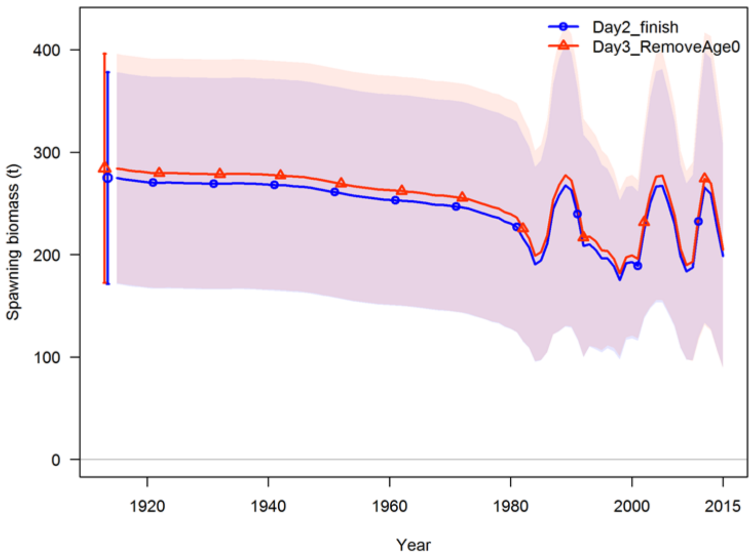
Response: The STAT completed this request (below), noting that different columns in the MRFSS database had integer values during different time periods. The blue line in the figure below shows the results from dropping the MRFSS index (Request 3.1).



Request 3.3: Remove the age-0 fish from the special project, adjust the selection curve for these data to start at age 1, and continue to estimate male parameter values to be equal to female parameter values for the CV young and length at Amin. Maintain the population length bin structure. It would be best to estimate the CV-old parameter value.

Rationale: These changes were examined by the panel and provided a better internal fit to growth using a simpler approach, but estimating all relevant parameters.

Response: The STAT team agreed and provided results from the model run (below), which indicated relatively little effect on the spawning biomass trajectory.



Request 3.4: Use cabezon as a proxy for estimating ageing error. Assume no ageing error for ages 0 and 1, and then ramp to the ageing error for age-3 in the cabezon ageing error matrix.

Rationale: In the absence of ageing imprecision estimates for kelp greenling, this seems a better proxy than lingcod, which were aged using fin rays.

Response: The STAT team agreed and made the necessary changes.

Request 3.5: Filter the commercial logbook index to include three years of good logbook records per permit-holder, rather than 10 years.

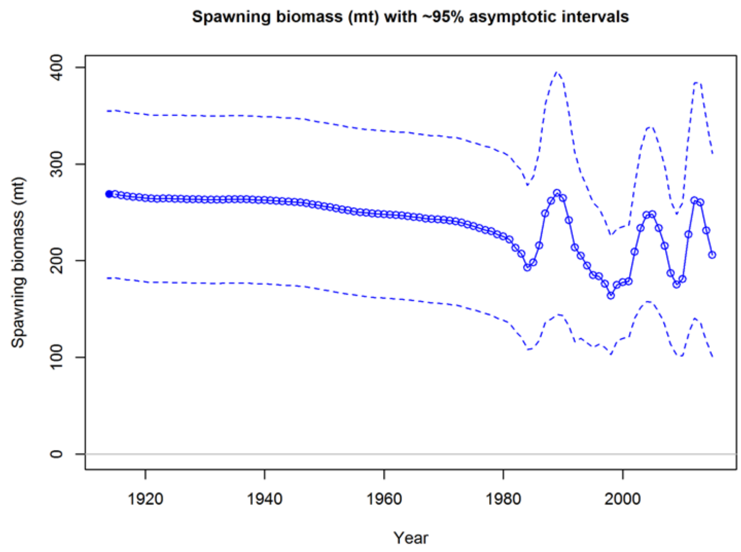
Rationale: This will increase the amount of data and reduce the CV on this index.

Response: The STAT team reran the index analysis with the filtering code set to 3 years. This resulted in reduced CVs and improved standardization-model fit diagnostics.

Request 3.6: Tune the new potential base model by applying harmonic mean weighting and provide diagnostics. If there is a problem with the SS feature that bounds the Input-N values at 1, then adjust the weighting multipliers using the lambda approach.

Rationale: This seems the most appropriate available weighting method for weighting length compositional data that avoids the problem of SS bounding *Input-N* values at 1.

Response: The STAT team tuned the new base model using harmonic mean weights (below). There was not an issue with *Input-N* values being bounded at 1.



Request 3.7: Provide a sensitivity analysis which varies the shore-based and estuary catches using the minimum and maximum catch estimates. If this does not result in adequate contrast in the assessment results, increase the range of catches for these modes.

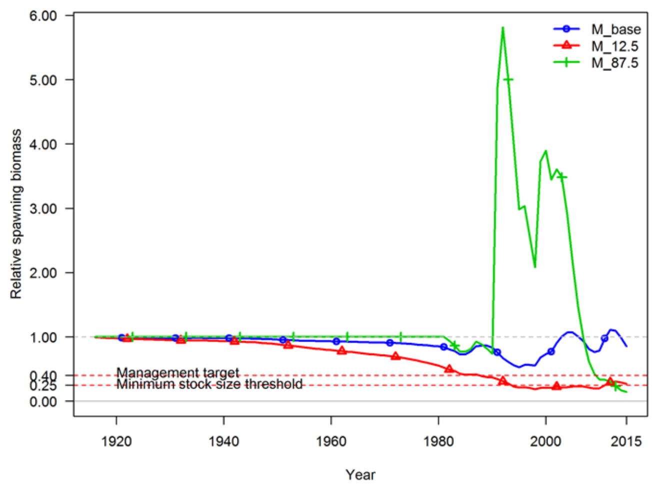
Rationale: Uncertainty in shore-based and estuary catches could be an axis of uncertainty for the decision table.

Response: Given the relative importance and number of the other requests, the STAT team didn't have time to address this request.

Request 3.8: Provide a sensitivity that varies *M* according to the 12.5th and 87.5th percentiles of the prior distributions.

Rationale: This is a candidate for the major axis of uncertainty for the decision table.

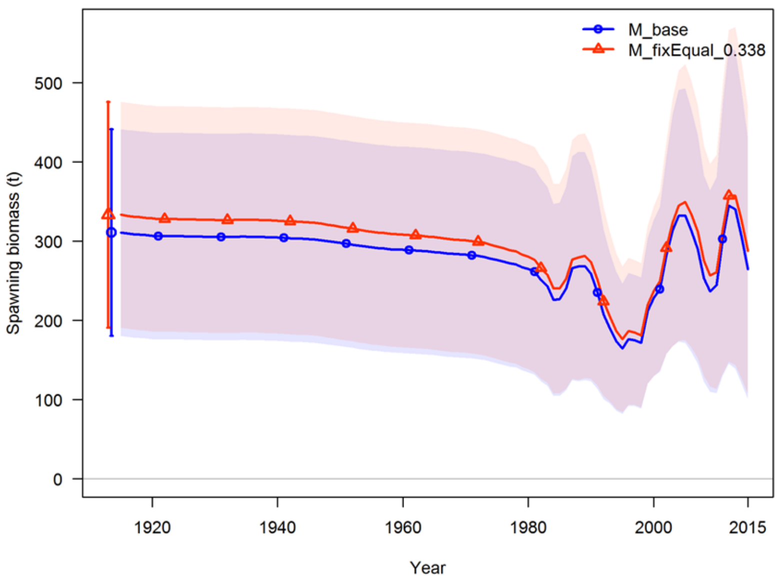
Response: The STAT team provided this sensitivity run as a guide for developing bounds for an axis of uncertainty. The relative spawning biomass trajectory was very sensitive to the value for *M* (below), but it was not clear that the model with high M had converged.



Request 3.9: Provide a sensitivity that uses the same *M* for males and females.

Rationale: This is a more parsimonious model and may improve fits.

Response: The STAT team provided this sensitivity, although based on differences in the likelihood, the model provided a better fit when there were separate *M* values for males and females. The spawning biomass trajectory was relatively insensitive to using the same or sex-specific values for *M* (below).



Requests 1-6 below are for the proposed base model:

Request 4.1: Clean up the MRFSS length comps.as follows: 1980-89 – use only integer values of T_Len; omit 1993; 1994-2002 - use only integer values for LNGTH

Rationale: Removes suspected calculated lengths as opposed to observed lengths.

Response: The STAT team agreed and completed this task acknowledging that this is an acceptable approach given uncertainties that remain in the MRFSS database.

Request 4.2: Maintain the model excluding the MRFSS index.

Rationale: MRFSS catch and effort data appear to not be incorrectly aggregated at the trip level.

Response: The STAT team agreed and maintained this feature in the base model.

Request 4.3: Maintain the model where the age-0 fish from the special project are removed, adjust the corresponding selection curve to start at age 1, and continue to estimate male values to be equal to female values for the *CV-young* and *Length-at-Amin* parameters. Maintain the population length bin structure.

Rationale: These changes were examined by the panel and provided a better internal fit to growth.

Response: The STAT team agreed and maintained this in the new base model.

Request 4.4: Maintain use of cabezon as a proxy for estimating ageing error. Assume zero ageing error for ages 0 and 1, and then ramp linearly to the age-3 value in the cabezon ageing error matrix.

Rationale: This is a better proxy than lingcod, which were aged using fin rays.

Response: The STAT team agreed and maintained this feature in the base model.

Request 4.5: Use the filter of the commercial logbook index where three years of good logbook records per permit-holder are retained, rather than 10 years.

Rationale: This will increase the number of CPUE observations and reduce the CV on this index, and appears to be the best available configuration of this index.

Response: The STAT team agreed and maintained this feature in the base model.

Request 4.6: Tune the new base - apply harmonic mean weighting and provide diagnostics.

Rationale: This seems the most appropriate weighting method we have for weighting length-compositional data.

Response: The STAT team agreed and maintained this feature in the base model.

Request 4.7: If time permits, explore a configuration for the growth curves where male *k* equals female *k* (*L*[*Amax*] would be the only sex-specific parameter; all growth parameters are estimated). Specify male parameters as offsets (parameter offset approach 3 in the control file) to estimate a single growth CV for old and young fish of both sexes.

Rationale: The growth curves were very similar and this model configuration would be more parsimonious.

Response: Based on model fit, it was more parsimonious to have male *k* equal female *k*. *L*[*Amax*] remains the only sex-specific parameter, with all growth parameters being estimated. CV for old and young fish are estimated as a single parameter (using the SS offset flag = 3 as requested).

Request 4.8: Explore a configuration for the major axis of uncertainty for the decision table as follows: use a fixed *M* based on a range of maximum ages (±2 years) for the prior probability distributions for male-*M* and female-*M*.

Rationale: Working directly from the prior for *M* seemed too broad; this request may provide a suitable compromise.

Response: The STAT team completed this as requested and this range of M seems a better reflection of realistic bounds of uncertainty for *M* and is consistent with rough biomass density extrapolations as described in Appendix H of the document.

Request 4.9: Explore the historical catch series uncertainty prior to 1980 and the recent period since 2006 for shore-based and estuary modes using multipliers of 0.5 and 1.5.

Rationale: These catch series are uncertain and this uncertainty may be a candidate for the axis of uncertainty in decision table.

Response: The STAT team completed this as requested, but noted that the requested range for the catch multipliers resulted in new spawning biomass estimates that were well within the error bounds of the base model estimates.

Final Request 1: Using the agreed final base model as specified in requests 4.1 to 4.7, develop a decision table using the *M* contrast as specified in Request 4.8.

Rationale: This provides adequate contrast and is the major axis of uncertainty .

Response: There was insufficient time for the STAT to accomplish this final request during the STAR Panel meeting, but will do so following the meeting.

Final Request 2: Use the following catch streams in the decision table: low catch stream = current OR HG, high catch stream = the 40-10 ACL assuming a sigma of 0.36 (or ending biomass variance if higher) coupled with P* = 0.45. The middle catch stream and the fleet proportions to assume in projections would be based on further deliberations between the STAT and ODFW managers.

Rationale: The low and high catch streams are reasonable bounds given proxy reference points and the current harvest specification framework.

Response: There was insufficient time for the STAT to accomplish this final request during the STAR Panel meeting, but will do so following the meeting.

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

The base model is a single, two-sex population for Oregon coastal waters, with an annual time step covering the period 1915 to 2014. The four fishing fleets are the recreational ocean-boat, estuary-boat, and fishing from shore modes and one commercial fleet, which included a combination of hook-and-line and longline gear types. Data consisted of all commercial and recreational landings, a GLM standardized CPUE abundance index and length-compositions for each fleet, age- and length-compositions from the recreational ocean-boat fleet, and mean-weight for each fleet. Discard mortality rates were used for each fleet to expand total landings to total catch. Conditional age-at-length compositional data were used to estimate growth. The harmonic mean weighting approach was applied to tune the composition data.

The following additional changes were made to the base model during the STAR review:

- The MRFSS length compositions were used as follows: for 1980-89 only integer values of the "T_Len" field were used as original measurements; 1993 was omitted as measurements were inconsistent in this year; for 1994-2002 only integer values for the field "LNGTH" used as original measurements.
- The MRFSS CPUE index was excluded, because the catch and effort data appear to be incorrectly aggregated at the trip level.
- The age-0 fish were removed and the corresponding selection curve was started at age-1.
- The growth parameters for K, the CV of length-at-age, and the length at A_{min} were not estimated separately by sex, so L_∞ is the only sex-specific parameter. The growth CV was estimated as a single parameter (young CV = old CV), shared by both sexes.
- Cabezon replaced lingcod as the proxy species for estimating ageing error. Ageing error was assumed to be 0.0 for ages 0-1 and then ramped linearly to the value for age-3 onwards.

Only catch and effort information from permit holders with three years of good logbook records were retained in the commercial logbook index, rather than the original filtering with 10 years.

The alternative models used to bracket uncertainty were fixed natural mortality based on a range around the separate males and females maximum ages. The range was based on the likely ageing error of ±2 years.

Technical Merits of the Assessment

The STAT worked very hard during this panel to reconcile data and modelling issues identified in the base case model presented to the STAR Panel. The revised base case addressed the major concerns to the degree that they were tractable during the course of the review.

The model makes use of all available data. A wide range of sensitivity analyses explored uncertainty allowing an appropriate axis of uncertainty to be identified.

Technical Deficiencies of the Assessment

The most significant problems were with the data rather than the model. Generally, the data for kelp greenling were not informative for this assessment, with little contrast and much noise throughout.

There were particularly significant problems with the MRFSS data that still need to be resolved. These data are considered important because they cover the longest time period.

Historical and recent catches for the shore-based and estuary fisheries are highly uncertain for kelp greenling and may not provide an accurate estimate of the initial depletion. The method for recent estimation consists of a linear extrapolation, which must be at best a temporary measure pending development of a better method and, preferably, actual sampling of this significant source of removals. The historical estimates are based on license sales and are not based any actual sampling of even aggregate categories of fish landed.

Growth may not be well estimated. There was a lack of small young fish in the samples, and ages were represented by whole numbers, which may not be precise enough for a fast growing species.

The ‘stock’ included in this assessment (Oregon only) does not necessarily correspond to any biologically-based definition.

Ageing error was not based upon kelp greenling, but on cabezon as a proxy species. Estimates of ageing error are required for this species.

Areas of Disagreement Regarding STAR Panel Recommendations

None

Management, Data, or Fishery Issues Raised by the GMT or GAP Representatives During the STAR Panel Meeting

None

Unresolved Problems and Major Uncertainties

The unresolved problems are:

- MRFSS data apparently contain many errors; a cleaned and standardized data set needs to be provided for any stock assessments requiring access to such data.
- Ageing error information for this species was not available.
- The weighting for composition data within the stock assessment can be based on different methods, such as the effective sample size using the harmonic mean or the Francis (2011) methods. For this assessment, the harmonic mean was used. The best way to approach this weighting (if there is a “best” method) remains unresolved for all stocks.

The major uncertainties are:

- Natural mortality is highly uncertain and could not be estimated in the model. The assumed femal and male values were based on observations of maximum age, which are likely imprecise and biased.
- Early catches before 1980 and more recent shore/estuary catches are not well estimated and may be unreliable.

Recommendations for Future Research and Data Collection

Specific recommendations for the next assessment

- Acquire estimates of reader error for kelp greenling through routine double-reading samples of otoliths rather than relying on error estimates for other species, which may not accurately reflect actual read errors for this species.
- Acquire more age-readings, particularly of younger fish caught in the shore based or estuary fisheries, and try to estimate the full set of growth parameters.
- Consider seasons or a shorter time step for the model than a year (e.g., a quarter) or request a modification to Stock Synthesis to allow non-integer growth increments to increase accuracy for the estimated growth rate and error.
- Composition data weighting should start with the number of samples as the effective sample size rather than the number of fish.
- Sample catches from the shore and estuary fisheries so that they can be estimated and characterized.
- Explore starting the model at the historical point where removals become more reliable (e.g., 1970-1980) and estimate initial conditions reflecting prior exploitation such as free numbers at age and an offset to equilibrium recruitment.
- Consider estimating recruitment deviations for the entire time-period of the assessment model.
- Density estimates from visual surveys and other methods could be used to derive a prior for unexploited biomass (perhaps transformed to R_0). This could help with the very poorly estimated scale in the current assessment.
- Future assessments should consider assessing a single stock for Washington, Oregon and California; this analysis could include explicit spatial areas and or state-based fleets as necessary. This was also a specific recommendation of the 2005 STAR panel. Expanding the spatial scale could make the interpretation of steepness based on life history theory more straightforward.
- The next assessment should be an update, given the status and trends. There is no urgency to update the assessment, unless negative trends appear in biological or catch-rate data.

Specific suggestions for the SSC

- Given current estimates of growth and natural mortality, kelp greenling is probably much more productive than an $F_{45\%}$ policy would imply. None of the data series show any signal of depletion. The SSC may wish to consider recommending a different target SPR rate for this species.

General recommendations for nearshore species assessments

- It may be more accurate in some circumstances to consider when historical catch history is so uncertain that the model should be started in a later year with the initial depletion estimated by the model.
- Consider the development of a coastwide fishery-independent survey for nearshore stocks. Any work to commence collection of such a measure for nearshore stocks, or use of existing data to derive such an index would greatly assist with this assessment.
- MRFFS data are difficult to use properly, making quantities derived from it potentially unreliable. Broadly, the MRFSS database needs to be cleaned (e.g., removing derived estimates that are not easily identified as such and that currently appear to be observed ‘data’), better documented, and

made more accessible for future assessment authors. It is important that the work of cleaning and interpreting these data not have to be repeated for each assessment. No further MRFSS data will ever be collected.

- For CPUE abundance indices, further evaluation of the Stephens-MacCall method would be valuable to ensure that the filtering method is robust. For example, the Stephens-MacCall method for filtering logbook records produced anomalous inclusion of the same species as both a positive and negative indicator in similar datasets. Pooling among similar series (e.g., charter boats and private boats from the same areas) to develop the filtering criteria could make this more stable. More generally, a multi-species simulation study to test whether the Stephens-MacCall filtering may lead to a bias in abundance estimates given differences in abundance trends among species should be considered. It is the understanding of the panel that some simulation testing has been done; these results should be made generally available. A comparison of alternative filtering procedures should also be considered.
- Definition and measurement of suitable habitat for nearshore species such as kelp greenling, especially when combined with density estimates, would assist assessments, particularly as an independent indicator of plausible relative scale of modeled virgin biomass by area/region/state.

General recommendations for all assessments

- Whenever age-readings are done, some portion of the effort should routinely include double-reads for estimating ageing error.
- Consider developing an alternative likelihood formulation for compositional data (condition length on age) to make better use of ages to inform on population age structure where a significant proportion of aged fish are within one standard deviation of the asymptotic length. This would be limited to sampling that is random with respect to age or length.

Acknowledgements

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References

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