Petrale Sole

Stock Assessment Review (STAR) Panel Report

Hotel Deca, Seattle, Washington

20-24 June 2011

STAR Panel Members

Yong Chen	Center for Independent Experts (CIE)
Ray Conser (Chair)	NMFS, Southwest Fisheries Science Center PFMC Scientific & Statistical Committee (SSC)
James Ianelli	NMFS, Alaska Fisheries Science Center
Kevin Stokes	Center for Independent Experts (CIE)

Pacific Fishery Management Council (PFMC) Advisors

John DeVore	PFMC Staff
Dan Erickson	PFMC Groundfish Management Team (GMT)
Pete Leipzig	PFMC Groundfish Advisory Subpanel (GAP)

Stock Assessment Team (STAT)

Melissa Haltuch	NMFS, Northwest Fisheries Science Center
Allan Hicks	NMFS, Northwest Fisheries Science Center
Kevin See	University of Washington

Overview

The Petrale Sole STAR Panel (Panel) met in Seattle, Washington during 20-24 June 2011 to review a draft stock assessment of petrale sole (*Eopsetta jordani*) off the U.S. west coast, prepared by the petrale sole stock assessment team (STAT). Dr. Ray Conser (Panel Chair) welcomed participants; reviewed the Pacific Fishery Management Council's (PFMC) *Terms of Reference for the Groundfish Stock Assessment and Review Process*; and discussed the background material and logistics for the Panel meeting. Dr. Kevin Stokes agreed to serve as rapporteur. A list of participants is provided in Appendix 1.

The draft assessment document (including model input and output files) and extensive background material (previous assessments, previous STAR Panel reports, etc.) were provided (via the PFMC FTP site) to the Panel two weeks in advance of the Panel meeting. The FTP site was also used for common access to all presentation material and the additional model runs that were conducted during the course of the Panel meeting.

Dr. Melissa Haltuch led the presentation of the draft assessment document and subsequent analyses carried out during the week. Allan Hicks and Kevin See presented parts of the draft assessment and subsequent analyses.

Petrale sole was last assessed in 2009 using the Stock Synthesis (SS) model. The results from that first U.S. coast-wide stock assessment – in particular, the estimated terminal year depletion ratio of 0.116 (SSB_{2009}/SSB_0) – led to the stock being classified as overfished and the subsequent development of an PFMC rebuilding plan for petrale sole.

The 2011 stock assessment used an updated version of SS with data from the commercial trawl fisheries (landings, discards, and length- and age-compositions); standardized CPUE indices of abundance from the winter trawl fisheries off Washington, Oregon, and California (1987-1997); two indices from the triennial shelf trawl survey (1980-1992 and 1995-2004); the NWFSC shelf/slope trawl survey index (2003-10); and length- and conditional age-at-length compositions from the surveys. As with past stock assessments, linkages with petrale sole in British Columbia (via movement of adults or larval transport) were assumed to be negligible in this assessment. Multiple model runs were conducted and reviewed to examine model assumptions and structure, and to identify uncertainties in the assessment.

Petrale sole stock status – as indicated by the terminal year depletion ratio of 0.180 (SSB_{2011}/SSB_0) from the base model – has improved from that reported in the 2009 assessment. Incorporation of the CPUE data from the winter trawl fisheries into the base case (for the first time) and a strong 2007 recruitment contributed to the more optimistic status of the stock

determination. Various interpretations of the relationship between the winter CPUE indices and the true population exploited biomass constituted a major uncertainty in the assessment (Figure 1), as did the appropriate natural mortality rate for females. The latter formed the basis for states of nature in the management decision table (Table 1).

The Panel concluded that the petrale sole assessment was based on the best available data; the new assessment results constitute the best available information on stock status, and are suitable to serve as the basis for fishery management decisions.

The Panel commends the STAT for their excellent presentations, well-written and complete documentation, their willingness to respond to the Panel's requests for additional analyses, and their dedication in finding possible solutions to difficult assessment problems. The NWFSC and PFMC staffs are thanked for arranging the meeting facilities, hotel accommodations, and the FTP site containing the background materials.

Discussion and Additional Analyses Requested by the STAR Panel

Initially, Panel discussion focused on the key changes incorporated into the 2011 draft assessment base case relative to the last assessment conducted in 2009, namely:

a. all data sources used in the 2009 assessment were updated to include two additional years (2009-2010), and minor changes to earlier years were incorporated in order to reflect data base corrections;
b. significant changes throughout most of the time series of Oregon landings were incorporated based on the newly available reconstruction of historical Oregon landings;
c. all fisheries data were assigned to "fishing years" (beginning on November 1st) and further into "winter" and "summer" seasons within each fishing year;
d. the latest update of the Stock Synthesis model (v 3.21d) was used with an annual (fishing year) time step and winter/summer seasons, as described above;
e. discard ratios were estimated in SS rather than estimating the discarded biomass directly;
f. age compositions for each fleet were assigned to the specific agency that had carried out the ageing work; new age error analyses were incorporated using the results from triple reads and Inter-Lab comparisons (CAP and WDFW); and
g. priors were used for both natural mortality rate (M) and spawner-recruit steepness (h).

Then based on the background documents, the material presented, and the ensuing discussions, the Panel initiated an iterative process of (i) making requests of the STAT for additional information and analyses, (ii) reviewing the results of same (usually the next day),

and (iii) making additional follow-up requests of the STAT. This process continued throughout the course of the meeting with results of the final requests being presented to the Panel during the morning of the last meeting day. The goal of this process was to achieve an agreed base case and to fully characterize the uncertainty about the base case results. The next section describes each request as well as the rationale for the request and the results of the analysis conducted by the STAT.

STAR Panel Requests

1) **Review Canadian petrale sole biomass estimates and stock status from the recent 2009 Canadian stock assessment.**

Rationale Canadian and U.S. catches of petrale sole are continuous across the border and the stock(s) are likely related or common. Linkages with petrale sole in British Columbia (via movement of adults or larval transport) may be important for proper understanding of the U.S. assessment results, e.g. in the interpretation of spawner-recruit steepness when estimated using only U.S. data.

Results A variety of figures and bullet points were provided that summarized recent Canadian stock assessment findings. These were provided in a consolidated presentation including catch histories relative to U.S. catches, age compositions (by sex), and recruitment patterns. Canadian landings averaged around 3,000 mt annually from the late 1940s to late 1950s and assessments suggest the stock was at a low level during the 1980s and 1990s. The Canadian fisheries appear to have taken larger and older fish than U.S. fisheries, including throughout the low stock period of the 1980s and 1990s. There is no information on ageing error in Canada but the methods used for otolith reading are more likely to underestimate than overestimate ages. It is therefore considered highly likely that the Canadian catches do have a higher representation of older fish. Survey data in Canadian waters is limited and assessments are dependent on commercial CPUE. The general stock patterns, including recruitment, in Canadian and U.S. waters appear consistent, suggesting the stock(s) are likely continuous.

2) **Provide plots of the maturity ogive and the priors on the natural mortality rate (M) and spawner-recruit steepness (h).**

Rationale These plots were not part of the draft assessment document.

Results The plots were presented to the Panel.

3) **Provide a presentation on the meta-analysis supporting the prior on the natural mortality rate used in the assessment.**

Rationale The meta-analysis work on natural mortality has yet to be published. The Panel needed more information regarding this supporting analysis.

Results Dr. Owen Hamel presented a detailed description of the background theory and methods used for developing the prior.

4) **Provide a description of the bomb radiocarbon U.S. west coast reference curve and ageing error work for petrale sole as referred to in the assessment document and presentation.**

Rationale The bomb calibration work has yet to be published. The Panel needed more information regarding the analysis.

Results A draft manuscript by Haltuch et al. was provided via the PFMC FTP site for the Panel's review (*A California current bomb radiocarbon reference chronology and petrale sole age validation*).

5) **Re-examine the Pikitch discard estimates used in the draft assessment document. In particular, include the winter fishery.**

Rationale The Pikitch discard estimates used in the draft assessment were annual summer estimates for 1985-87 as estimated by Sampson et al. (1999). Dan Erickson (GMT Advisor) provided an analysis of the Pikitch data averaged over the 1985-1987 time period for both the winter and summer petrale sole fisheries.

Results The discard rates provided by Erickson were preferable, mainly because they covered the winter fisheries. These data were incorporated in all subsequent runs.

6) **Provide a run in which the Triennial Survey size and age composition samples are downweighted.**

Rationale All model runs in the draft assessment document (base case and sensitivity runs) exhibited a lack of fit to the Triennial Survey – particularly in the early years. The composition sample sizes were large. It would be informative to know if there is a conflict between the index and the compositions and more importantly, whether the index could be better fit without the influence of the composition data.

Results Even with the composition samples downweighted significantly, the lack of fit to the index persisted.

7) Compare spatial extent of NWFSC Survey area and areas covered by the fishing grounds identified in the CPUE analysis.

Rationale This request was a follow-up from the previous request. The intent was to compare the NWFSC survey coverage and fisheries distributions to check on the stability of petrale sole distributions and potential biases in survey indices.

Response: The relative spatial coverage of surveys and fisheries were presented. The Panel asked for more detailed annual maps of survey stations and fishing distributions. Maps showing survey stations and fishing effort for 2003-2008 for the entire U.S. west coast were subsequently presented and discussed. The spatial extent of the survey appeared to cover the fishing grounds adequately, including the fishing grounds hotspots in most years. There was agreement that the survey was likely unbiased for petrale sole.

8) Provide a run with growth parameters fixed at the values from the 2009 stock assessment.

Rationale The growth parameter estimates (especially k) from the base case in the draft assessment document were quite different than the parameters estimated in the 2009 assessment. This run could serve as a bridge from the 2009 assessment.

Results The bottom line results (e.g. depletion) did not differ greatly but the base model with the new growth estimates fit much better – even after accounting for the additional parameters that were estimated.

9) Plot unfiltered winter and summer CPUE data for the 80%, 90% and 100% selection criteria used in defining the petrale sole fishing grounds for use in standardizing CPUE.

Rationale To check on potential sensitivity of CPUE indices to selection criteria, especially for the winter CPUE series.

Results Graphs were provided as requested. As expected, there is little effect of filtering on the summer CPUE or the spatial extent of the area covered. For the winter CPUE area definitions, however, a major difference was seen in moving from 100% to 90% filtering (i.e. removing areas representing the lowest 10% of catch rates) – a process that seemed reasonable for defining petrale habitat. Additional filtering (80%) made little difference.

10) Provide spatial plots of unfiltered effort data by year for the winter fisheries.

Rationale: To check for stability of fishing effort and possible fishery/population hotspots (spawning aggregations that the winter fishery targets). More generally, to consider the potential utility of the winter CPUE indices as credible indices of abundance and to help guide

possible requests for assessment runs investigating the relationship between winter CPUE and abundance.

Response and Resultant Discussion: Summary graphs showing aggregated data (for confidentiality reasons) were provided not only for the winter fisheries, as requested, but for the summer fisheries as well.

The Panel was initially concerned because the winter fisheries are on spawning aggregations and the resulting CPUE could be hyper-stable. However, the standardized CPUE indices all display considerable range with continuous rather than abrupt changes. Examination of the plots suggested that the spatial foot print of the fishing effort was stable and not expanding or contracting spatially in response to abundance changes. It was further noted that compared to the summer fisheries, management measures have had a lesser effect on the timing and intensity of the winter fisheries. The Panel suggested that the winter CPUE might be useful for indexing abundance and requested some exploratory runs (see Request 11, below)

With respect to the summer CPUE indices, the Panel considered and rejected inclusion of the summer CPUE in the base case model due to considerable management change affecting trawl efforts on the continental shelf. The trawl Rockfish Conservation Area (RCA) was first implemented at the end of 2002, which significantly affected the distribution of trawl effort targeting petrale sole and other species occurring on the continental shelf during the summer season. There have been both seasonal changes of RCA boundaries and periodic closures within certain latitude boundaries (e.g., north of Cape Alava at 48°10' N. latitude to the U.S.-Canada border starting in 2007) that could potentially affect the usefulness of a summer CPUE time series as an index of relative abundance. Further and perhaps more importantly with respect to CPUE standardization, there have been significant seasonal trawl trip limit adjustments of target shelf species in the summer in an effort to reduce trawl bycatch of the overfished shelf rockfish species, such as canary rockfish, during this time period. The Panel concluded that it would be very difficult to effectively standardize the summer CPUE indices to properly account for these management actions.

11) Provide exploratory runs that incorporate the CPUE from the winter fisheries as indices of abundance.

Rationale: As outlined above, the winter CPUE indices warranted further investigation.

Response: A linear relationship between the Washington, Oregon, and California winter CPUE indices and exploitable biomass was assumed. Overall model fits were good but the predicted exploitable biomass time series was not nearly as dynamic as the CPUE indices. There appeared to be no tendency for hyper-stability in the indices. However, the recent-year increases in the spawning biomass estimates from SS –particularly the 2011 estimate – were

less than credible. Further, the estimated M from this SS run was considerably greater than M estimates previously estimated and used in petrale sole assessments.

12) Explore the use of a nonlinear relationship between the winter CPUE indices and exploitable biomass.

Rationale: From the trial runs, the relationship may be nonlinear. While no hyper-stability was evident, hyper-depletion may warrant further investigation.

Response: In Stock Synthesis, the general relationship between CPUE and biomass (B) is $CPUE=qB^{(\beta+1)}$ When $\beta=0$, the relationship is linear; when $\beta<0$, CPUE is hyper-stable; and when $\beta>0$, CPUE exhibits hyper-depletion. Three runs were made with β fixed at 0, 0.5 and 1.0, respectively. In a fourth run, β was estimated for each on the three indices (WA, OR, and CA). When β was estimated, the fit was significantly better than when the parameter was fixed at $\beta=0$. No patterns in the residuals were evident. The estimated β was approximately 1.5 for the WA and OR CPUE and approximately 0.8 for the CA CPUE. Further, the spawning biomass estimates in recent years and the estimate M were much more reasonable than when β was fixed at $\beta=0$.

The Panel suggested that the winter CPUE indices (with β estimated) could be used in the base model pending the resolution of other issues addressed in the requests, below.

13) Provide aggregated fits to compositions by gear across years for the initial candidate base model run

Rationale: Examination of gear specific fits to the composition data is a useful modelling diagnostic for model misspecification.

Response: Graphs were provided for all fleets and surveys for both length and age compositions. The Panel noted the generally poor fits to the length compositions, particularly to discard data for both males and females. Also of note was that the fits to the Triennial Survey suggested males were generally underestimated and females overestimated. Consideration of age composition fits suggested potential utility in combining Washington and Oregon fleets. It was noted that the data for the states could not be combined at this stage but that one possibility would be to fit a combined selectivity for the two fisheries. The STAT suggested that some of the misfitting was driven by model estimates of large standard deviation (sd) in length at the older ages but the raw data from the ageing work showed constant sd over all ages. It was suggested that for subsequent model runs, sd in length at age be held constant over all ages.

14) Provide a model run with the sd in length at age held constant.

Rationale: This was a follow-up from the previous request.

Response and Resultant Discussion: The constant sd in length at age alleviated many of the issues outline in the previous request. However, poor fits to the size compositions in the early years persisted. The possibility of changes in growth over time was suggested as a potential reason for the misfit in the early years. Plots of mean length at age by year were then presented. There were no apparent trends or step changes in mean length at age. The Panel and STAT discussed possible further analyses on growth but decided there was no evidence for changes in growth to justify trying to model and fit them. Finally, the STAT noted that some of the size bins for large fish had very few observations and may be introducing artifacts in the model fits.

15) Explore options within Stock Synthesis for dealing with the small number of observations in the size bins for large fish, e.g. dynamic binning, modification of the robustification constant, etc.

Rationale: This was a follow-up from the previous request.

Response and Resultant Discussion: The STAT conducted a comprehensive examination of this issue resulting in a large number of SS runs for the Panel to consider. The dynamic binning option in SS did not improve the fits because in addition to the few observations in the size bins for the largest fish, there were also a significant number of zeros in bins smaller that the largest. Dynamic binning large enough to encompass the zeros would have resulted in large truncation of the size range and a loss of many observations. Stepwise increases in the SS robustification constant from the value used in the base model (0.0001) to 0.01 was a more productive exercise. The fits could be improved but the bottom line results (e.g. depletion) were sensitive to the constant, especially when it was set at 0.01 – a value that *ex post facto* was too large given the data. It was suggested that the process for selecting the appropriate constant should be data driven, and that a reasonable rule of thumb might be to use the lowest observed proportion in the size compositions, namely 0.001. All subsequent runs were made using this robustification constant.

16) Re-examine the use of the newly available Oregon catch reconstruction as the basis of the landings time series for petrale sole.

Rationale: The GAP advisor pointed out that when compared to the landings time series used in the 2009 assessment, there appeared to be some inconsistencies and possible double counting of Oregon landings.

Response and Resultant Discussion: The STAT re-examined the issue and concurred. While the two time series (i.e. 2009 assessment and this assessment) were quite similar through the mid-

1980s, important differences were found in some of the ensuing years. Part of the discrepancy lies with the differing strata used to reconstruct the Oregon landings and the strata employed in the assessment. The former used calendar years and allocated landings between Oregon and Washington based on the port of landing; while the latter used fishing years (November through October) and allocated landings by area fished. Reconciling these differences was beyond the scope of what could be done during the Panel meeting. The STAT and the Panel agreed that for this assessment, the 2009 assessment landings time series (OR and WA) should be used through the terminal year of the 2009 assessment (2008), with updates for 2009-2010.

17) Produce a likelihood profile on the natural mortality rate for females (M).

Rationale: The series of SS runs made prior to and during the Panel meeting indicated that the model results were sensitive to M.

Response and Resultant Discussion: The likelihood profile was produced. The STAT and the Panel agreed that the profile could be used for defining states of nature for a petrale sole decision table with M=0.16 yr^{-1} representing the central tendency (*Pr* = 0.50); M=0.13 representing a more pessimistic state of nature (*Pr* = 0.25); and M=0.19 representing a more optimistic state of nature (*Pr* = 0.25).

Description of base model and alternative models used to bracket uncertainty

The final base model assumes a U.S. coast-wide stock and uses catch data split by sex, state, and winter and summer seasons. The catch history starts in 1876. The model estimates separate selectivity curves for each of the commercial fleets (state and season) in the periods 1876 to 1972, 1973-1982, 1983-1992, 1993-2002, and 2003-2008. The NWFSC survey and the Triennial survey data are used to develop indices of abundance (the latter survey is split in 1995 to form two time series). The model also fits to winter standardized CPUE indices by state (WA, OR, and CA) assuming a non-linear relationship to U.S. coast-wide abundance. A Beverton-Holt stock recruitment relationship is assumed. Length compositions and conditional age-at-length data from the surveys are fit; while length and age compositions (appropriately weighted) are fit for the commercial fleets. Agency specific ageing is used for the surveys and fleets. Discard ratios are estimated. New priors are used for natural mortality and steepness.

The current assessment and the 2009 assessment provide similar biomass and depletion trajectories, with overlapping confidence intervals and similar estimates during the 1980-2000 period. The 2009 assessment suggested that recent decadal biomass generally increased through 2005, then declined afterwards. The current assessment confirms this general pattern. Since the last assessment, the management reference points for flatfish have changed. The

current assessment suggests that the stock was below the MSST (12.5% of SSB_0) from about 1980 to 2003 but has since increased and is currently 18% of SSB_0 .

The various interpretations of the relationship between the winter fishery CPUE indices and the true population exploited biomass constituted a major uncertainty in the assessment (Figure 1), as did the appropriate natural mortality rate for females. The latter formed the basis for states of nature in the management decision table (Table 1) since it was possible to objectively assign probabilities to the three states of nature (M=0.13, M=0.16, and M=0.19) through use of the likelihood profile on M (see discussion under Request 17, above). Although the Panel and STAT were unable to objectively assign probabilities to the three CPUE interpretations, it should be noted that some of the results of management interest (including terminal year depletion) exhibited a broader range of uncertainty across the three CPUE interpretations than the corresponding uncertainty range across M (see Figure 1 and the discussion under Request 12, above).

Comments on the technical merits of the assessment

The petrale sole stock assessment was carried out in a highly professional manner. The draft document was complete, well written, and distributed to the Panel well in advance of its meeting. The presentations prepared by the STAT were clear, comprehensive, and supplemented the written document quite well. While there were no major flaws in the draft analyses, the Panel made numerous requests of the STAT in order to better understand the analyses and the underlying data and ultimately, to improve the assessment. The STAT responded admirably to all of the Panel's requests, and incorporated the agreed suggestions into a new base case.

The Panel concluded that the petrale sole stock assessment was based on the best available data, the new assessment results 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.

Unresolved 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 modelling. But the overarching unresolved problem / major uncertainty that most greatly affects scientific interpretation of the assessment results is the stock structure issue. The U.S. petrale sole "stock," as modeled in the assessment, is almost certainly shared to some important degree with Canada. Yet Canadian catches and other important information from the Canadian fisheries and surveys are not considered. While resolution of this issue is beyond the scope of what can be reasonably expected from the STAT, it is critical for the credibility of the management system to establish a formal framework and to conduct petrale sole assessments (and perhaps other transboundary stocks) jointly with Canada.

Concerns raised by the GMT and GAP advisors during the meeting

As discussed in the Requests, above, the GMT advisor raised concern regarding the use of the discard data for petrale sole from the Pikitch studies (see Request 5, above); and the GAP advisor had concerns regarding the use of the newly available Oregon reconstructed catch time series (see Request 16, above). In both cases, the modelling and base case development were altered to accommodate these concerns. The Panel and STAT were greatly appreciative of these interventions by the advisors as they very much improved the stock assessment.

Research Recommendations

Expand the stock assessment area to include Canadian waters to cover the entire biological range of petrale sole (see more complete discussion of this recommendation under the *Unresolved Problems and Major Uncertainties* section, above).

Conduct a formal review of all historical catch reconstructions and if possible stratify by month and area. The mixing of U.S. and Canadian catches is of particular concern for the Washington fleet.

Discard estimates from the WCGOP should be documented, presented and, reviewed (similar to catch reconstructions) outside of the STAR panel process. The reviewed WCGOP data should then be made available to the assessment process.

Consider combining Washington and Oregon fleets in future assessments within a coastwide model.

The petrale sole maturity and fecundity information is dated and should be updated.

As noted by the previous STAR Panel, the current assessment platform (SS3) is structurally complex, making it difficult to understand how individual data elements are affecting outcomes. The Panel recommends, where possible, investigating simpler, less structured models, including statistical catch/length models, to compare and contrast results as data and assumptions are changed.

The length binning structure in the stock assessment should be evaluated, including tail compression fitting options.

The residual patterns in the age-conditioned, length compositions from the surveys should be investigated and the potential for including time-varying growth, selectivity changes, or other possible solutions should be examined.

Management strategy evaluation is recommended to examine the likely performance of new flatfish control rules.

Table 1. Decision table of 12-year projections for alternate states of nature (columns) and management options (rows) beginning in 2011. Relative probabilities of each state of nature are based on low and high values for the rate of female natural mortality.

			State of nature					
			Female M=0.13		Base case Female M estimated = 0.16		Female M=0.19	
Relative probability			0.25		0.5		0.25	
Management decision	Year	Catch (mt)	Depletion	Spawning biomass (mt)	Depletion	Spawning biomass (mt)	Depletion	Spawning biomass (mt)
25-5 catches from base case	2013	2,766	24.1%	7,085	28.0%	7,361	32.6%	7,689
	2014	2,831	25.7%	7,547	29.6%	7,791	34.1%	8,039
	2015	2,799	25.9%	7,614	29.7%	7,803	33.7%	7,942
	2016	2,725	25.5%	7,481	29.0%	7,614	32.4%	7,653
	2017	2,603	24.9%	7,304	28.2%	7,403	31.3%	7,372
	2018	2,653	24.4%	7,184	27.6%	7,248	30.6%	7,212
	2019	2,575	24.0%	7,048	27.3%	7,165	30.1%	7,095
	2020	2,565	23.7%	6,975	27.2%	7,135	30.0%	7,073
	2021	2,563	23.6%	6,922	27.1%	7,133	30.0%	7,083
	2022	2,564	23.4%	6,878	27.2%	7,141	30.1%	7,099

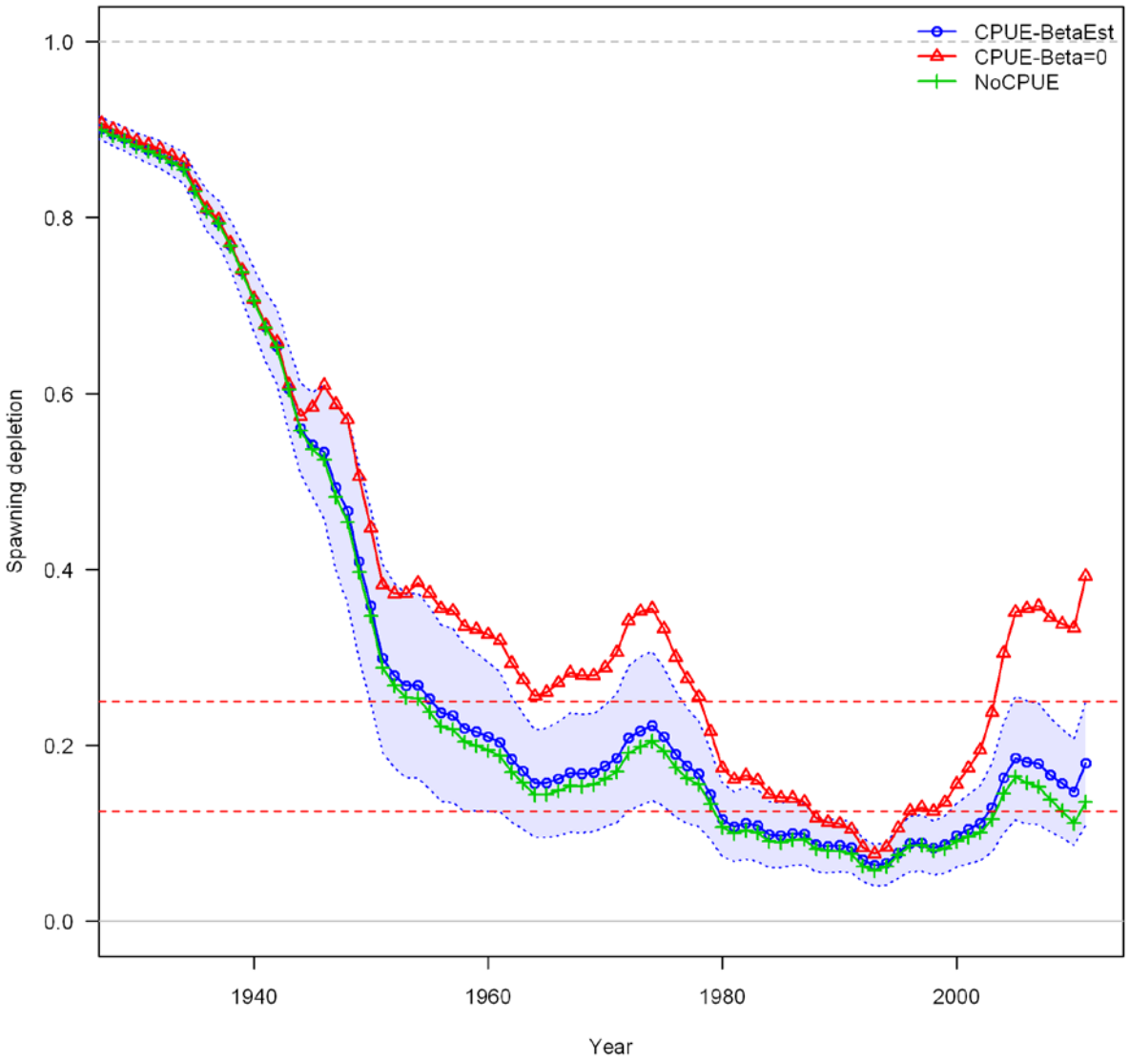

Figure 1. Spawning biomass depletion under three interpretations of the relationship between the winter CPUE indices and the true population exploited biomass, i.e. (i) no relationship – CPUE not used (NoCPUE); (ii) a linear relationship (CPUE-Beta=0), and (iii) a nonlinear relationship with beta estimated (CPUE-BetaEst). The nonlinear relationship with beta estimated was used as the base case. The shaded band represents a 95% confidence interval about the base case.

Appendix 1. List of Participants

STAR Panel Members

Yong Chen	Center for Independent Experts (CIE)
Ray Conser (Chair)	NMFS, Southwest Fisheries Science Center PFMC Scientific & Statistical Committee (SSC)
James Ianelli	NMFS, Alaska Fisheries Science Center
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Melissa Haltuch	NMFS, Northwest Fisheries Science Center
Allan Hicks	NMFS, Northwest Fisheries Science Center
Kevin See	University of Washington

Others in Attendance

Jim Hastie	NWFSC
Stacey Miller	NWFSC
Jason Cope	NWFSC
Martin Dorn	AFSC
Chantel Wetzel	NWFSC
Brad Pettinger	
Corey Niles	WDFW
Colby Brady	

Appendix 2. List of acronyms and other terms used in this report

ABC	Allowable Biological Catch
AFSC	Alaska Fisheries Science Center
CAP	Cooperative Ageing Program
CDFG	California Department of Fish and Game
CIE	Center for Independent Experts
CPFV	Commercial passenger fishing vessel
CPUE	Catch per unit effort
CRFS	California Recreational Fisheries Survey
CV	Coefficient of variation
GAP	Groundfish advisory subpanel
GLM	Generalized linear model
GMT	Groundfish management team
h	Steepness of the spawner-recruit relationship
M	Natural Mortality rate
MSST	Minimum Spawning Stock Threshold
NMFS	National Marine Fisheries Service
NWFSC	Northwest Fisheries Science Center
ODFW	Oregon Department of Fisheries and Wildlife
OFL	Overfishing limit
Panel	Shorthand for the Stock Assessment Review Panel
SS	Stock Synthesis (model)
SSB	Spawning stock biomass
SSB_0	Spawning stock biomass in the absence of fishing
SSC	Scientific and Statistical Committee (of the Pacific Fishery Management Council)
STAR	Stock Assessment Review
STAT	Stock Assessment Team
SWFSC	Southwest Fisheries Science Center
WDFW	Washington Department of Fish and Wildlife