2009 petrale sole stock assessment addendum: SSC requests

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This document addresses the requests made on July 8 after the SSC review of the petrale assessment at the June 2009 PFMC meeting. The SSC requests were prepared under two general headers (1) Parameter confounding and (2) Use of model-based BMSY vs. the Council proxy for management advice with multiple deliverables under each heading. This document is structured by the deliverables requested with a note showing which main SSC request contained each deliverable.

1. **MCMC results for the base model and sensitivity model run with the steepness prior** SSC (1 & 2)

There were some bugs in Stock Synthesis with regard to the treatment of the recruitment deviations when conducting MCMC that were completely resolved on August 10. Due to a power shut down August 15-16 at the Montlake Lab the correct set of MCMC model runs for the petrale assessment were not started until August 17 and are currently running. These results are not included in this document but will be presented to the SSC groundfish subcommittee meeting during August 31 to September 2.

Specific items requested include:
Provide bi-variate plots of MCMC draws of NWFSC q, natural mortality, and stock recruit parameter of steepness and Rzero.
Characterize uncertainty in B_0, B_{MSY}, F_{MSY}, stock depletion, and $B_{40\%}$.
Use the asymptotic STdevs and the MCMC output
Annual SS3 SSB estimates and their variances from MCMC output.

2. Comparison of US and Canadian landings and size/age composition data
SSC (1)

The recent Canadian stock assessments of petrale sole (Fargo and Starr 2004, Fargo 2006) both suggest that Canadian landings of petrale sole in the B.C. trawl fishery averaged around 3000 mt annually between the late 1940s and the late 1950s. U.S. trawlers fishing in Canadian waters also landed substantial amounts of petrale sole during this period. However, the landings time series in these assessment models begins during 1956 (2004) and 1966 (2006), and do not include the peak removals of petrale sole in B.C. that occurred during the 1940's and early 1950's. The landings data from the Canadian stock assessments are available only in summarized form. Landings from 1966 to 1978 are summarized based on the calendar year while 1979-2006 are based on a fishing year beginning on April 1 and ending on March 31. The monthly Canadian landings data were requested in mid-July but are not available at this time. The lack of monthly landings data results in a mismatch between the seasonal structure of the US fleets in the US petrale sole stock assessment and the available Canadian landings data. To use the Canadian landings in the US petrale sole stock assessment the yearly Canadian data were allocated to the winter and summer fleets based on the seasonal proportions of catches from the Washington fleet.

While the Canadian assessments do not include the peak fishery removals during the 1940s and early 1950s both assessments note that by the mid-1960s landings had decreased (Figure 1) and petrale sole abundance had declined substantially (Ketchen and Forrester 1966). Both Canadian assessments concur that the petrale stock was at low abundance during the 1980s and 1990s and a TAC of 497 mt was established for this species in 1997 (Fargo and Starr 2004, Starr 2006). The TAC has increased to 600 mt in recent years (Star 2006).

The WDFW provided internal documents by Alverson and Chatwin (1957) that have area specific information on historical petrale sole landings in Canadian waters from 1938-1955. These landings are of the same order of magnitude suggested by the two previous Canadian petrale sole stock assessments, except for the peak catches in 1948 at around 6200 mt, which is coincident with the period of peak landings recorded in the US. A second grey literature document from WDFW (Anon. 1956) records landings from the period 1942-1949 of similar magnitude but the landings in this document are not used due to a lack of area specific information (it is not possible to separate US and Canadian catches from Canadian waters) and the shorter time series. Alverson and Chatwin (1957) also report results from petrale sole tagging experiments that record petrale sole moving as much as 350 miles. Since petrale sole are known to have the ability to move such long distances all landings in Canadian waters (PSMFC areas 3C, 3D, 5A, 5B, 5C, 5D, and 5E), with the exception of those from the Strait of Georgia, are included in the Canadian landings history used as a sensitivity model run in the US petrale sole stock assessment. In summary the Canadian landings data are taken from the following sources:

1. 1938-1955 Alverson and Chatwin (1957)
2. 1956-1978 2004 assessment
3. 1979-2009 2006 assessment
4. 2006-2008 assumed equal to TAC of 600 mt

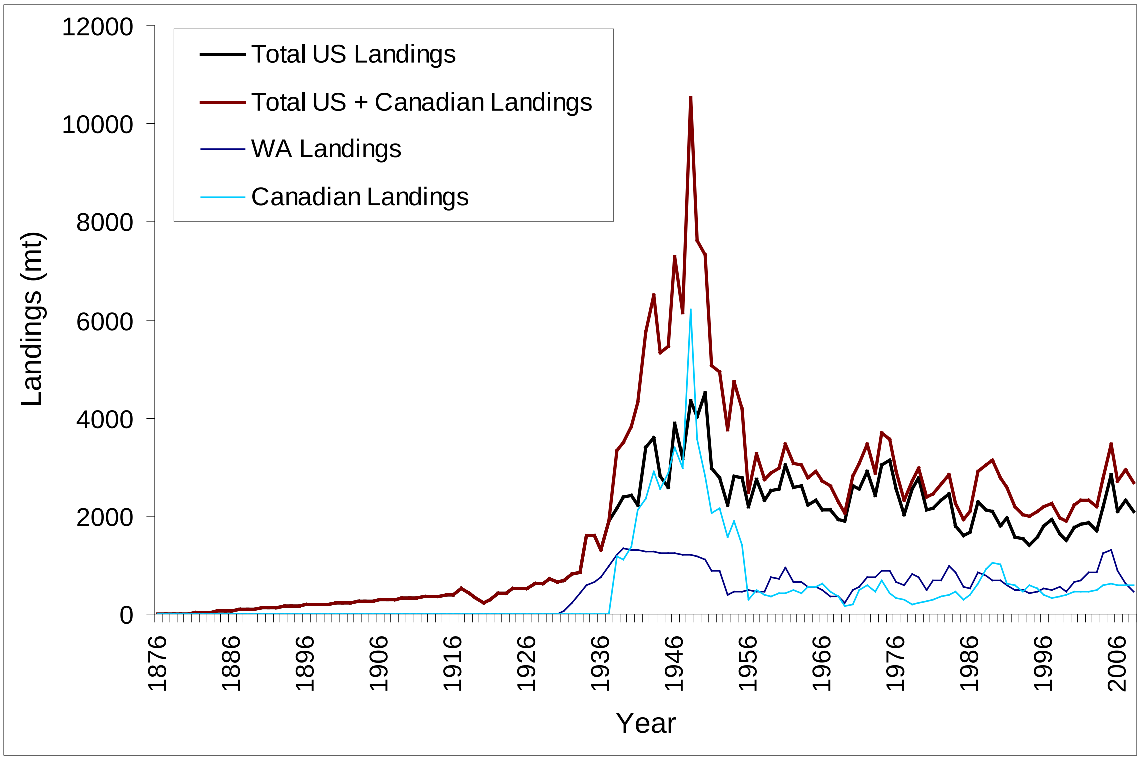

Figure 1. Landings of petrale sole from Washington, Canada, total US, and combined US and Canadian waters.

The two previous Canadian stock assessments used delay difference models due to sparse fishery data with low sample sizes and spatially limited research samples from the early 2000s that are not representative of the stock (Fargo and Starr 2004, Starr 2006). However, we received the raw Canadian age- and length-composition data on August 10 and present these data. The age and length compositions discussed below are expanded by the total weight for each sample but are not expanded by the total catch for each area. Where data are sparse the compositions are presented annually using the fishing year (November – October) as described in the 2009 petrale sole assessment. The data presented seasonally use the same seasons as the 2009 petrale sole stock assessment.

Petrale sole begin to be observed in both the Canadian and Washington petrale sole fisheries around 4 years old, although the Washington fishery has more frequent observations of 2 and 3 year old fish (Figures 2-3). However, the maximum ages observed in the Canadian commercial data are greater than the ages from the Washington commercial data (Figures 2-3). Male petrale sole aged greater than 20 years are routinely present in the Canadian commercial age data whereas the Washington fishery rarely takes male petrale sole older than 10 years. Similarly female petrale sole aged greater than 20 years, and up to 40 years, are commonly observed in the Canadian fishery, while female petrale sole taken in the Washington fishery are rarely older than 15 years. The marked difference in ages between petrale sole observed in the commercial fisheries in US and Canadian waters suggest a more lightly exploited stock in Canada.

Comparisons between the US and Canadian commercial length-composition data suggest that both fisheries start to routinely take petrale sole around 30 cm (Figures 4-5). The Canadian fishery observations generally take larger petrale sole (males 50 cm, females 65 cm) compared to the US fishery (males 45 cm, females 55 cm) (Figures 4-5).

Canadian age data from research samples are very sparse and do not cover the full range of the stock. It is also difficult to compare the US survey data and Canadian research samples since these samples do not cover the same period of time (Figure 6-7). Therefore we do not try to draw conclusions from these data. The same patterns persist between the US and Canadian length-composition data from survey/research samples as those described above for the commercial samples (Figure 8-9).

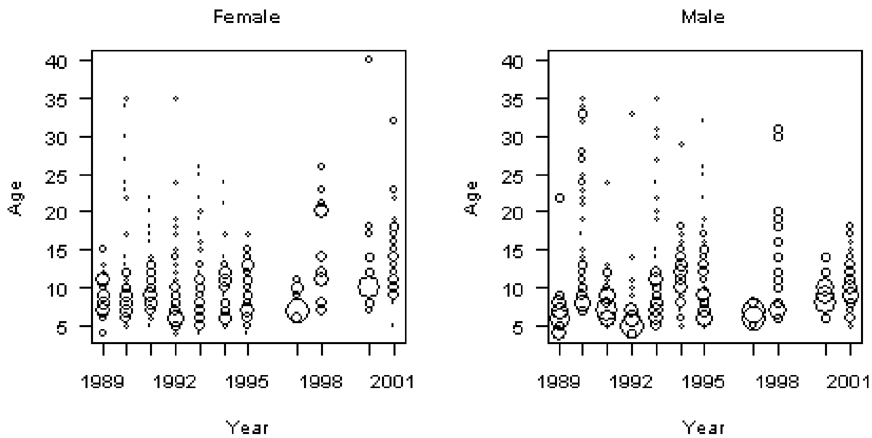

Figure 2. Canadian petrale sole commercial age compositions, observed ages range from 4 to 40.

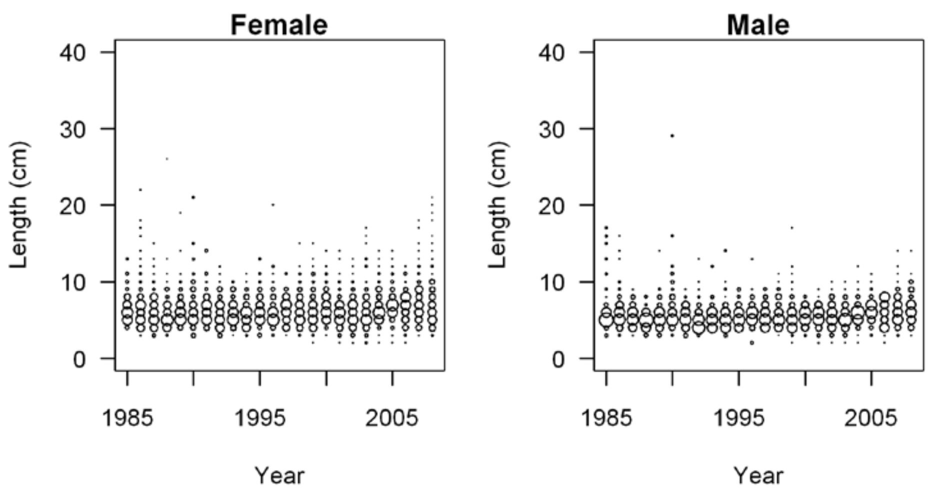

Figure 3a. Age-frequency data by gender for the Washington fleets for 1985 -2008.

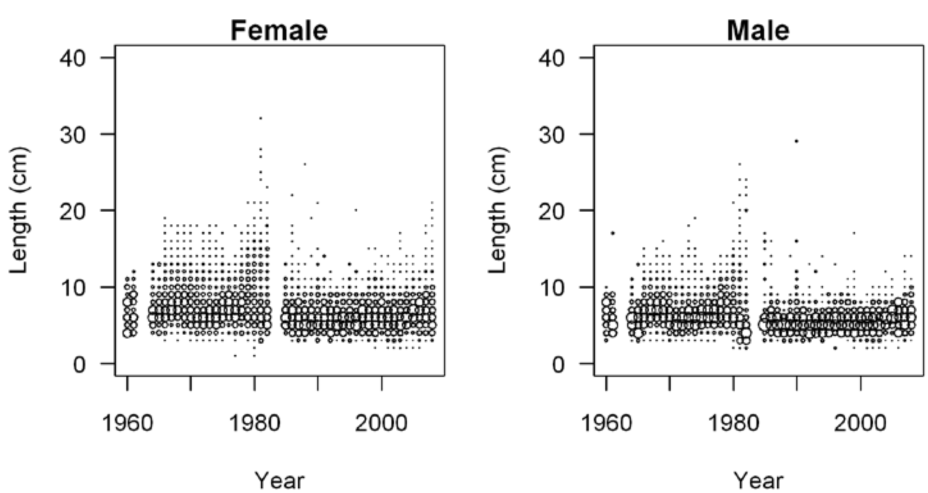

Figure 3b. Age-frequency data by gender for the Washington fleets for all years with data.

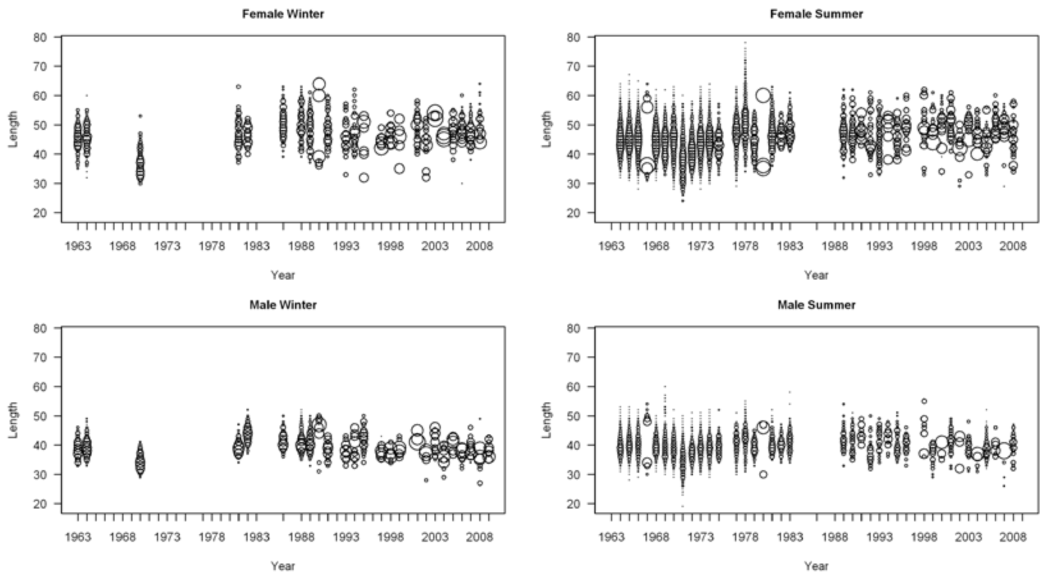

Figure 4. Canadian petrale sole commercial length compositions, observed lengths range from 19 to 82 cm.

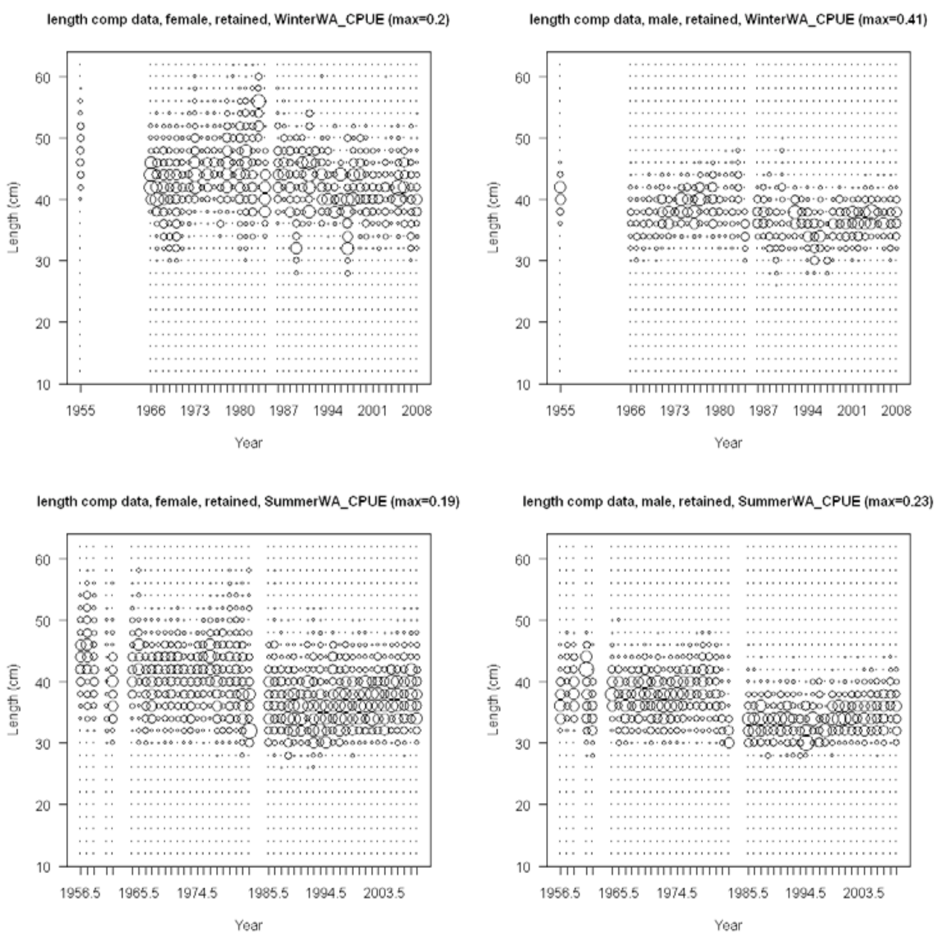

Figure 5. Length-frequency data by gender and season for the Washington fleets (Figure 30 from the 2009 stock assessment).

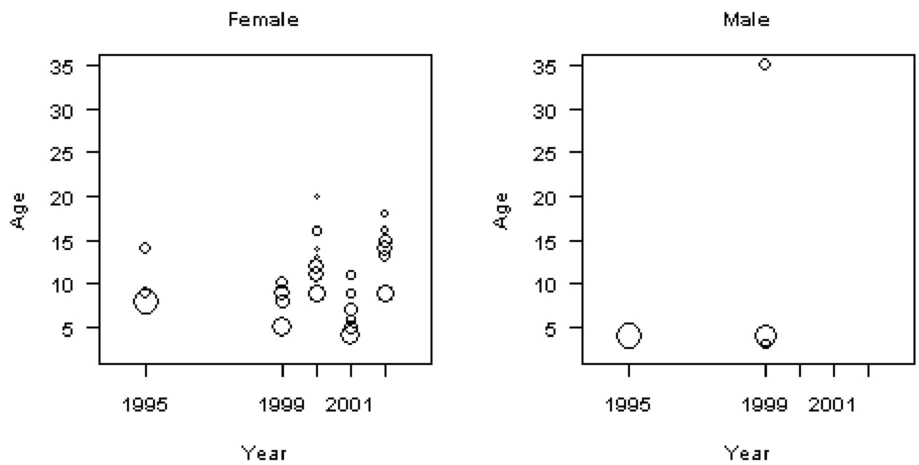

Figure 6. Canadian petrale sole research age compositions, observed ages range between 2 and 35 years.

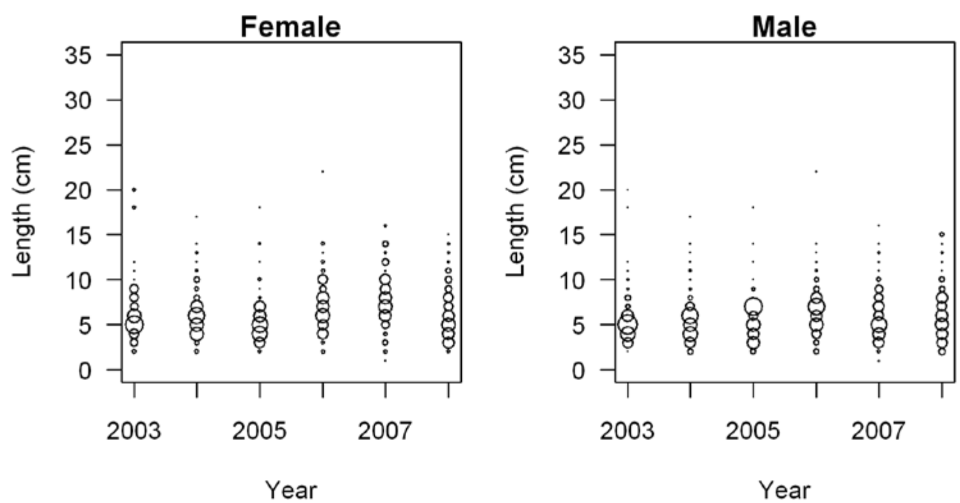

Figure 7. Age frequencies from the Vancouver and Columbia NWFSC survey.

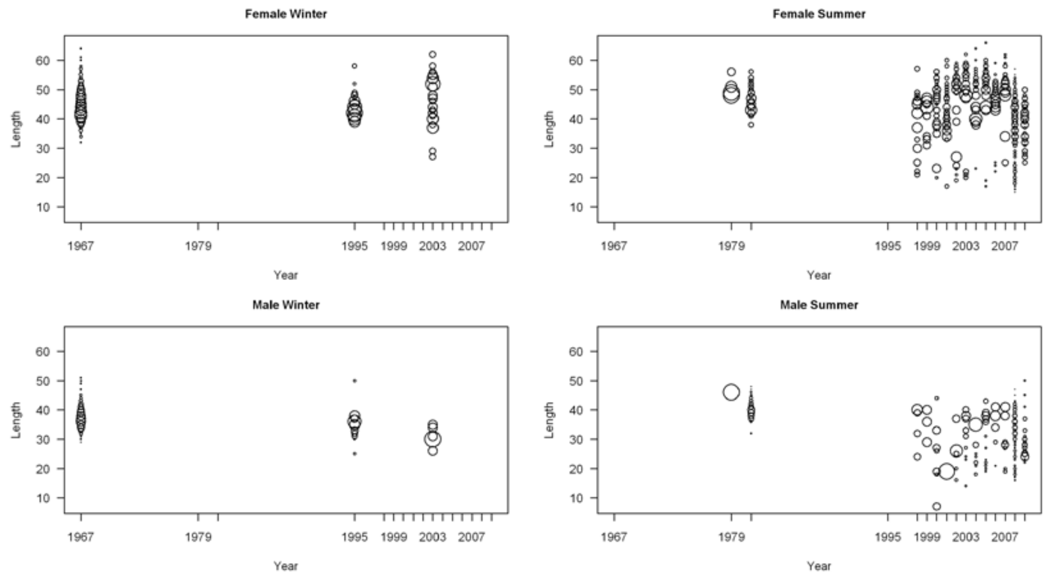

Figure 8. Canadian petrale sole research length compositions, observed lengths range between 7 and 65 cm.

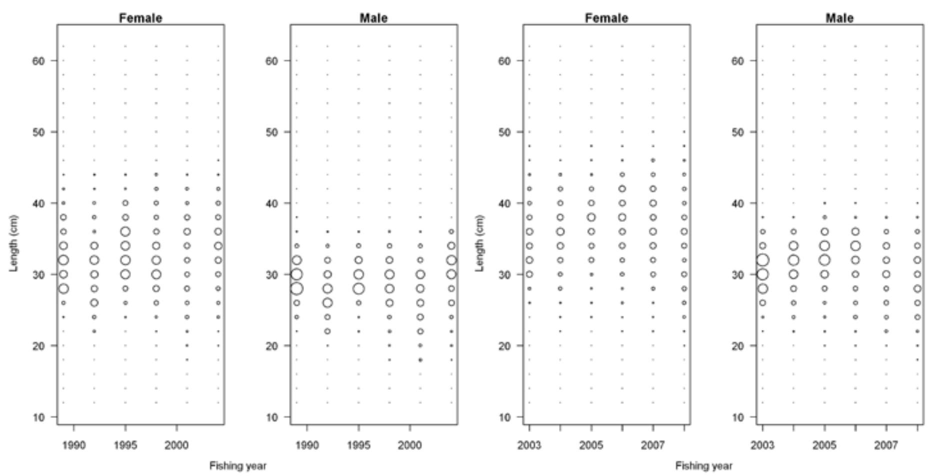

Figure 9. Plots of length frequencies from the triennial survey (left panels) and NWFSC survey (right panels) (Figures 18 and 9 from the 2009 stock assessment).

3. **Model sensitivity with Canadian data** (SSC 1)

The Canadian landings are included in the base model using multiple methods. The first method adds the Canadian landings directly to the Washington landings. Method 1 was not successful, the model was poorly behaved, took about 10 hours to run, and clearly did not converge. The second method includes the Canadian landings as catches from a separate fleet and then mirrors the Canadian fleet retention and selectivity to the Washington fleet. Similarly to method 1, method 2 was poorly behaved, did not converge, and took a very long time to run. Both of these methods implicitly assume that the Canadian 'fleet' shares the same characteristics as the Washington fleet. This assumption is less than satisfactory for the following reasons:

1. In order to correctly remove the catch from the population (to estimate selectivity) the model needs length and/or age data from the catch. Furthermore, the time blocking on selectivity is based upon management actions that affected the behavior of the US fleets and does not necessarily impact the Canadian fleet, particularly since 1977.
2. In order to account for discarding the model needs estimates of discard rates from the Canadian fleet as well as length and/or age compositions of the discard (to estimate retention. While discard practices may have been more similar in the pre1977 fisheries more recent regulations have likely impacted discard practices in the Canadian fleet.
3. The survey indices that are currently in the model are spatially inconstant with the area covered by the Canadian fleet in the model. To do this properly requires a survey index from Canadian waters.
4. The NWFSC survey is the main source of information for estimating growth in the assessment model. However the survey does not extend into Canadian waters so the growth must be assumed to be the same between the US and Canada, which may not necessarily the case.
5. While the Canadian ages are break and burn reads and likely to have low levels of bias and imprecision it is unclear what, if any, information exists to estimate the correct ageing error bias and imprecision associated with the age data for inclusion in the model.

A third method for including the Canadian catches allowed the free estimation of selectivity curves for the Canadian fleet, did not estimate a retention curve, and did not use the time blocks that were used for the Washington fleets. This model also failed to converge and had extremely long run times. The results from these model sensitivity runs are not presented under deliverable 4 since there were obvious problems with lack of convergence.

Given the points above and the multitude of problems with including only the Canadian catches in the model the STAT feels that it is necessary to include all of the appropriate Canadian data to evaluate the impact of the Canadian fleet on the petrale sole population ranging from B.C. to California. This is a substantial undertaking that would result in an essentially new assessment for petrale sole. A joint US-Canadian assessment will require buy-in from staff at the Canadian Department of Fisheries and Oceans since considerable collaborative effort between US and Canadian stock assessors will be needed to complete a joint assessment. The management implications of such an assessment should also be considered prior to such an undertaking.

4. **Model sensitivity runs** SSC (1)
    a. steepness prior of Pleuronectids in Meyers (1999), mean = 0.794, standard deviation = 0.093.
    b. a more informative prior on female M, mean 0.2, standard deviation 0.0125
    c. Canadian landings (not included, see point 3)

The full comparison of the requested model sensitivities with the base case model is shown in Table 1 below. The model sensitivity with the Meyers (1999) pleuronectid prior on h has a marginally higher negative log likelihood but essentially fits the data equally well. The estimate of h decreased from 0.95 to 0.91 and the estimate of M increased from 0.15 to 0.17. The unfished biomass decreased and the current biomass increased to produce a final stock status of 13% depletion rather than 12% depletion (Figure 10). The model sensitivity with a more restrictive prior on M has a worse fit to the data. This model produces a higher estimate for female M (0.18) and a lower estimate of h (0.86). The unfished biomass decreased and the current biomass increased to produce a final stock status of 14% depletion rather than 12% depletion (Figure 10). It is notable that the depletion relative to the estimated Bmsy remains the same across both the h and M model sensitivity runs (Table 1).

Table 1. Model sensitivity runs.

Description	baseMay08	baseMay08-priorSteepness	baseMay08-strongMprior
Nparameters	182	182	182
Gradient	0.0025	0.00024	0.00024
Negative log-likelihoods			
Total	3075.82	3076.81	3104.83
Indices	-25.16	-25.14	-25.08
Length-frequency data	1178.07	1179.32	1211.77
Age-frequency data	1925.71	1925.19	1919.67
Discard biomass	97.04	96.99	98.39
Discard mean weight	-71	-71	-71.16
Recruitment	-30.88	-30.11	-29.78
Priors	1.974	1.508	0.944
Forecast recruitment	0.012	0.008	0.006
Select parameters			
Stock-recruit, productivity			
R_0	9.52	9.72	9.9
Steepness (*h*)	0.95	0.91	0.86
Recruitment Variability (out)	0.33	0.33	0.33
Female M	0.15	0.17	0.18
Male M offset	0.11	0.11	0.1
Survey catchability & selectivity			
Triennial survey catchability (*q*) early	0.26	0.25	0.24
Triennial survey catchability (*q*) late	0.36	0.35	0.34
NWFSC survey catchability (*q*)	3.07	2.98	2.86
Individual growth			
Female length at age min	17.25	17.22	17.14
Female length at age max	52.68	52.66	52.61
Female von Bertalanffy *K*	0.16	0.16	0.16
Female SD of length-at-age min	2.83	2.83	2.83
Female SD of length-at-age max	0.16	0.17	0.16
Male length at age min	-0.03	-0.03	-0.03
Male length at Linf	-0.24	-0.24	-0.24
Male von Bertalanffy *K*	0.62	0.61	0.6
Male SD of length-at-age at age min	-0.32	-0.31	-0.3
Male SD of length-at-age at age max	0.59	0.59	0.55
Management quantities			
Spawning Biomass	25334	23700	22870
2009 Spawning biomass	2938	3011	3135
2009 Depletion	0.12	0.13	0.14
2009 1-*SPR*	0.9	0.88	0.86
2008 instantaneous fishing mortality	0.29	0.28	0.27
SSB MSY	4796	4938	5157
1-SPR MSY	0.8	0.77	0.74
F MSY	0.23	0.22	0.21
2009 Depletion Relative to SSB MSY	0.61	0.61	0.61
MSY Catch	2376	2393	2425

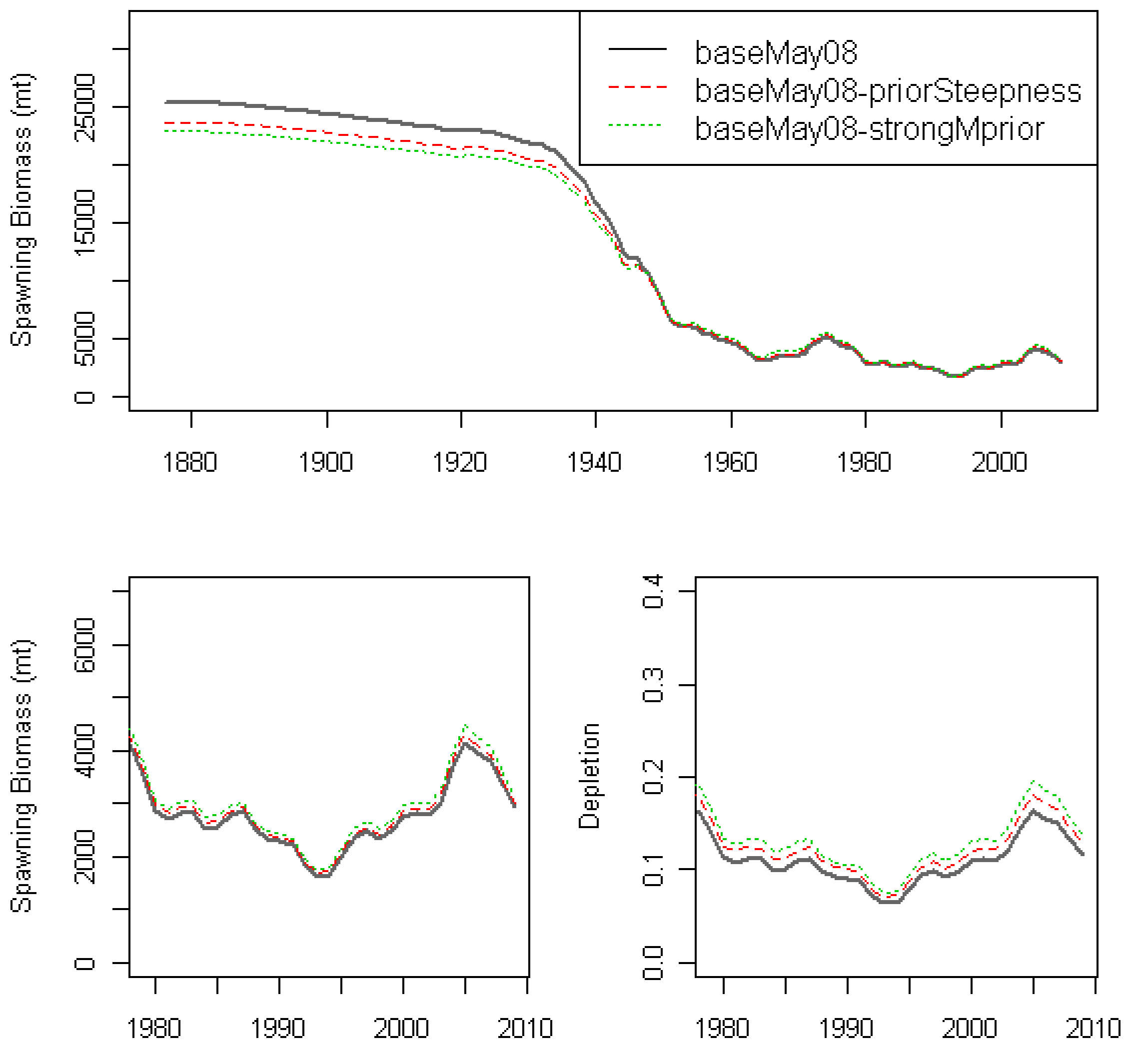

Figure 10. Time series of spawning biomass and stock depletion (as a function on unfished biomass) for the base model and model sensitivity runs.

5. **Sensitivity of Bmsy to selectivity patterns and the distribution of catch among fleets** SSC (2)

The original SSC request was to examine the impact of selectivity patterns on the estimates of the MSY spawning biomass. However, the STAT feels that the distribution of catch between fleets, particularly as the fishery shifted from the summer to the winter season, is potentially more important than changes in selectivity. The intent was to present results for both changing selectivity and catches between fleets. Unfortunately the STAT discovered a bug in the SS forecast report for seasonal models shortly before this meeting. The program is not changing the selectivity patterns, regardless of the choice of years specified for averaging selectivity over in the forecast.SS file. The program does correctly use the distribution of catches between fleets provided in the forecast.SS file. Therefore, the STAT provides a set of MSY reference points for six scenarios, whereby all of the catch is taken by each fleet in turn. The STAT feels that this will provide some information on the range of plausible MSY reference points.

The results are presented for MSY based management quantities for the average catches between fleets during each of the selectivity time blocks as well as for all catches being taken evenly between either the summer or winter fleets given the 2003-2008 selectivity patterns (Table 2a). The results of each of the six petrale sole fleets taking all of the catch given the 2003-2008 selectivity patterns are shown in Table 2b. These scenarios are meant to bound the range of potential values for the reference points. Table 3 shows the management quantities from the base model for comparison. When the catches are taken only during the summer and winter the MSY reference points are more variable (Tables 2a and 2b). The estimates of MSY spawning biomass range between a low of 4,277 mt and a high of 5,010 mt when all of the catch is taken by an individual fleet (Tables 2a and 2b). The current base model estimate is 4,796 mt (Table 3). The stock depletion as a fraction of the estimate Bmsy is ranges between 57%-69% (Tables 2a and 2b). Depending upon the distribution of catches between fleets the MSY catches range between 2,148 and 2,740 mt.

Table 2a. MSY based biological reference points from the 2009 petrale sole stock assessment base case model considering the time blocks on fishery selectivity as well as the distribution of catches between fleets.
**Only the distribution of catches between fleets, not selectivity patterns, are changing in this table due to the SS bug discussed above.

Distribution of Catches Between Fleets	Reference Point	Time/Selectivity Block** 1973-1982	1983-1992	1993-2002	2003-2008
All Summer	SSB MSY				4444
	1-SPR MSY				0.8
	F MSY				0.22
	2009 %Bmsy				0.66
	Tot MSY catch				2204
	Ret MSY catch				2101
	Disc MSY catch				103
Average F for each selectivity block	SSB MSY	4696	4812	4815	4840
	1-SPR MSY	0.8	0.8	0.8	0.8
	F MSY	0.22	0.23	0.23	0.23
	2009 %Bmsy	0.63	0.61	0.61	0.61
	Tot MSY catch	2297	2370	2373	2379
	Ret MSY catch	2205	2310	2314	2313
	Disc MSY catch	92	60	59	66
All Winter	SSB MSY				4848
	1-SPR MSY				0.8
	F MSY				0.24
	2009 %Bmsy				0.61
	Tot MSY catch				2498
	Ret MSY catch				2493
	Disc MSY catch				5

Table 2b. MSY based biological reference points from the 2009 petrale sole stock assessment base case model considering the total catch is taken by each fleet.

Reference Point	WA-winter	WA summer	OR winter	OR summer	CA winter	CA summer
SSB MSY	5010	4657	4380	4400	4919	4277
1-SPR MSY	0.79	0.81	0.82	0.82	0.80	0.82
F MSY	0.25	0.23	0.25	0.22	0.23	0.22
2009 %Bmsy	0.57	0.63	0.67	0.67	0.60	0.69
Tot MSY catch	2740	2300	2486	2148	2410	2185
Ret MSY catch	2731	2115	2484	2039	2405	2153
Disc MSY catch	9	185	2	109	5	32

Table 3. Management quantities from the 2009 petrale sole stock assessment base model.

	baseMay08
SB0	25334
2009 SpBio	2938
2009 Depl	0.12
2009 1-SPR	0.9
2008 instant F	0.29212
SSB MSY	4796
1-SPR MSY	0.8
F MSY	0.23
2009 %Bmsy	0.61
Tot MSY catch	2376
Ret MSY catch	2337

6. **State the case for using either revised proxy reference points or species specific estimates of Bmsy from the assessment model** SSC (2)

The STAR panel review report and the 2009 petrale sole stock assessment provide results regarding the reliability of the estimated reference points presented in the 2009 petrale sole stock assessment. The choice of approached for quantifying reference points, either the current 40% Bmsy proxy, the estimate of Bmsy, or some revised proxy based on a value such as Bmsy/B0, should be independent of the acceptance of the assessment. Below, the STAT summarizes the STAR report, assessment results, and further investigations requested after the June 2009 SSC meeting regarding the reliability of the Bmsy estimates from the 2009 petrale sole stock assessment that can inform this management choice.

- The STAR panel notes that annual catches since 1951 have been fluctuating around the estimated MSY. The MSY-based reference points from the 2009 assessment suggest that the spawning biomass has largely been between the estimated Bmsy and 50% Bmsy, since about 1958 with the exception of a few years above B_{MSY} during the mid-1970s, and a series of years below B_{MSY} between the late 1980s to mid-late 1990s.
- The estimates of Bmsy as a fraction of B0 from recent flatfish assessments on the west coast that report Bmsy, petrale sole, English sole, and arrowtooth flounder, are consistently around 20% B0. The estimated Bmsy reported in the 2005 Dover sole assessment is roughly 25% of B0. These are much less than the proxy management target of 40% B0. Flatfish generally have higher natural mortality, grow faster, and mature earlier than many rockfish, making them more productive, which is illustrated by the typical estimates of 20-25% of B0 for flatfish assessments.
- The choice of an assumed stock-recruitment relationship is uncertain in the petrale sole assessment. While there are theoretical reasons to expect a Ricker stock-recruitment relationship, there is insufficient evidence to choose between Ricker and Beverton-and-Holt, and the panel defaulted to the more commonly used B&H relationship. Choosing a Ricker relationship, however, would result in a lower B_0 estimate and thus a higher ratio of $B_{CURRENT}$ to B_0. The difference in perception between the two assumptions is smaller if MSY based reference points are used. Therefore, the panel recommended that reference points based on MSY are investigated as an alternative MSST.
- Both the current and 2005 assessments agree that the stock declined below the B40% reference point during the 1950s to an all time minimum stock size during the early 1990s, followed by increases in the stock up to 2005. The current flatfish proxy reference points (40% B0 and 25% B0) suggest the stock has been below the current overfished threshold since the 1950s and that catches in excess of F40% have been occurring for nearly this entire time period. However, the petrale sole stock is productive enough to have maintained stable catches over the past approximately 50 years and has shown

large recruitments at low stock sizes, resulting in increases in abundance since the early 1990s.

Literature

Alverson, D.L., and Chatwin, B.M. (1957) Results from tagging experiment on a spawning stock of petrale sole (Eopsetta jordani). Washington Department of Fish and Wildlife grey literature.

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Fargo J. and Starr, P.J. 2004. Petrale sole stock assessment for 2003 and recommendations for management in 2004. Canadian Scientific Advisory Secretariat Research Document 2004/036. Canadian Groundfish Research and Conversation Society, Nanaimo, B.C., Canada and Department of Fisheries and Oceans Canada, Nanaimo, B.C., Canada

Starr, P.J. 2006. Draft Petrale sole (*Eopsetta jordani*) in British Columbia, Canada: Stock assessment for 2006-2007 and advice to managers for 2007-2008. PSARC Working Paper G2007-01. Canadian Groundfish Research and Conversation Society, Nanaimo, B.C., Canada.