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Rebuilding analysis for widow rockfish in 2007 – An update

Xi He[1], Andre Punt[2,] Alec D. MacCall[1], and Stephen Ralston[1]

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[1]National Marine Fisheries Service
Southwest Fisheries Science Center
Fisheries Ecology Division
110 Shaffer Road
Santa Cruz, CA 95060

[2]School of Aquatic and Fishery Sciences
Box 355020
University of Washington
Seattle, WA 98195-5020

Introduction

In 1998, the PFMC adopted Amendment 11 of the Groundfish Management Plan, which established a minimum stock size threshold of 25% of unfished spawning potential. Based on the stock assessment in 2000 (Williams et al. 2000), widow rockfish was formally declared to be overfished in 2001, thereby requiring the development of a rebuilding plan. The 2003 stock assessment (He et al. 2003b) estimated that the spawning output in 2002 was just below 25% of unfished spawning output. However, in recent stock assessment (He et al. 2005, He et al. 2007), the assessment models estimated that the population has never been overfished. This rebuilding analysis is an update analysis based on this year's assessment. It provides information needed to develop the Rebuilding Plan for widow rockfish, and is in accord with the SSC Terms of Reference for Groundfish Rebuilding Analyses.

It is important to point out that although the widow population was declared to be overfished in 2001 (Williams et al. 2000), recent assessments (He et al. 2006a and He et al. 2007) have indicated that the population was never overfished. Depletion rates (ratio of current spawning output over virgin spawning output) in 2001 were estimated to be 31.6% in the 2005 assessment and 35.5% in the current assessment, respectively. Therefore, some rebuilding results presented in the report, such as rebuilding time and Pmax calculations, are solely based on the 2001 population status. These results are more for reference purposes to previous rebuilding analysis since no information on the population from 2002 to 2006 were considered in the analysis. Rebuilding results that use all information up to 2006 are also presented in this report, which are more appropriate as management references.

Data and Parameters

This rebuilding analysis uses the SSC Default Rebuilding Analysis program as implemented by Punt (2006) (Version 2.10a, December 2006). Historical estimates of spawning output and recruitment are taken from the 2007 assessment by He et al. (2007). Life history parameters and selectivity are based on a simplification of the two-area, two-sex, four-fishery selectivity model used in the assessment. The rebuilding analyses are based on a coastwide population. However, fecundity- and weight-at-age differ between the southern and northern areas. Therefore, spatially-averaged fecundity- and weight-at-age, based on a weighting factor computed from the total catches for two areas from the last seven years, are used in the rebuilding analysis. The age-specific selectivity pattern is calculated by averaging selectivity functions for four fisheries, using weighting factors computed from the total catches by each fishery over the last five years. Fecundity-at-age, weight-at-age and selectivity-at-age are presented in Figures 1 and 2. These functions are very similar to those used in the previous rebuilding analysis for widow rockfish (MacCall and Punt 2001, He et al. 2003a, He et al. 2006a). In this analysis, we calculate depletion rates using the same method as in the 2003 rebuilding analysis (He et al. 2003), and in the 2005 assessment and 2005 rebuilding analysis (He et al 2006a, He et al 2006b), which used the average of spawning outputs from 1958 to 1982 as unfished spawning output ($\boldsymbol{B_0}$).

Management Reference Points

***B_{MSY}*:** The rebuilding target is the spawning output that produces MSY, B_{MSY}. B_{MSY} cannot be determined easily, but experience in other fisheries has shown that B_{MSY} is often near 40% of the average initial unfished spawning output (B_0), and this value ($B_{40\%}$) is used here as a proxy for B_{MSY} (see the SSC's Terms of Reference). Values of B_0 are estimated by multiplying mean recruitment by the spawning output-per-recruit at F=0. As in the previous rebuilding analysis, the average recruitment used when computing B_0 was based on the pre-fishery recruitments (the 1958-79 year-classes). The following table shows the current population status from current (2007) stock assessment, and the population status estimated in the 2005 base model stock assessment.

Estimated parameter	Value (2007)	Value (2005)
Estimated B_0 (millions of eggs)	50,746	49,676
Rebuilding target (millions of eggs)	20,298	19,870
Current spawning output (millions of eggs)	17,999	15,444
Percent of B_t/B_0 (depletion rate)	35.47%	31.09%

Mean generation time: If the stock cannot be rebuilt within ten years, then the maximum time allowed for rebuilding, T_{max}, is the length of time required to rebuild at F=0 (T_{min}) plus one mean generation time. Mean generation time can be estimated from the net maternity function (product of survivorship and fecundity at age), and for widow rockfish is estimated to be 17 years, which is same as in the 2005 rebuilding analysis (He et al. 2006b).

Simulation Model

The simulation model tracks numbers at age, with age 20 being treated as a plus-group. Fecundity-, weight-, and selectivity-at-age are given in Appendix A and plotted in Figures 1 and 2. When computing $T_{\min}$, the population simulations begin with the age-structure at the start of 2001 because 2001 was the year in which widow rockfish was declared to be overfished. The 2006 age-structure was used for estimating the population status for 2007 and beyond at each proposed catch level. The detailed specifications of the simulation model are given by Punt (2006).

Initial test runs were conducted to determine the number of simulations needed to achieve stable outputs. The test was conducted using the base model from the stock assessment with 500, 1,000, 2,000, 3,000, 5,000, and 10,000 simulations. The results showed that the outputs did not change much with increasing numbers of simulations once the number of simulations reached 2,000. To be conservative, all of the model runs in this rebuilding analysis are based on 5,000 simulations.

Eleven simulation scenarios were constructed from a combination of starting year, future catch level, and pre-determined fishing mortalities and recovery year (Table 1). In all simulations, the stock-recruitment relationship estimated in the assessment model was used for generating future recruitments. Detail specifications of all eleven runs (Run0 to Run10) are listed in Table 1. Run 7 to Run10 were requested runs by the October 2007 Mop-up Panel. For Run0, starting year is 2001 (year declared overfished). This run (Run0) is mainly for comparing rebuilding parameters that were used in the 2005 rebuilding analysis (Table 2). Since no

information on the population and fisheries is used in Run0, the results are not useful in determining future catch levels.

Run1 to Run6 use pre-determined future annual catch levels ranged from no catch to 4000mt. Run 7 to Run10 are based current SPR rates, Ttarget, and ABC level.

Rebuilding Projections

The rebuilding projections used $B_{40\%}$ as the rebuilding targets. Table 3a lists proposed future catch level and estimated exploitable biomass for six rebuilding runs (Run1 to Run6) from 2009 to 2018 (also see Figure 3). In all runs, the population is estimated to recover to 40% of pre-fishing biomass by 2009 with the probability of recovery of 1.0. Estimated average SPR rates and fishing mortalities are also presented. The estimated biomass is the highest for Run1, which simulates no fishing after 2007. All runs except Run6 show that the population will be able to sustain above the target biomass during the period (Figure 4). Run6 shows that the population will fall below the target biomass in 2015, and continues to decline in the following years.

These runs are probably very optimistic, given that the population was declared to be overfished just six years ago. The main reasons for this are probably related to the fact that (1) there have been relative low catches in the last few years, and (2) the relative strong recruitment of 1999 year class has grown to spawning class and they will remain in the population for next few years (see this year's assessment document, He et al. 2007, for more discussions). Uncertainty in the assessment as well as in these rebuilding projections still remain as all projections depend on the estimated current population status and future recruitments.

Addition four runs (Run 7 to Run 10) were requested during the Mop-up Panel in October 2007. Corresponding annual catches (mt) for these four runs are plotted in Figure 5. Run 7 and Run8, that uses current SPR rates and have future catch levels ranged from 311 mt to 522 mt, shows that the population will be above the target level in all future years (Figure 6). Run 9 uses fishing mortality that corresponding to 50% probability of rebuilding by 1015 (Ttarget year). This run yields very high catch levels in the near future. However, the population will not be able to sustain above the target level (Figure 6). Run 10 uses fishing mortality at ABC level of F50%. It has the highest catches among all runs. However, the population will fell below the target level after 2011 (Figure 6).

References

He, X., A. Punt, A. D. MacCall, and S. Ralston. 2003a. Rebuilding analysis for widow rockfish in 2003. Status of the Pacific coast grounfish fishery through 2003, stock assessment and fishery evaluation, Volume 1. Pacific Fisheries Management Council, August 2003.

He, X., A. D. MacCall, S. V. Ralston, D. E. Pearson, and E.J. Dick. 2003b. Status of the widow rockfish resource in 2003. Status of the Pacific coast grounfish fishery through 2003, stock assessment and fishery evaluation, Volume 1. Pacific Fisheries Management Council, August 2003.

He, X., S.V. Ralston, A.D. MacCall, D.E. Pearson, and E.J. Dick. 2006a. Status of the widow rockfish resource in 2005. Status of the Pacific coast groundfish fishery through 2003, stock assessment and fishery evaluation, Volume III. Pacific Fisheries Management Council, April 2006.

He, X., A. Punt, A.D. MacCall, and S. Ralston. 2006a. Rebuilding analysis for widow rockfish in 2005. Status of the Pacific Coast Groundfish Fishery through 2005, Stock Assessment and Fishery Evaluation: Stock Assessments and Rebuilding Analyses (Volumes III). Pacific Fisheries Management Council, April 2006.

He, X., D.E. Person, E.J. Dick, J.C. Field, S.V. Ralston, and A.D. MacCall. 2006b. Status of the widow rockfish resource in 2005. Status of the Pacific coast groundfish fishery through 2003, stock assessment and fishery evaluation, Volume III. Pacific Fisheries Management Council, April 2006.

He, X., D.E. Person, E.J. Dick, J.C. Field, S.V. Ralston, and A.D. MacCall. 2007. Status of the widow rockfish resource in 2007, An update. Document submitted to the Pacific Fisheries Management Council, July 2007.

Punt, A. 2006. SSC default rebuilding analysis (Version 2.10a, December 2006). University of Washington, Seattle.

Williams, E. H., A. D. MacCall, S. V. Ralston, and D. E. Pearson. 2000. Status of the widow rockfish resource in Y2K. In: Appendix to Status of the Pacific coast groundfish fishery through 2000 and recommended acceptable biological catches for 2001. Stock assessment and fishery evaluation. Pacific Fishery Management Council. 2130 SW Fifth Avenue, Suite 224, Portland, OR, 97201.

Table 1. Specifications of seven rebuilding runs based on different starting year and time series of total catches for future years (also see Figure 1). Future recruitments are generated using the stock-recruitment relationship estimated in the stock assessment. Maximum fishing mortalities for all future years are set to *Fmsy*. Note that for Run0, no information from 2002 to 2006 is used in the simulation.

Run name	Start Year	Catch time series
Run0	2002	No catch and no information after 2001
Run1	2007	368 mt of catch in 2007, and then no catch thereafter
Run2	2007	368 mt of catches in 2007 and 2008, 500 mt thereafter
Run3	2007	368 mt of catches in 2007 and 2008, 1000 mt thereafter
Run4	2007	368 mt of catches in 2007 and 2008, 1500 mt thereafter
Run5	2007	368 mt of catches in 2007 and 2008, 2000 mt thereafter
Run6	2007	368 mt of catches in 2007 and 2008, 4000 mt thereafter
Run7	2007	Using current SPR rate F95%
Run8	2007	Using SPR rate that corresponds 2009-10 OY of 368mt
Run9	2007	50% of probability of rebuilding by current Ttarget of 2015
Run10	2007	ABC level of F50%

Table 2. Comparisons of rebuilding parameters between this year's run (Run0) and the base model run (Model T2) in the 2005 rebuilding analysis. Note that because the population was declared overfished in 2001, no information on the population and fisheries from 2002 to current years were used in these simulations. This table is only for comparisons to the 2005 rebuilding run.

Parameter vale	Run0	Model T2 (2005 rebuilding run)
Virgin spawning output (million of eggs)	50,748	49,678
Target spawning output (million of eggs)	20,299	19,871
Current spawning output (million of eggs)	17,999	15,444
Spawning output in 2001 (million of eggs)	16,459	15,691
Minimum rebuilding time (number of year)	13	15
Maximum rebuilding time (number of year)	22	26
Year for rebuild	2031	2033

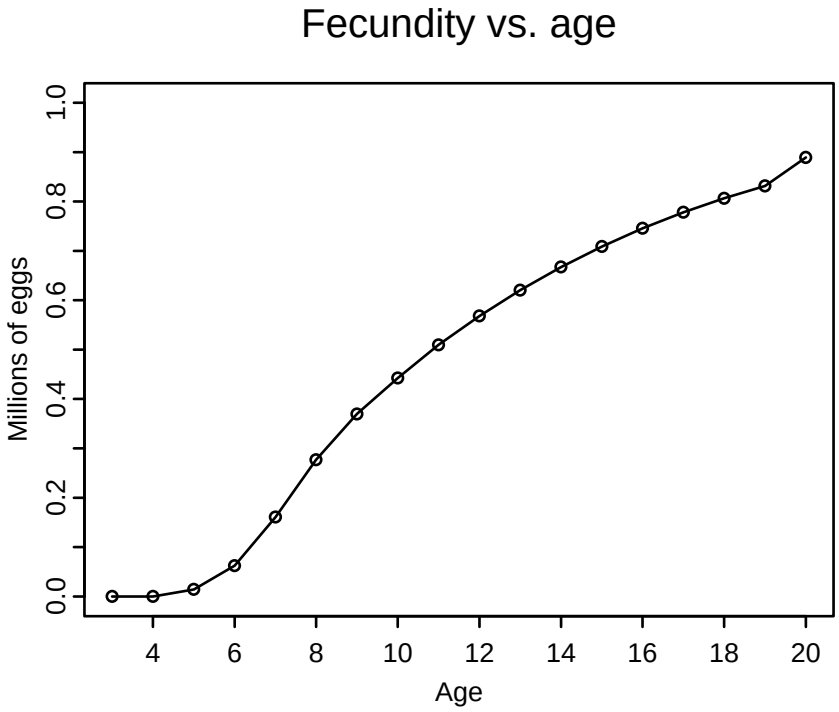
Table 3a. Proposed future catches (mt) and estimated exploitable biomass (mt) for ten rebuilding runs from 2009 to 2018. Run 7 to Run10 are requested runs by the October 2007 Mop-up Panel. The population is estimated to recover in 2009. SPR rates and fishing mortalities are average values from 2007 to 2018.

	Run1		Run2		Run3		Run4		Run5		Run6	
Probability of recovery	1.0		1.0		1.0		1.0		1.0		1.0	
Recovery time	2009		2009		2009		2009		2009		2009	
SPR rate	1.000		0.9479		0.8863		0.8356		0.7861		0.6020	
Fishing mortality	0.0000		0.0081		0.0155		0.0232		0.0313		0.0681	
	Catch	Biomass	Catch	Biomass	Catch	Biomass	Catch	Biomass	Catch	Biomass	Catch	Biomass
2009	0	67193	500	66703	1000	66501	1500	66299	2000	66097	4000	61109
2010	0	65869	500	65052	1000	64489	1500	63926	2000	63363	4000	56296
2011	0	63346	500	62275	1000	61420	1500	60565	2000	59710	4000	51885
2012	0	60671	500	59416	1000	58342	1500	57267	2000	56192	4000	48512
2013	0	58624	500	57239	1000	55995	1500	54749	2000	53508	4000	46276
2014	0	57431	500	55937	1000	54554	1500	53173	2000	51809	4000	45039
2015	0	57020	500	55442	1000	53985	1500	52503	2000	51020	4000	44389
2016	0	57275	500	55598	1000	54022	1500	52427	2000	50831	4000	43937
2017	0	57891	500	56093	1000	54400	1500	52690	2000	50962	4000	43381
2018	0	58480	500	56533	1000	54700	1500	52855	2000	50986	4000	42897

Table 3b. Proposed future catches (mt) and estimated exploitable biomass (mt) for ten rebuilding runs from 2009 to 2018. Run 7 to Run10 are requested runs by the October 2007 Mop-up Panel. The population is estimated to recover in 2009. SPR rates and fishing mortalities are average values from 2007 to 2018.

	Run7		Run8		Run9		Run10	
Probability of recovery	1.0		1.0		1.0		1.0	
Recovery time	2009		2009		2009		2009	
SPR rate	0.950		0.964		0.650		0.500	
Fishing mortality	0.0078		0.0056		0.0670		0.1210	
	Catch	Biomass	Catch	Biomass	Catch	Biomass	Catch	Biomass
2009	522	66694	371	66755	4338	65142	7728	63737
2010	509	65032	362	65201	4051	60840	6937	57215
2011	487	62260	347	62511	3738	56143	6191	51070
2012	465	59420	332	59729	3464	52033	5592	46125
2013	448	57274	320	57625	3266	49057	5174	42681
2014	438	55987	313	56365	3148	47283	4928	40655
2015	435	55546	311	55936	3092	46432	4801	39606
2016	436	55703	312	56124	3074	46175	4745	39139
2017	440	56217	315	56673	3067	46063	4676	38574
2018	444	56689	317	57163	3048	45783	4588	37845

Figure 1. Fecundity-at-age and weight-at-age by sex for widow rockfish as used in the rebuilding analyses.



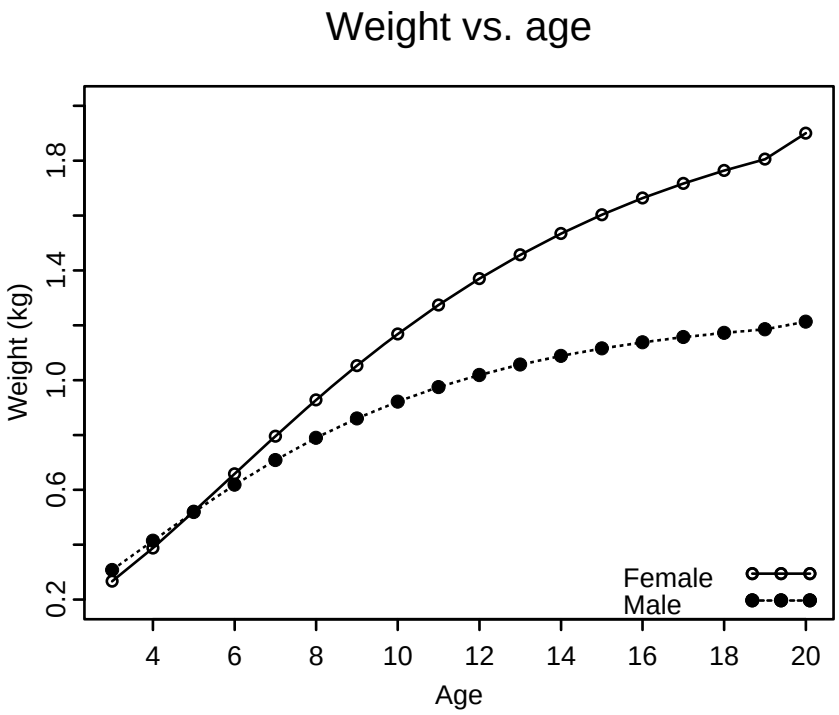


Figure 2. The selectivity pattern for widow rockfish used in the rebuilding analyses.

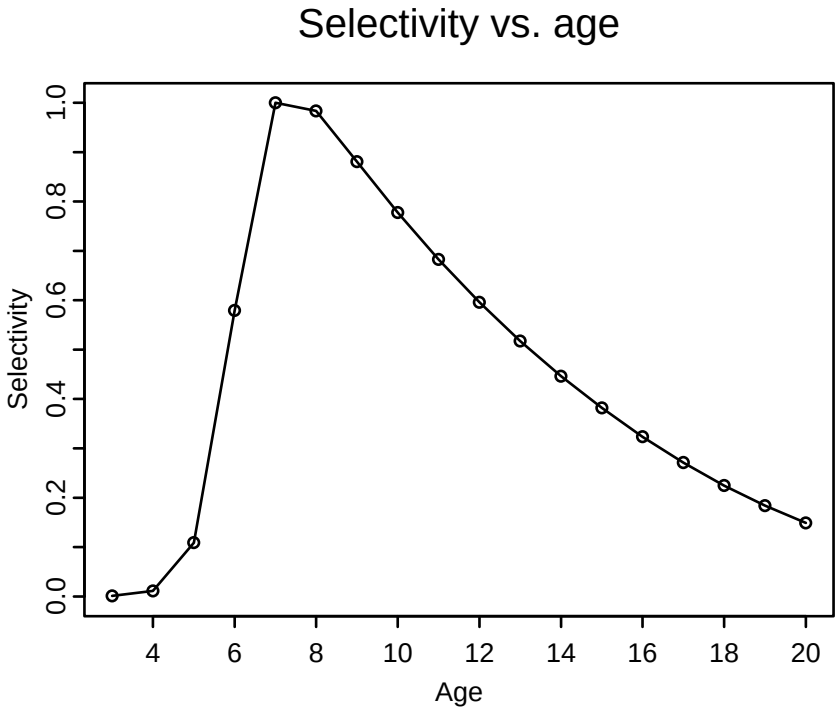


Figure 3. Proposed constant annual catches (mt) for six simulation runs (Run1 to Run6).

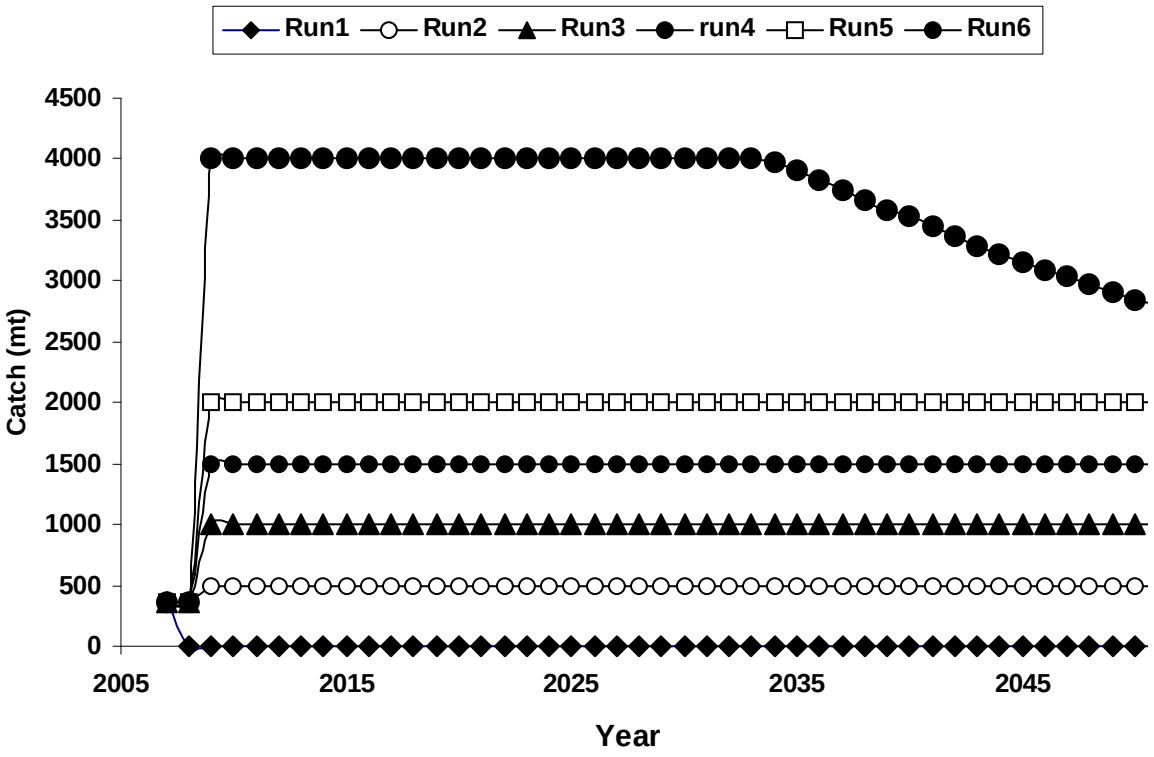


Figure 4. Time series of spawning biomass over target for six simulation runs with constant annual catches (Run1 to Run6). Note that only Run6 (annual catch of 4000mt) results in the spawning biomass fell below the target level (spawning biomass over target equals to 1).

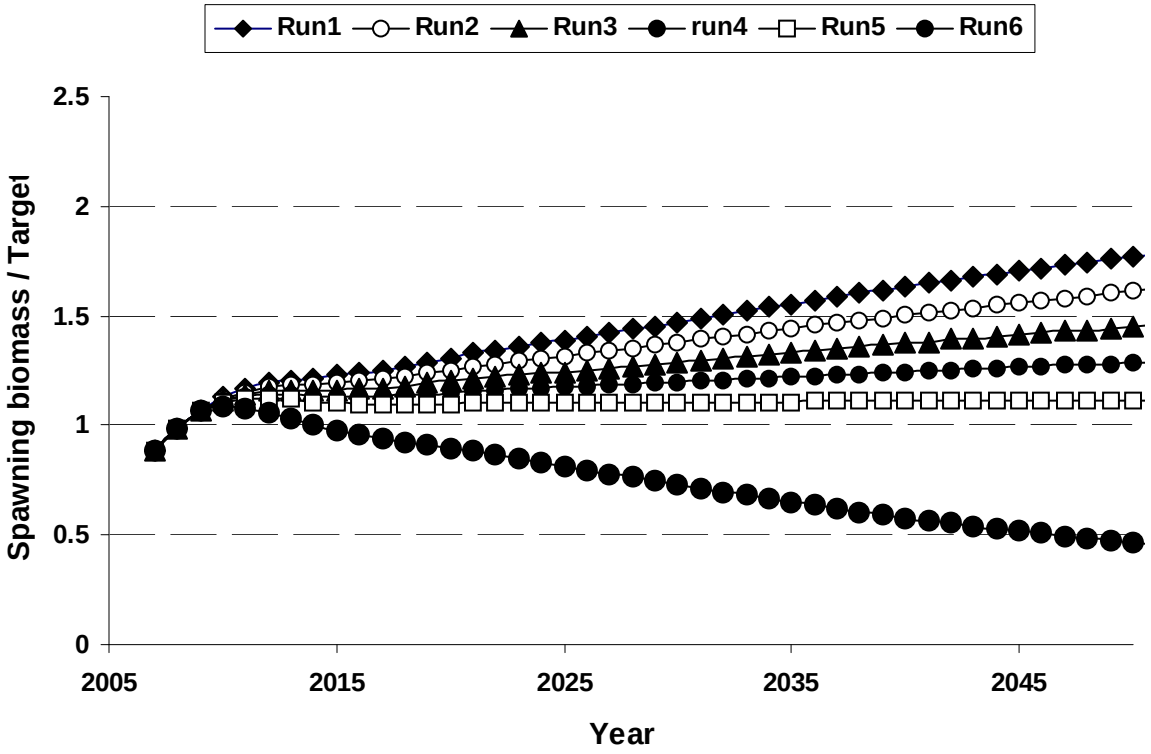


Figure 5. Time series of annual catches (mt) for proposed four runs (Run7 to Run10).

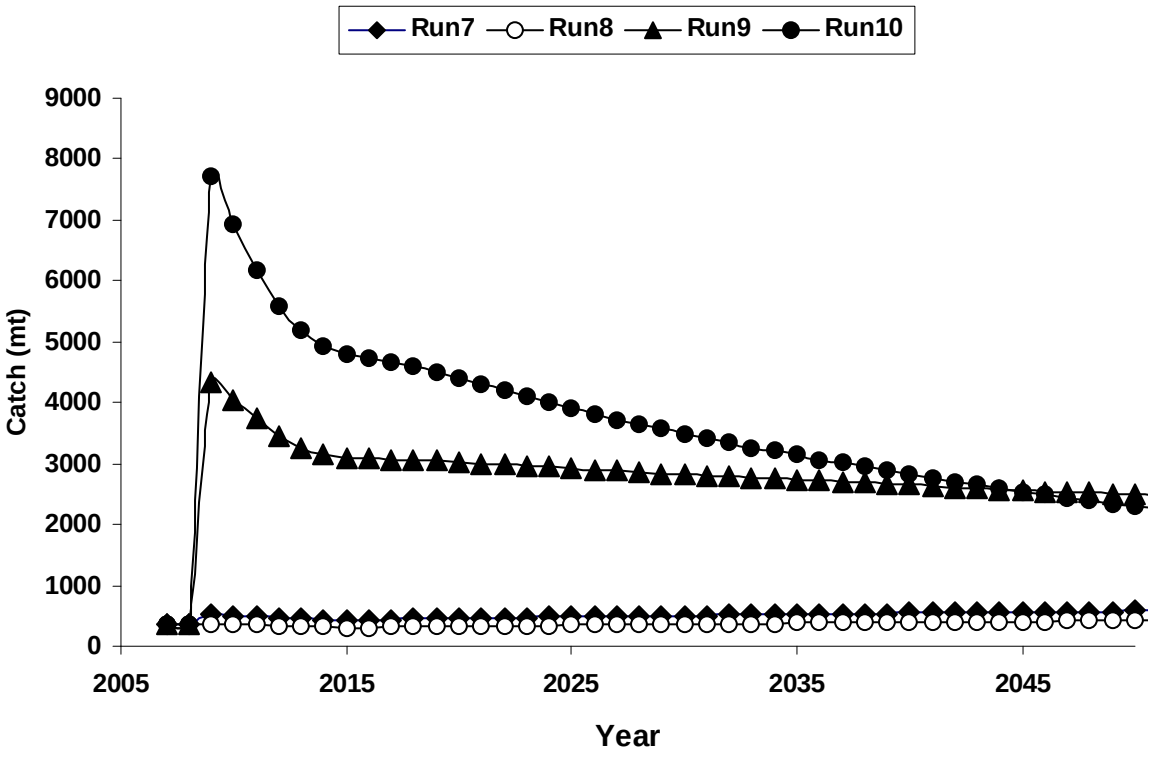
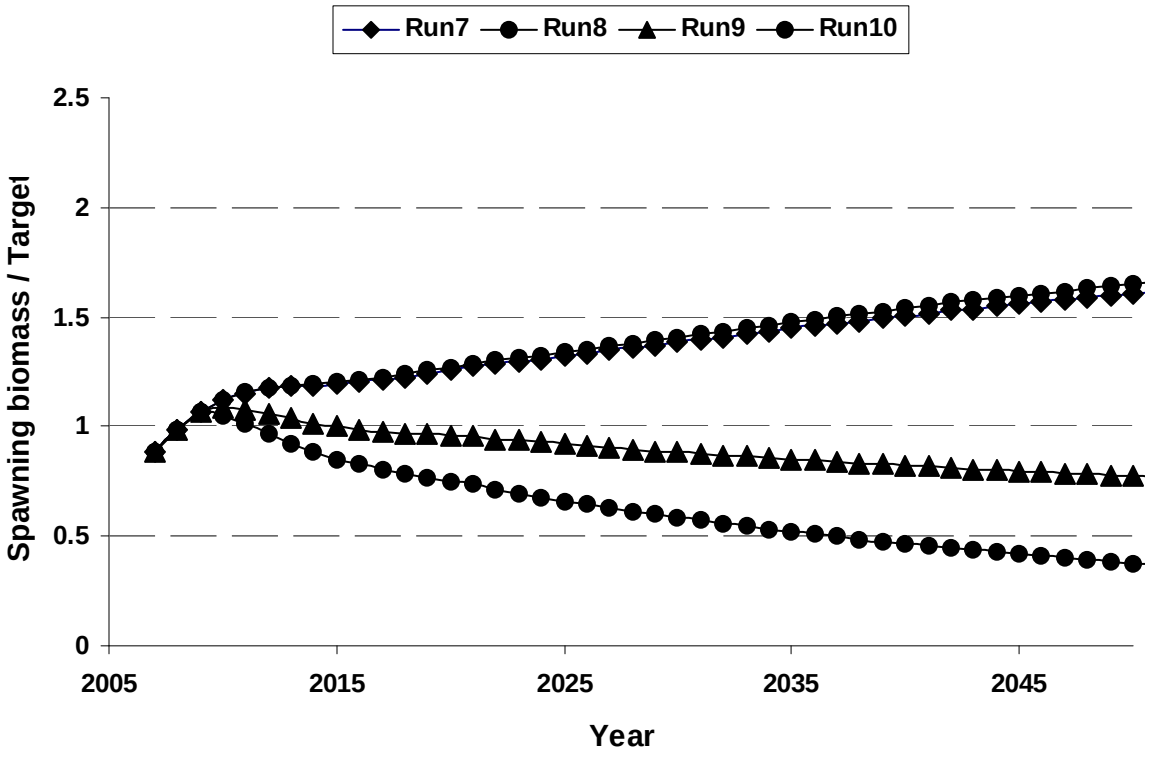


Figure 6. Time series of spawning biomass over target for four simulation runs requested by the October 2007 Mop-up Panel (Run7 to Run10).



Appendix A. The “rebuild.dat” file used in the rebuilding analysis for Run1.

```
# Rebuild.dat for 2007 widow rebuiding
Widow (RecruitOverRiding=0, UseXHhPrior=1, PowCoefficientSCLabIndex= )
# Number of sexes
2
# Age range to consider (minimum age; maximum age)
3 20
# Number of fleets to consider
1
# First year of the projection
2007
# Year declared overfished
2001
# Is the maximum age a plus-group (1=Yes;2=No)
1
# Generate future recruitments using historical recruitments (1), historical recruits/spawner
(2), or a stock-recruitment (3)
3
# Constant fishing mortality (1) or constant Catch (2) projections
1
# Fishing mortality based on SPR (1) or actual rate (2)
2
# Pre-specify the year of recovery (or -1) to ignore
-1
# Fecundity-at-age
# A blank comment line - needed for the program to run
 0.0000 0.0001 0.0141 0.0624 0.1609 0.2770 0.3698 0.4423 0.5099 0.5682 0.6206 0.6674 0.7090
0.7458 0.7782 0.8068 0.8318 0.8895
# Age specific information (Females then males), weight and selectivity
# Females
 0.2663 0.3880 0.5210 0.6587 0.7955 0.9276 1.0523 1.1681 1.2742 1.3704 1.4569 1.5342 1.6028
1.6636 1.7172 1.7642 1.8055 1.9008
 0.0010 0.0112 0.1087 0.5792 1.0000 0.9837 0.8811 0.7780 0.6827 0.5959 0.5174 0.4463 0.3819
0.3236 0.2712 0.2246 0.1839 0.1490
# Males
 0.3073 0.4137 0.5188 0.6180 0.7086 0.7893 0.8601 0.9214 0.9740 1.0187 1.0566 1.0886 1.1154
1.1379 1.1568 1.1725 1.1856 1.2133
 0.0010 0.0112 0.1087 0.5792 1.0000 0.9837 0.8811 0.7780 0.6827 0.5959 0.5174 0.4463 0.3819
0.3236 0.2712 0.2246 0.1839 0.1490
# Age specific information (Females then males), natural mortality and numbers at age
# Females
 0.1250 0.1250 0.1250 0.1250 0.1250 0.1250 0.1250 0.1250 0.1250 0.1250 0.1250 0.1250 0.1250
0.1250 0.1250 0.1250 0.1250 0.1250
     8196.66     7605.13     6247.63    22727.19     5474.55     5967.47     2294.15     1551.54
1271.08     1854.62     1707.29     1204.61     3092.11     1568.31      653.18      512.84
627.09     4555.84
# Males
 0.1250 0.1250 0.1250 0.1250 0.1250 0.1250 0.1250 0.1250 0.1250 0.1250 0.1250 0.1250 0.1250
0.1250 0.1250 0.1250 0.1250 0.1250
     8196.66     7605.13     6247.63    22727.19     5474.55     5967.47     2294.15     1551.54
1271.08     1854.62     1707.29     1204.61     3092.11     1568.31      653.18      512.84
627.09     4555.84
# Initial age-structure (for Tmin)
    11251.89     4344.48     2980.03     2532.77     3793.78     3476.26     2427.41     6168.87
3100.68     1281.04      998.69     1213.56      424.43      781.70      835.80      672.52
549.44     5381.58
    11251.89     4344.48     2980.03     2532.77     3793.78     3476.26     2427.41     6168.87
3100.68     1281.04      998.69     1213.56      424.43      781.70      835.80      672.52
549.44     5381.58
# Year for Tmin Age-structure
2001
# Number of simulations
5000
# Recruitment and Spanwer biomasses
# Number of historical assessment years
49
```

```
# Historical data: Year, Recruitment, Spawner biomass, Used to compute B0, Used to project based
# on R, Used to project based on R/S
 1958 1959 1960 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970 1971 1972 1973 1974 1975 1976
1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006
   34152   34221   34248   34108   33555   32982   31526   31650   28162   35997   39154   40511
42282   44704   41551   90448   32579   13728   11264   17009   21795   11539   39262   59049
22302   66907   80725   29116   29471   29931   23296   10683   24898   16128   16102   29824
45363   13939   15758   13534    7470    7663    9847   22504   18126   66180   16045   17236
16393
   47481   47481   47488   47514   47576   47670   47776   47875   47941   47125   46127   45536
45384   45410   45694   46298   47013   48104   49697   51534   52503   52133   50269   43657
35867   28812   26352   25142   24840   25488   25960   26185   25053   23792   22929   21803
20150   18887   17764   17372   17280   17387   17107   16444   16040   15905   15963   16544
17839
 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1
# Number of years with pre-specified catches
2
# Catches for years with pre-specified catches
2007 368
2008 368
# Number of future recruitments to override
0
# Process for overiding (-1 for average otherwise index in data list)
# Which probability to product detailed results for (1=0.5,2=0.6,etc.)
2
# Steepness and sigma-R and auto-correlations
  0.290376  0.500000 0.000000
# Target SPR rate (FMSY Proxy)
0.500000
# Target SPR information: Use (1=Yes) and power
0 20
# Discount rate (for cumulative catch)
0.100000
# Truncate the series when 0.4B0 is reached (1=Yes)
0
# Set F to FMSY once 0.4B0 is reached (1=Yes; 2=Apply 40:10 rule after recovery)
0
# Percentage of FMSY which defines Ftarget
0.900000
# Maximum possible F for projection (-1 to set to FMSY)
-1
# Conduct MacCall transition policy (1=Yes)
0
# Defintion of recovery (1=now only;2=now or before)
2
# Results for rec probs by Tmax (1) or 0.5 prob for various Ttargets
1
# Definition of the 40-10 rule
10 40
# Produce the risk-reward plots (1=Yes)
0
# Calculate coefficients of variation (1=Yes)
0
# Number of replicates to use
20
# First Random number seed
-89102
# Conduct projections for multiple starting values (0=No;else yes)
0
# File with multiple parameter vectors
MCMC.PRJ
# Number of parameter vectors
100
```

```
# User-specific projection (1=Yes); Output replaced (1->6)
1 2 0 0.5
# Catches and Fs (Year; 1/2 (F or C); value); Final row is -1
2009 2 500
2010 2 500
2011 2 500
2100 2 500
-1 -1 -1
# Split of Fs
2007 1
-1 1
# Time varying weight-at-age (1=Yes;0=No)
0
# File with time series of weight-at-age data
HakWght.Csv
# User-specific projection (1=Yes); Output replaced (1->9)
0
# Target Depletion
0.400000
# Project with Historical recruitments when computing Tmin (1=Yes)
0
# CV of implementation error
0
```