Status of the widow rockfish resource in 2005

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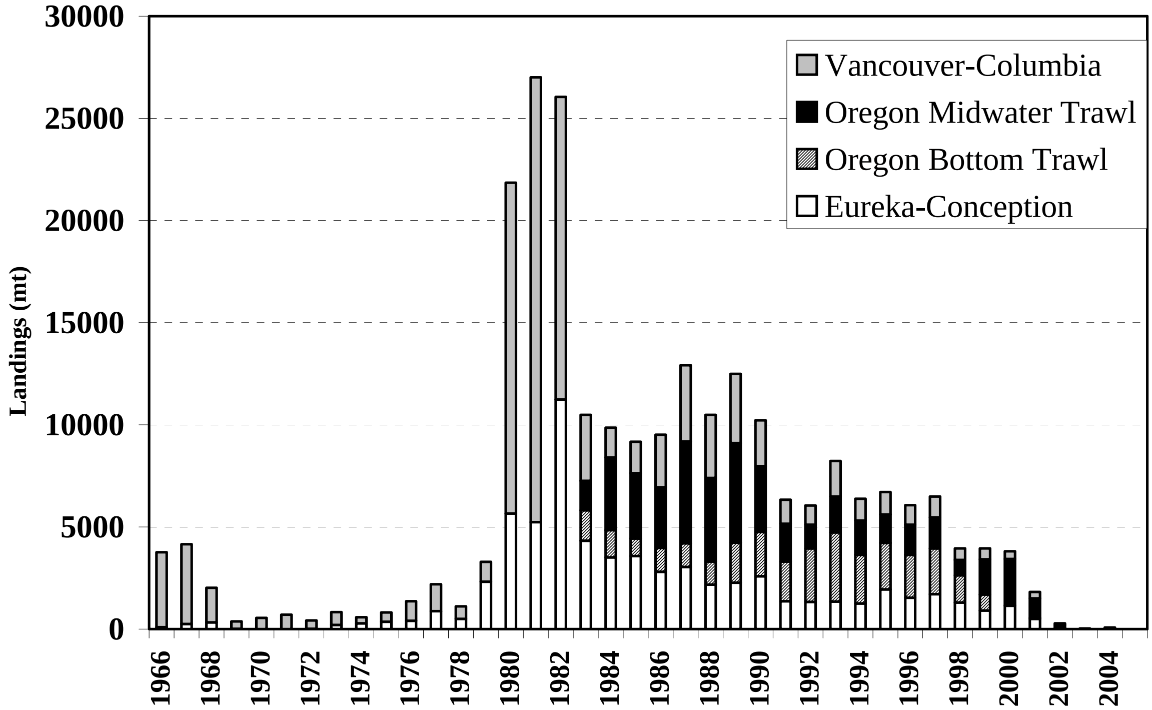
Executive Summary

Stock: This assessment applies to widow rockfish (*Sebastes entomelas*) located in the territorial waters of the U.S., including the Vancouver, Columbia, Eureka, Monterey, and Conception areas designated by the International North Pacific Fishery Commission (INPFC). The stock is assumed to be a single mixed stock and subject to four major fisheries (see figure below).

Catches: The earliest records of foreign landings of widow rockfish were in 1966. U.S. catches of widow rockfish began in 1973, peaking in 1981. Since the 1981 peak there has been a steady decline in the landings of widow rockfish to 28 in 2003 and to 73 mt in 2004 (2004 catch estimate may not be complete). Catches were mostly from commercial fisheries. Catches from recreational fisheries ranged from 3 mt in 2002 to 375 mt in 1982. The dominant gear type historically has been the midwater trawl. During the early 1990s, bottom trawl catches nearly matched the midwater trawl catches.

Recent landings (mt) of widow rockfish by four fisheries from 1990 to 2004.

Year	Vancouver, Columbia	Oregon Midwater Trawl	Oregon Bottom Trawl	Eureka, Monterey, and Conception	Total
1990	2241	3235	2167	2579	10222
1991	1176	1846	1940	1369	6331
1992	946	1149	2624	1331	6051
1993	1747	1755	3386	1347	8235
1994	1074	1678	2382	1248	6384
1995	1087	1394	2278	1944	6703
1996	965	1464	2114	1529	6072
1997	1016	1523	2245	1707	6492
1998	563	758	1330	1304	3955
1999	525	1721	794	902	3943
2000	380	2276	16	1141	3813
2001	302	966	39	505	1812
2002	65	155	6	51	276
2003	16	8	0	5	28
2004	30	12	2	28	73



Total landings of widow rockfish from 1966 to 2004

<u>Data and assessment</u>: The last assessment of widow rockfish was conducted in 2003 using an age-based population model. All fishery data, including landings, age composition, and logbook catch rates, were recently downloaded from the PacFIN, CALCOM, and NORPAC databases, or provided by state agencies. Like the 2003 assessments, this assessment used a Delta-GLM (generalized linear model) method to derive CPUE indices. Like the last assessment, an age-based population model was used in this assessment, and the model was programmed in AD Model Builder (ADMB) (He et al. 2002). In addition to including the new data from 2003 to 2004, this assessment added new CPUE indices and used some new methods in the assessment model. These include:

- AFSC triennial bottom survey indices from 1977 to 2004 are included;
- Depletion rate is computed in the same way as in the 2003 rebuilding analysis (He et al. 2003);
- Power coefficient of midwater juvenile survey index is estimated instead of using a fixed value;
- An informative prior for recruitment steepness is included in the likelihood functions (He et al., in review);
- Sample sizes for age composition data are replaced by effective sample sizes.

The 2005 STAR Panel (STAR Panel Report, 2005) recommended four alternative models to measure uncertainty in the stock assessment, and selected one of them as the base model for this assessment. Key features for four models are listed below:

Model name	Recruitment steepness	Natural mortality	Selectivity
Model T1	0.45	0.125	Double logistic / logistic
Model M015	0.25	0.15	Double logistic
Model T2 (base model)	0.28	0.125	Double logistic
Model M011	0.32	0.11	Double logistic

Unresolved problems and major uncertainties:

1. The primary source of information on trends in abundance of widow rockfish comes from the Oregon bottom trawl logbook data, which is a questionable source of information for widow rockfish. In addition, no information after 1999 in the Oregon bottom trawl logbook data can be used in the assessment because the catch rates were very low due to trip limits and other management regulations. Based on a recommendation by the 2003 STAR panel, triennial survey indices have been used in this assessment as an additional abundance index.
2. Natural mortality was fixed at 0.15 in previous assessments. The 2005 STAR panel recommended natural mortality to be fixed at 0.125, but the validity of this estimate is still uncertain.
3. There exist uncertainties in estimating stock-recruitment relationships. Similar to other rockfish species in the area, the biomass of widow rockfish has decreased steadily since the early 1980s and recruitment during early 1990s is estimated to have been considerably smaller than before the mid 1970s. The reason for the lower recruitment during the period could be due to lower spawning stock biomass, but it could also be due to a lower productivity regime. However, there is evidence that recruitment of many rockfish species since 1999 has been higher than the average of the 1990s. This is also supported by the most recent juvenile survey data and age composition data.
4. The uncertainties in stock-recruitment relationship would lead to greater uncertainties in the rebuilding analysis because it largely depends on how future recruitments are generated.
5. There was considerable discussion about the appropriate use of the Santa Cruz juvenile survey data in the 2003 and 2005 STAR Panel reviews. It was noted that the survey indices are highly variable, that the index has not always identified strong year-classes, and that power transformation of this index has some influences on the results. Future assessments should further examine utilities of this index.
6. Stock structure issues, in particular the relationship to the Canadian stock, remain an important source of uncertainty.

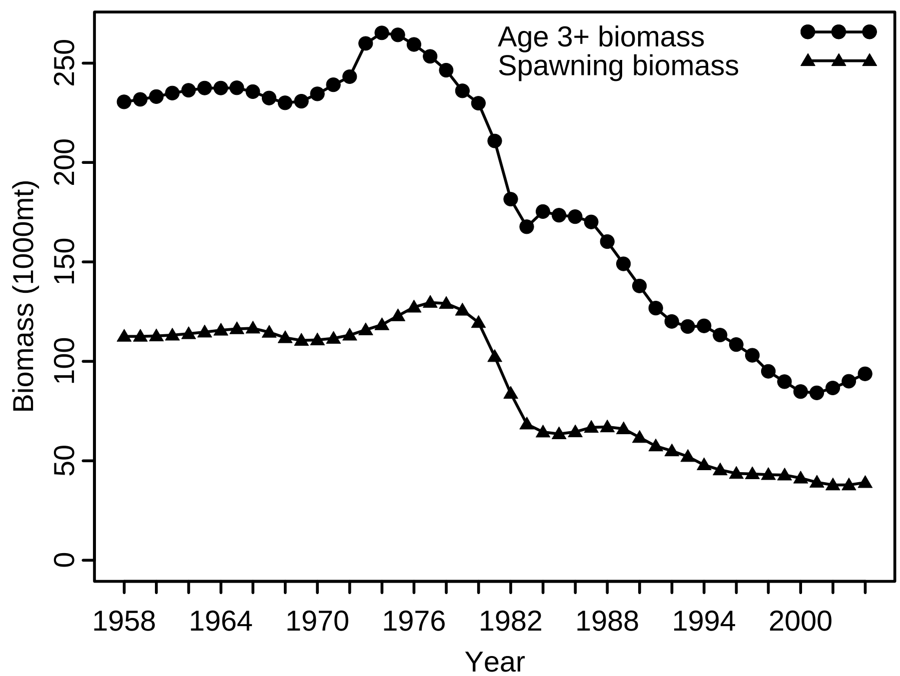
Reference points: The percentage ratio of spawning output in 2004 to unfished spawning output (B_0) is the population status ("depletion rate"). A population status below 25% indicates an overfished stock, and population statuses between 25% and 40% indicate a precautionary zone. A population status over 40% is a healthy stock. The following reference points were obtained from the base model:

Quantity	Value
Unfished spawning output (B_0)	49678 (millions of eggs)
Current spawning output (B_t)	15444 (millions of eggs)
Depletion rate	31.09 (%)
Spawning output at MSY (B_{msy})	19871 (millions of eggs)
Basis for B_{msy}	$B_{40\%\ proxy}$
F_{msy}	0.1154
Basis for F_{msy}	$F_{50\%\ proxy}$

Stock biomass: Spawning biomass peaked in 1977 and has shown a steady decline since then. Stock biomass has shown a steady decline between 1977 and 2000, soon after the fisheries for widow rockfish began. Since 2001, stock biomass has shown an increasing trend. The following table and figure show time series of estimated catches, discards, stock biomass, fishing mortality, and recruitments from the base model.

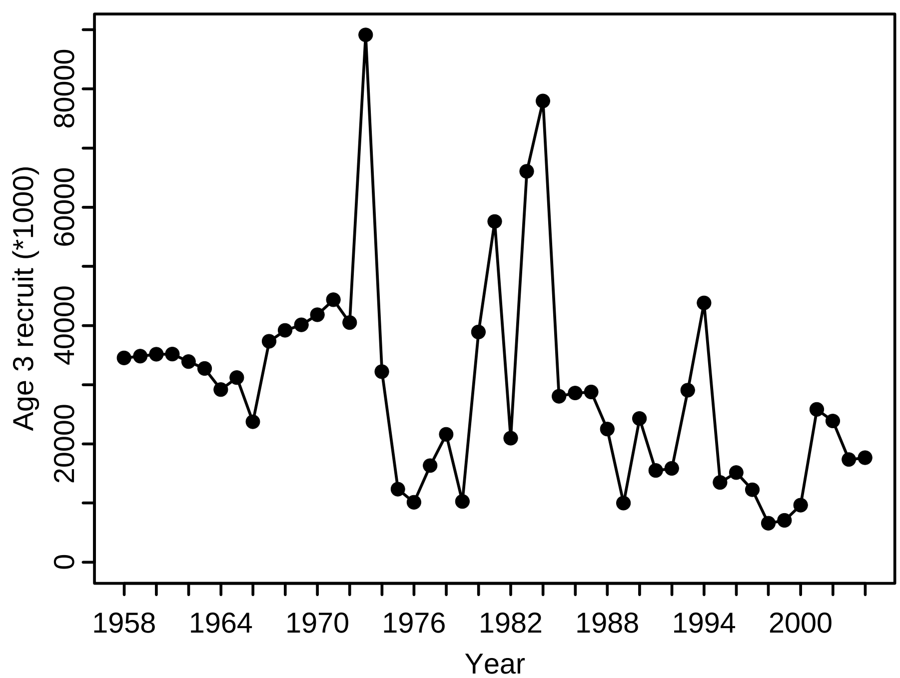
Year	Total biomass (mt)	Spawning biomass (mt)	Recruitment (*1000)	Landing (mt)	Discard (mt)	Fishing Mortality	Exploitation rate	Depletion (%)
1990	137886	61695	24254	10218	1635	0.1829	0.1539	47.7
1991	126762	57451	15480	6336	1014	0.1218	0.1050	45.1
1992	120069	54981	15827	6055	969	0.125	0.1098	43.6
1993	117532	52088	29059	8223	1316	0.1915	0.1623	41.5
1994	117762	47939	43799	6365	1018	0.1638	0.1391	38.3
1995	113199	45415	13461	6685	1070	0.1832	0.1582	36.0
1996	108431	43681	15161	6057	969	0.1691	0.1451	34.1
1997	102960	43489	12223	6476	1036	0.1635	0.1412	33.5
1998	94967	43083	6587	3955	633	0.0951	0.0849	33.2
1999	89754	42852	7052	3947	632	0.1044	0.0886	33.5
2000	84788	41348	9623	3822	612	0.1126	0.0926	32.9
2001	84099	39120	25820	1813	290	0.0587	0.0492	31.6
2002	86604	37790	23850	276	44	0.0100	0.0082	30.7
2003	89937	37848	17341	28	5	0.0010	0.0009	30.6
2004	93685	39033	17644	73	12	0.0022	0.0020	31.1

Age 3+ biomass and spawning biomass

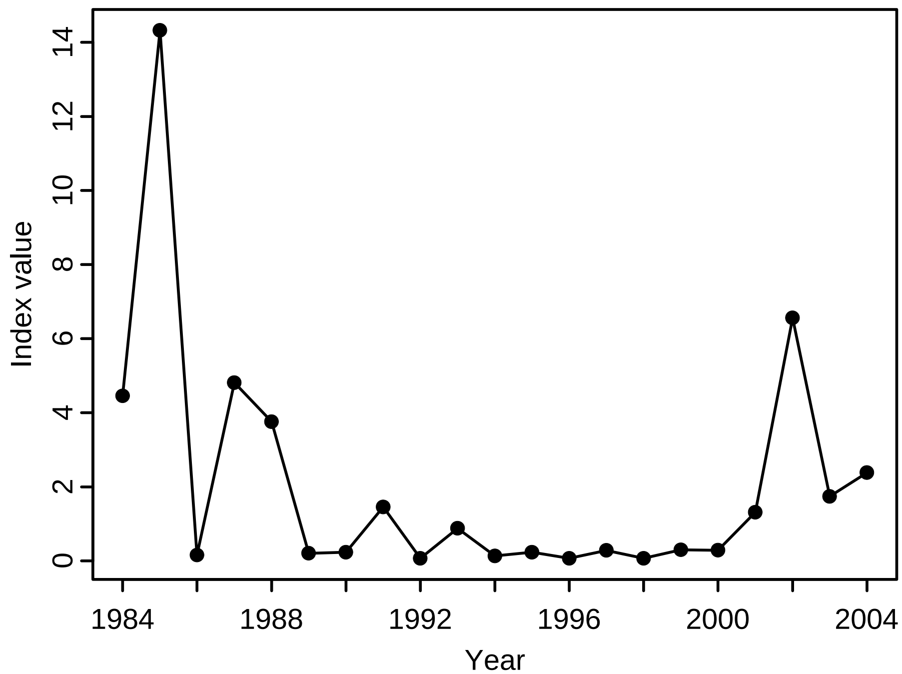


Recruitment: The model estimated time series of recruitment of age 3 fish from 1958 to 2001. The highest recruitment occurred in 1972. Recruitments remained generally low in the early 1990s as compared to the long-term average, but showed an increasing trend in recent years.

Age 3 recruit



Midwater juvenile surveys by the Santa Cruz Laboratory, however, showed a great increase of age 0 fish abundance in 2002. This datum point has no influence in the current stock assessment, but could have large impacts on the rebuilding analysis.



Exploitation status: The point estimate of the current spawning output, from the base-model run, is at 31.09% of the unfished level (see table above).

Management Performance: See below.

Year	Harvest Guideline	Allowable Biological Catch	Landings
1989	12100	12400	12486
1990	12400	8900	10222
1991	7000	7000	6331
1992	7000	7000	6051
1993	7000	7000	8235
1994	6500	6500	6384
1995	6500	7700	6703
1996	6500	7700	6072
1997	6500	7700	6492
1998	5090	5750	3955
1999	5090	5750	3943
2000	5090	5750	3813
2001	2300	3727	1812
2002	856	3727	276
2003	832	3871	28
2004	284	3460	73
2005	284	3460	

Forecasts: Forecasts of spawning outputs and optimal yield (OY) from the base model are given in the following table. This is based on the assumptions that (1) future recruitments are governed by the stock-recruitment relationship estimated by the current assessment; and (2) there is 60% of probability that the population will recover to 40% of pre-fishing level by 2033. Details of forecasts using other alternative models, other methods of generating future recruitments, and other pre-set recover time are given in the rebuilding analysis for widow rockfish (He et al., in preparation).

		Model T2 (base model)	
Year	OY catch (mt)	Spawning output (million of eggs)	Depletion (%)
2005	284	15444	31.1
2006	1200	16018	32.2
2007	1287	16654	33.5
2008	1319	17240	34.7
2009	1292	17632	35.5
2010	1236	17866	36.0
2011	1192	17993	36.2
2012	1159	18059	36.4
2013	1140	18093	36.4
2014	1128	18123	36.5
2015	1123	18190	36.6

Decision Table: States of nature are represented by four alternative models. Management actions include the catches predicted by each of these four alternative models. The same assumptions used in the Forecasts Section are used here for predicting catches in each model. It is important to notice that if management actions use the catches predicted by Model 011, all four models predict that the population will decline and be more depleted in the future than the current level. Results are listed in the following table (series in bold font show decreasing population abundance). Also notice that catch for 2006 for Model M011 is not pre-specified because of difficulty in obtaining rebuilding results.

Management action	Year	Total catch (mt)	State of Nature: Model T1 Spawning output	Model T1 Depletion (%)	Model M015 Spawning output	Model M015 Depletion (%)	Model T2 (base) Spawning output	Model T2 (base) Depletion (%)	Model M011 Spawning output	Model M011 Depletion (%)
Model T1	2005	285	8992	25.3	12052	25.8	15444	31.1	20351	38.5
	2006	289	9746	27.4	12546	26.8	16018	32.2	21030	39.8
	2007	2277	10655	30.0	13234	28.3	16839	33.9	21149	40.0
	2008	2312	11092	31.2	13477	28.8	17230	34.7	21625	40.9
	2009	2298	11361	31.9	13524	28.9	17407	35.0	21910	41.4
	2010	2275	11527	32.4	13408	28.7	17421	35.1	22058	41.7
	2011	2262	11648	32.8	13195	28.2	17328	34.9	22135	41.9
	2012	2272	11754	33.0	12933	27.7	17185	34.6	22166	41.9
	2013	2302	11880	33.4	12697	27.2	17016	34.3	22139	41.9
	2014	2333	12030	33.8	12465	26.7	16847	33.9	22111	41.8
	2015	2376	12214	34.3	12292	26.3	16720	33.7	22088	41.8
Model M015	2005	285	8992	25.3	12052	25.8	15444	31.1	20351	38.5
	2006	289	9746	27.4	12546	26.8	16018	32.2	21030	39.8
	2007	538	10655	30.0	13234	28.3	16839	33.9	21149	40.0
	2008	556	11459	32.2	13832	29.6	17590	35.4	21989	41.6
	2009	556	12113	34.1	14248	30.5	18150	36.5	22665	42.9
	2010	544	12663	35.6	14493	31.0	18548	37.3	23213	43.9
	2011	533	13153	37.0	14618	31.3	18824	37.9	23683	44.8
	2012	524	13604	38.3	14668	31.4	19035	38.3	24093	45.6
	2013	523	14058	39.5	14715	31.5	19182	38.6	24427	46.2
	2014	523	14512	40.8	14751	31.6	19331	38.9	24751	46.8
	2015	527	14997	42.2	14844	31.8	19512	39.3	25079	47.4
Model T2 (base)	2005	285	8992	25.3	12052	25.8	15444	31.1	20351	38.5
	2006	289	9746	27.4	12546	26.8	16016	32.2	21030	39.8
	2007	1352	10655	30.0	13234	28.3	16839	33.9	21149	40.0
	2008	1385	11287	31.7	13666	29.2	17421	35.1	21819	41.3
	2009	1375	11759	33.1	13907	29.7	17801	35.8	22310	42.2
	2010	1343	12129	34.1	13982	29.9	18017	36.3	22670	42.9
	2011	1311	12449	35.0	13950	29.8	18125	36.5	22955	43.4
	2012	1287	12746	35.8	13864	29.7	18170	36.6	23190	43.9
	2013	1282	13061	36.7	13788	29.5	18184	36.6	23363	44.2
	2014	1277	13382	37.6	13718	29.3	18206	36.6	23530	44.5
	2015	1283	13748	38.7	13700	29.3	18270	36.8	23717	44.9
Model M011	2005	285	**8992**	**25.3**	**12052**	**25.8**	**15444**	**31.1**	**20351**	**38.5**
	2006	4388	**9746**	**27.4**	**12546**	**26.8**	**16018**	**32.2**	**21030**	**39.8**
	2007	4503	**10655**	**30.0**	**13234**	**28.3**	**16839**	**33.9**	**21149**	**40.0**
	2008	4440	**10624**	**29.9**	**13025**	**27.9**	**16771**	**33.8**	**21162**	**40.0**
	2009	4285	**10425**	**29.3**	**12624**	**27.0**	**16483**	**33.2**	**20969**	**39.7**
	2010	4109	**10159**	**28.6**	**12101**	**25.9**	**16058**	**32.3**	**20665**	**39.1**
	2011	3964	**9901**	**27.8**	**11538**	**24.7**	**15577**	**31.4**	**20330**	**38.4**
	2012	3869	**9679**	**27.2**	**10988**	**23.5**	**15102**	**30.4**	**19996**	**37.8**
	2013	3823	**9546**	**26.8**	**10515**	**22.5**	**14661**	**29.5**	**19664**	**37.2**
	2014	3764	**9446**	**26.6**	**10083**	**21.6**	**14242**	**28.7**	**19351**	**36.6**
	2015	3729	**9415**	**26.5**	**9735**	**20.8**	**13914**	**28.0**	**19080**	**36.1**

Recommendations:

1. There are increasingly fewer reliable abundance indices for widow rockfish. Recent management measures have undermined the ability to continue fishery dependent time series of relative abundance from the Oregon bottom trawl fishery and Pacific whiting fishery since 1999. The constant flux of the management regime suggests that there is little likelihood that meaningful CPUE indices can be developed from these fisheries in the future. The triennial bottom trawl survey may be the only data that can provide abundance indices in the future. More analysis should be done to either calibrate or compare triennial survey results with those from the NWFSC Combined survey.
2. Long-term recruitment index is a key datum series in the stock assessment. Continuation of the midwater juvenile trawl survey and recent increases in sampling intensity and spatial coverage will improve estimation confidence and data quality. Comparison and possibly integration of the existing juvenile survey results with a recently initiated survey by the fishing industry (Vidar Wespestad, pers. comm.) could also broaden the spatial extent of this index. The ability to infer direct and indirect estimates of year class strengths from surveys and other sources, as well as to better understand the relationship between environmental conditions in the California Current System, should improve short-term forecasts of productivity, biomass levels and allowable catches from stock assessments.
3. Preliminary information from recent bycatch monitoring suggest that discards may have decreased substantially compared to the assumed 16% currently used. New discard data should be analysed and, if warranted, past discard estimates should be adjusted.
4. The utility of hydro-acoustic surveys on widow rockfish abundance should be evaluated in future assessments.
5. Sample sizes for existing age-collection programs (by fishery and survey) should be increased substantially.
6. The age-composition for the triennial survey should be determined by applying year-specific age-length keys to the survey length-frequencies, and included in future assessments as a basis for estimating survey selectivity.

Introduction

Widow rockfish (*Sebastes entomelas*) is an important commercial groundfish species belonging to the scorpionfish family (Scorpaenidae). It ranges from southeastern Alaska to northern Baja California, where it frequents rocky banks at depths of 25-370m (Eschemeyer et al. 1983, Wilkins 1986). In those habitats it feeds on small pelagic crustaceans and fishes, including especially *Sergestes similis*, myctophids, and euphausiids (Adams 1987). There is no evidence that separate genetic stocks of widow rockfish occur along the Pacific coast and the species has been treated as one stock with four separate fisheries (Hightower and Lenarz 1990; Rogers and Lenarz 1993; Ralston and Pearson 1997, Williams et al. 2002).

A midwater trawl fishery for widow rockfish developed rapidly in the late 1970s and increased rapidly in 1980-82 (Gunderson 1984, Fig. 1 and Table 1). Large concentrations of widow rockfish had evidently gone undetected because aggregations of this species form at night and disperse at dawn, an atypical pattern for rockfish. Since the fishery first developed, substantial landings of widow rockfish have been made in all three west-coast states.

Management of the fishery began in 1982 when 75,000 lbs trip limits were introduced in an effort to curb the rapid expansion of the fishery (Tables 2-3). These were reduced to 30,000 lbs in 1983 and the fishery was managed by alteration of trip limits within the fishing season. A 10,500 mt/yr Allowable Biological Catch (ABC) for widow rockfish was instituted in 1983 (Table 3), but no harvest guideline was established. This form of management continued with alterations in ABC and trip limits until 1989 when a 12,100 mt/yr harvest guideline was implemented (Tables 2-3). From 1994-1997 the harvest guideline was changed to 6,500 mt and then reduced to 5090 mt/yr for 1998 to 2000. Based on the 2000 stock assessment and the rebuilding analysis of 2001 and 2003, the harvest guidelines were further reduced to 2,300 mt for 2001, 856 mt for 2002, 832 mt for 2003, and 284 mt for 2004 and 2005 (He et al. 2003a, He et al. 2003b).

This assessment used an age-based population model similar to those used in previous assessments (Ralston and Pearson 1997, Williams et al. 2000, He et al. 2003b). The model structure and code were similar as in the 2003 assessment (He et al. 2003b). In addition to including the new data from 2003 to 2004, this assessment examined the following options:

- Depletion rate is computed in the same way as in the 2003 rebuilding analysis (He and Punt 2003);
- Triennial survey index is included as abundance index;
- Power transformation of midwater juvenile survey index is estimated instead of using a fixed value;
- Sample sizes for age composition data are replaced by effective sample size (McAllister and Ianelli 1997, Maunder, in preparation);
- A prior probability for stock-recruitment steepness is included in the likelihood functions (He et al. in review).

Data

Biological information

Growth in length for widow rockfish has been described using von Bertalanffy growth equations in two papers by Lenarz (1987) and Pearson and Hightower (1991). In their analyses it was determined that females attain a larger size compared to males and fish from the northern part of the range tend to be larger at age compared to those in the south. For these reasons we chose to use the sex-specific and area-specific estimates for length-at-age. Furthermore, we chose to use the estimates listed in Pearson and Hightower (1991), shown below and in Figure 2, because they are from a more recent and comprehensive analysis of widow rockfish growth compared to the analysis by Lenarz (1987). In order to match the fisheries, we used the Columbia-Eureka INPFC area border (43^{o} Lat.) to delineate north from south.

Parameter	Females (north)	Males (north)	Females (south)	Males (south)
L_{inf} (cm)	50.54	44.0	47.55	41.5
K	0.14	0.18	0.2	0.25
t_0	-2.68	-2.81	-0.17	-0.28

Sex-specific weight-at-age estimates were computed using the length-at-age estimates above with sex-specific length-weight regressions for widow rockfish developed by Barss and Echeverria (1987) (Figure 2). The length-weight regression equation is $W = \alpha L^{\beta}$, where W is the weight (g) and L is the length (cm). The sex-specific parameter values used in this assessment are listed below:

Parameter	Females	Males
α	0.00545	0.01188
β	3.28781	3.06631

Estimates of maturity and fecundity of female widow rockfish were obtained from Barss and Echeverria (1987) and Boehlert et al. (1982), respectively. Age-specific maturity estimates were taken directly from the literature instead of fitting a parametric model (Figure 3), while age-specific fecundity was computed using the weight-fecundity regression:

$$F = 605.71W - 261830.7 \qquad (1)$$

where F is fecundity (number of eggs) and W is weight (g). The weight-fecundity regression applied to the southern weight-at-age estimates resulted in negative values for ages 3 and 4. The weight-fecundity regression developed by Boehlert et al. (1982) was based on fish captured from Oregon and apparently does not apply to widow rockfish in the south. The maturity estimates shown in Figure 3 indicate a substantial difference in maturity-at-age between the north and south, with the northern fish maturing at an older age. Lacking any other estimate of fecundity for the south, we applied the weight-fecundity regression from the north and modified the estimates for ages 3-5 to approximate an asymptote to 0 (Figure 3).

Landings

All landings for the period 1966-2002 were summarized into four areas (fisheries): (1) Vancouver-Columbia (VC); (2) Oregon mid-water trawl (ORMWT); (3) Oregon bottom trawl (ORBTWL); and (4) Eureka, Monterey, and Conception (EMC). Landings statistics used in this assessment were derived from four sources. First, all commercial landings from 1981 were extracted from the PacFIN database. Second, the very small annual recreational take of widow rockfish was extracted from the Marine Recreational Fishing Statistics Survey (MRFSS) database. Third, all landings from 1966 to 1972, and some landings from 1973 to 1976 were directly taken from a summary table in Rogers (2003), who recently compiled summaries of foreign catches in the period. Fourth, some landing from 1973 to 1976 and all landings from 1977 to 1979 were directly copied from the last assessment (Williams et al. 2000). Summarized landings by year are presented in Table 1 and Figure 1.

As in the last assessments of widow rockfish, the data were pooled over states into INPFC area blocks. These in turn were collapsed into northern and southern areas, representing the U.S. Vancouver and Columbia areas (VC, ORMWT, and ORBTWL) and the Eureka, Monterey, and Conception areas (EMC), respectively. The northern and southern areas are conveniently delineated by the 43^{o} latitude line. Within the southern area, widow rockfish landings were further condensed by summing over gears (i.e., trawl, other commercial, and recreational), providing annual estimates of landings from the southern area fishery. In the northern area, however, landings were partitioned into three separate fisheries; the Oregon midwater trawl fishery, the Oregon bottom trawl fishery, and the remaining catch of widow rockfish, referred to as the Vancouver-Columbia fishery. Because identification of gear types in Oregon (midwater or bottom trawl) did not begin until 1983, all landings in the northern area prior to that time were assigned to the Vancouver-Columbia "trawl" fishery.

It should be noted that there are some small discrepancies in the landing statistics between those recently extracted from the PacFIN data and those used in the last assessment. Overall, these discrepancies are very small.

Age composition data

Widow rockfish otolith samples collected coastwide since 1989 have been aged at the Santa Cruz (Tiburon) Laboratory using the break and burn aging method (Pearson and Hightower 1991). Prior to 1989, the ages of all Vancouver-Columbia fish were obtained by researchers in the State of Washington, who used surface readings. Prior to 1987, Oregon widow rockfish were aged by investigators in Oregon, who used the break and burn aging method. All California fish were aged by Santa Cruz Laboratory personnel using the break and burn aging technique.

Age validation of widow rockfish was conducted by marginal increment analysis (Lenarz 1987). Hyaline-zone formation, the measure of annual growth, appears to occur between December and April (Pearson 1996). For convenience all widow rockfish are assumed to be born on January 1. Variation in the timing of the hyaline-zone formation occurs between fish from Washington and California, which could affect age determination. Knowledge of the timing variation can be used to avoid mis-ageing and ultimately the variation in hyaline-zone formation is not likely to result in major age discrepancies (Pearson 1996).

Washington provided ageing data from samples collected during commercial market sampling. The data were then expanded using relative catches from US Vancouver and Columbia areas. Oregon provided raw sample data which were expanded using methods described in Sampson and Crone (1997). California age data was extracted and expanded from the CALCOM database (Pearson and Erwin 1997).

New otolith samples from the Eureka-Conception area from 1978 and 1979 were discovered last year. The samples were analyzed and included in this assessment. The complete sex specific age composition data and sample size information for the four fisheries are presented in Tables 4-8 and Figures 4-7.

Midwater trawl pelagic juvenile survey

Every year since 1983 the Groundfish Analysis Branch at the Southwest Fisheries Science Center's Santa Cruz/Tiburon Laboratory has conducted a midwater trawl survey, which is designed to assess the reproductive success of rockfish, including widow rockfish. The survey is conducted during May-June, the time of year when the pelagic juvenile stage is most susceptible to capture. Studies have shown that abundance statistics summarized from the survey gauge impending recruitment (Adams 1995; Ralston and Howard 1995; Ralston et al. 1996). Recent efforts to quantify spatial patterns of recruitment variability also suggests that there is substantial synchrony in year class strength over spatial scales on the order of 500-1000 km for widow, as well as chilipepper (*S. goodei*) and yellowtail (*S. flavidus*) rockfish (Field and Ralston, in press). Although much of the spatial variability in year class strength that does exist is associated with major geographic features such as Cape Mendocino and Cape Blanco, these results support the argument that recruitment variability is driven to a large extent by forcing factors operating over large spatial scales.

The survey index is calculated after the raw catch data are adjusted to a common age of 100-days to account for interannual differences in age structure. The abundance data are gathered during three consecutive sweeps of a series of 36 fixed stations that are arrayed over 7 spatial strata that extend from Carmel (36°30'N) to Bodega (38°20'N). As in the previous assessment, the index is calculated using Delta-GLM (Generalized Linear Model) method with lognormal error structure (Pennington 1986, 1996, Stefansson 1996):

$$\log(density) = \mu + Y_i + L_k + \varepsilon \qquad (2)$$

where u is the average $\log(density)$, Y_i is a year effect, L_k is a 'period' (bins of 10-julian days) effect, and ε is a normal error tern with mean zero and variance σ^2. The back-transformed year-specific index, with bias-correction, was then calculated as:

$$Index_i = \exp\left(\mu + Y_i + \bar{L} + \frac{\sigma^2}{2}\right)\pi_i \qquad (3)$$

where $\bar{L}$ is the mean period effect, and π_i is the predicted proportion of positive tows in year i:

$$\pi_i = \frac{\exp(\mu^{'} + y_i^{'} + \bar{L}^{'})}{1 + \exp(\mu^{'} + y_i^{'} + \bar{L}^{'})} \qquad (4)$$

where $\mu^{'}$ is the average, $y^{'}$ is the year effect, and $\bar{L}^{'}$ is the average period effect of the logit-transformed probabilities. The coefficient of variation (CV) for each index value was computed from the jack-knife method.

Data from 1983 were deleted from the analysis because of a small total number of datum points. Because no juvenile widow rockfish were caught in 1992, 1996, and 1998, index values for those years were set to one half of the historical low value, and CVs for those years were set to a high value of 2.0. The resulting indices were entered into the model as relative indices of one-year juvenile abundance (Table 9 and Figure 8). The index time series (1984-2004) was then shifted forward three years (1986-2007) to represent the abundance of age-3 widow rockfish, the age of recruitment in the assessment model.

Oregon bottom trawl logbook

Oregon logbook data from 1984 to 1986 were provided by the Oregon Department of Fish and Wildlife, and data from 1987 to 2002 were extracted from the PacFIN database. Catch per unit effort (CPUE) was computed as pounds of fish caught per hour trawled. The data were filtered before the analysis. Only records meeting the following criteria were used in the analysis: (1) the fishing gear code corresponded to bottom trawl or roller gear, (2) hauls were conducted during the months of January, February, or March, and (3) the location of the reported haul fell in the range of 42^{o}30'N to 46^{o}30'N latitude and 124^{o}36'W to 124^{o}54'W longitude. In addition, records associated with any vessel code or spatial unit that had less than 1000 pounds of widow catch over the entire period (1984 to 2002) were also deleted. Data from 2000 to 2002 were not used in the analysis because widow catches in those three years were very low due to trip limits and other management regulations (Tables 2 and 3).

Annual CPUE indices were derived using the Delta-GLM (Generalized Linear Model) method similar to that used for deriving midwater trawl pelagic juvenile survey (see previous section), with an additional factor (vessel) included:

$$\log(CPUE) = \mu + Y_i + V_j + L_k + \varepsilon_{ijkl} \qquad (5)$$

where u is the average $\log(CPUE)$, Y_i is a year effect, V_j is a vessel effect, L_k is a spatial (latitude and longitude) effect, and ε_{ijkl} is a normal error tern with mean zero and variance σ_ε^2. The back-transformed year-specific CPUE, with bias-correction, was then calculated as:

$$CPUE_i = \exp\left(\mu + Y_i + \bar{V} + \bar{L} + \frac{\sigma_\varepsilon^2}{2}\right)\pi_i \qquad (6)$$

where $\bar{V}$ and $\bar{L}$ are mean effects of vessel and spatial unit, respectively, and π_i is binomial coefficient:

$$\pi_i = \frac{\exp(\mu' + y_i' + \bar{V}' + \bar{L})}{1 + \exp(\mu' + y_i' + \bar{V}' + \bar{L})} \qquad (7)$$

where μ' is the average, y' is year effect, $\bar{V}'$ is average vessel effect, and $\bar{L}$ is average spatial effect. Derived annual CPUE indices are presented in Table 10 and Figure 9, which are same as in the 2003 assessment.

Pacific whiting bycatch indices

As in the previous assessments (Rogers and Lenarz 1993, Ralston and Pearson 1997, Williams et al. 2002), CPUE indices were computed that measured the incidental catch rate of widow rockfish in the at-sea pacific whiting fishery. Data from the foreign fishery, joint-venture fishery and recent domestic fishery were extracted from the NORPAC database.

Full descriptions on how the CPUE indices were derived are in Appendix A. Similar Delta-GLM approaches as used for the Oregon bottom trawl logbook is used in the analysis. Annual CPUE indices for the foreign fishery, joint-venture fishery, and domestic fisheries are presented in Table 11 and Figure 10. As recommended by the 2003 STAR Panel, annual CPUE indices from the domestic fishery after 1998 were excluded from the analysis because changes in management measures are expected to have more influence on the CPUE than changes in stock size. For this assessment, area-weighted CPUE indices were also computed, and comparisons of the assessment results between the indices used in this assessment and the area-weighted indices are presented in Appendix A.

Triennial trawl survey index

The AFSC/NWFSC triennial trawl survey index was not used in the last assessment because of very limited widow catches by the survey and very poor fit of the index in the assessment model (He et al. 2003). The 2003 STAR panel recommended the index be analyzed further and be considered for inclusion in the assessment. Another important reason to include the triennial survey index in the assessment is that the index is likely going to be the only abundance index available in the future because other abundance indices from commercial fisheries will not be suitable for the assessment due to management regulations. The analysis of the triennial survey data uses the similar Delta-GLM method as for other indices, the results are presented in Table 12 and Figure 11, and detailed description of the analysis is in Appendix B.

History of modeling approaches

Previous assessments for widow rockfish have been performed in 1989, 1990, 1993, 1997, 2000, and 2003 (Hightower and Lenarz 1989, 1990; Rogers and Lenarz 1993; Ralston and Pearson 1997, Williams et al 2000, He et al. 2003). In 1989 the assessment involved the use of cohort analysis and the stock synthesis program (Methot 1998). In 1993 and 1997, the age-based version of the stock synthesis program was used to assess the status of widow rockfish. In 2000 and 2003, the assessment of widow rockfish utilized AD Model Builder (ADMB) software (Otter Research, Ltd. 2001), and applied an age-based analysis of the population with methods very similar to those used in the stock synthesis program. The differences between the ADMB model and stock synthesis are minor. The ADMB model estimates landings with a very low coefficient of variation (0.05), while stock synthesis treats landings in a slightly different manner and the initial age composition estimation process is slightly different in the two models. A full description of the ADMB model follows and should clarify any further differences between this model and the stock synthesis program used in past assessments of widow rockfish.

Model description

General

This assessment uses an age-structured population model similar to the one used in the 2003 assessment (He et al. 2003). Full descriptions of the population dynamics, catch equations, and associated likelihood functions are given in Appendix C. The model is written in a C++ software language extension, AD Model Builder (ADMB) (Otter Research, Ltd. 2001), which utilizes automatic differentiation programming (Greiwank and Corliss 1991; Fournier 1996). The ADMB software allows for more rapid and accurate computation of derivative calculations used in the quasi-Newton optimization routine (Chong and Zak 1996). Further advantages of this software include the ability to estimate the variance-covariance matrix for all dependent and independent parameters of interest, likelihood profiling, and a Markov chain-Monte Carlo re-sampling algorithm for probability distribution determination.

The population model begins in 1958 and tracks numbers and catches of male and female widow rockfish in age classes 3-20 (age 20 is an age-plus group). In the 2000 assessment, a starting year of 1968 was chosen based on the assumption that the 1965 year class was the earliest recruitment which could be reasonably estimated given a starting year of 1980 for the age composition information. In the 2003 assessment and this assessment, the starting year was extended backward to 1958 because the new landing data from 1966 to 1972 were added. Recruitment estimates prior to 1958 are assumed equal to the 1958 estimate in the model, so that the model is estimating recruitment at age 3 for the years 1958-1999.

The data used in this model include 4 fishery catch-at-age compositions (sum across sexes equal to one), landings in weight for each fishery, NMFS Santa Cruz Laboratory midwater juvenile survey index, Oregon bottom trawl logbook CPUE, three whiting bycatch indices, and triennial survey indices. Predicted catch in each year is scaled to the fishery landings assuming a coefficient of variation of 5%. Double logistic selectivity functions by age were estimated for each fishery.

Natural mortality

Natural mortality (M) is assumed to be constant for all ages and in all years. The initial model allowed the model to estimate a slightly higher natural mortality for males than females based on the observation that there were more old females than males in the age data. The model was presented to the 2003 STAR Panel. It was noted that greater proportions of males at younger ages could be due to differences in selectivity by gender. Allowing for different natural mortality had little impact on model results and the differences in M were small (<0.01). The 2003 STAR Panel considered that until the reason for the difference in age composition has been elucidated, the same natural mortality value should be used for both sexes. Therefore, natural mortality was fixed at 0.15 for the 2003 assessment. The 2005 STAR Panel requested that natural mortality be estimated in the model. After a series of model runs, it was decided natural mortality to be fixed at 0.125 for the base model, and two other values (0.11 and 0.15) to be used in alternative models to embrace uncertainties of model estimates.

Age compositions

The age data are modeled as multinomial random variables, with the year-specific sample sizes set equal to the number of samples collected, rather than the number of fish, which often overstates the confidence of the data (Table 8) (Quinn and Deriso 1999). However, this assessment also examined an iterative-reweighting method to determine the effective sample size in the likelihood functions (details in the Likelihood component weighting section).

Ageing error

The only information available for determination of ageing error was based on two point estimates of percent ageing agreement from the last two assessments (Rogers and Lenarz 1993; Ralston and Pearson 1997). From the previous assessments an estimate of 75% agreement for age 5 fish and 66% agreement for age 20 fish was modeled by assuming a linear relationship of percent agreement with age. These estimates of percent agreement at age were then fit to a set of age-specific normal distributions, which approximated the level of ageing agreement. The resulting matrix of true age versus reader age was then placed in the model

$$A_t = EA_r \qquad (8)$$

where A_t and A_r are n*n matrices for true age and reader age, respectively, n is number of age classes, and E is a n*n matrix for ageing error with the sum across each column equals to one.

Landings

A constant CV of 0.05 is assumed for landing estimates. Year-specific fishing mortalities are computed for each fishery for those years in which there are landings estimates available. Fishing mortalities were zero from 1958 to 1965 since there are no landings estimates for those years.

Fraction of landings in the north

Since there are area specific (north and south) estimates for weight-at-age and maturity, it is necessary to determine the fraction of the population to which each of these area-specific estimates apply. We used the sum of the domestic landings in the Vancouver-Columbia and both Oregon trawl fisheries relative to the total landings as an estimate of the proportion of the population to which the northern weight-at-age and maturity functions could be applied. Foreign landings from 1966 to 1976 from Rogers (2003) were not used in computing the fractions. The annual change in this fraction seemed highly variable and not likely to be indicative of true declines in area abundances. For this reason, the time series of proportions of landings in the north were smoothed using a 7-year moving average (Figure 12). The results from the moving average were then put directly into the model, applying the 1973 value to the earlier years.

Discards

The level of discards of widow rockfish is virtually unknown in most of years. Age compositions in discards and landings can be very different (typically small fish are discarded) and can be important in determining discard rates (Williams et al. 1999). In past assessments a value of 6% of total weight was assumed for years 1958-1982 and 16% of total weight for the years 1983-2002 (Hightower and Lenarz 1990, Williams et al. 2000, He et al. 2003). The same discard rates (16%) were also applied for the years 2003-2004 in this assessment. The 16% estimate of discards is based on a dated study by Pikitch et al. (1988), which indicated most of the discards of widow rockfish were induced by regulations. The earlier 6% estimated is based on an ad hoc adjustment of the 16% by previous assessment authors (Hightower and Lenarz 1990). The 16% assumed value has likely become more uncertain in recent years due changes in regulations. For example, the most recent estimate on discard rate from the 2002 observer data, based on 89mt of widow rockfish catch, was 0.1%, which is much lower than the 16% assumed value.

Midwater juvenile trawl survey

The Santa Cruz Laboratory midwater trawl juvenile survey is scaled to represent an index of 100 day-old larvae. For inclusion in the model the time series was lagged to correspond with the appropriate year class. Within the model a catchability coefficient is estimated. In past assessments (Williams et al. 2002, He et al. 2003), a power coefficient was used for the midwater trawl survey. The power transformation was included to account for possible density dependent mortality occurring between 100 days of age and age 3 (the age of recruitment in the model), which likely results in higher variance levels in the survey time series relative to age 3 recruitment time series. However, the 2003 STAR panel argued that using power coefficient might dampen the estimate of recruitment variability. In this assessment, the power transformation is re-examined (see details in the Model Selection section). Test runs also showed that the results were only slightly different between using the power coefficient of 1.0 and 3.0, which was the default value in the 2003 assessment.

Logbook and bycatch indices

The Oregon bottom trawl logbook indices and whiting bycatch indices are treated as biomass indices and are estimated in the model with a catchability parameter for each index. Because there were no new data since the 2003 assessment, the same Oregon bottom trawl logbook indices from the last assessment are used in this assessment. The whiting bycatch indices are recalculated according to the 2003 STAR panel recommendations, however the results are very similar. Details on the calculations of the whiting bycatch indices using Delta-GLM methods are in Appendix A.

Calculation of depletion rate

Depletion rate is calculated as ratio of current spawning output over unfished spawning output. In the 2003 assessment, the depletion rate was calculated as ratio of the 2002 spawning output over the 1958 (first year in the model) spawning output. In this assessment, we calculate depletion rates using the same method as in the 2003 rebuilding analysis (He et al. 2003), which used the average of spawning outputs from 1958 to 1982 as unfished spawning output. This same calculation method will also be used for rebuilding analysis in 2005.

Likelihood component weighting

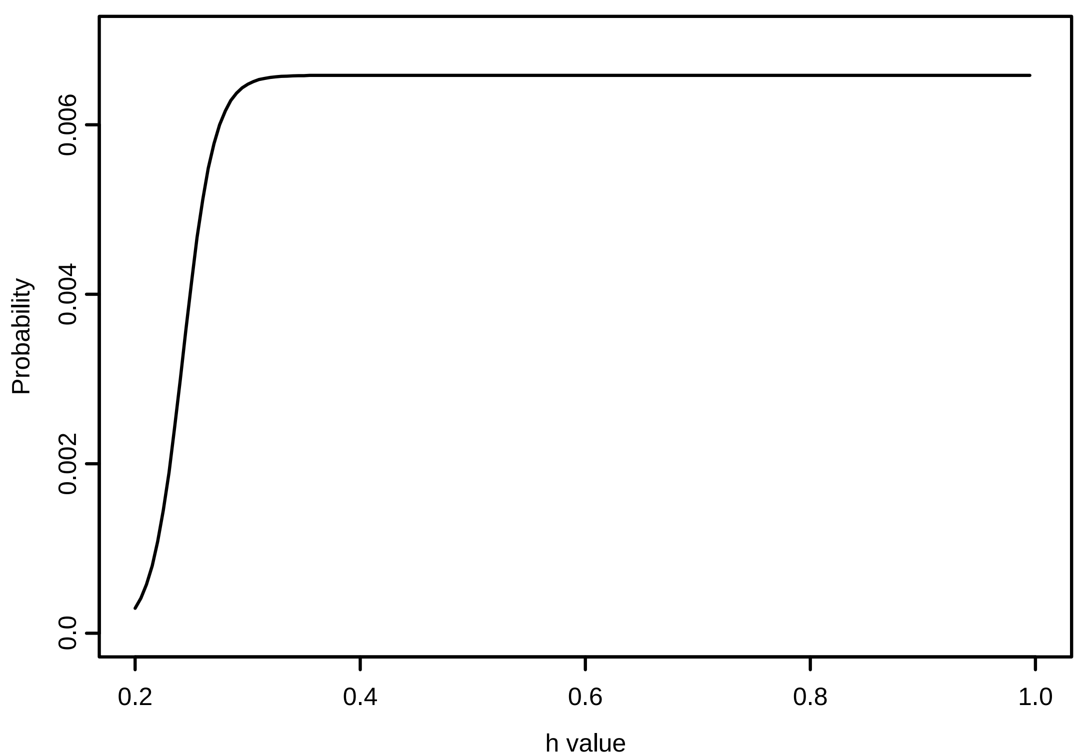
There are nine likelihood components in the model (Appendix C): age-composition data, landings, recruitment residuals, midwater juvenile trawl survey index, four fisheries CPUE indices, and triennial survey indices. Weighting in this assessment model has two levels. First, contribution of each datum point to its likelihood component is weighted by a fixed CV associated with the datum point. Details on how a fixed CV is determined for each component are discussed later. Second, a weighting factors (λ) is assumed for each likelihood component and the final likelihood value for each component is multiplied by its weighting factor (Appendix C). In this assessment model, all weighting factor (λ) have been set to 1, except for the recruitment residual component and the midwater juvenile survey index component, whose weighting factors are 0.5.

For age composition data, this assessment examines an iterative-reweighting method to determine the effective sample size in the likelihood functions (McAllister and Ianelli 1997, Maunder, in preparation) for each year in each fishery. Initial sample size for each age composition data is taken directly from real sample sizes of the fishery. After the model is fitted to the data, the observed and predicted proportions at age are used in the following equation to calculate effective sample size (T):

$$T = \frac{\sum_a \hat{p}_a \left(1 - \hat{p}_a\right)}{\sum_a \left(p_a - \hat{p}_a\right)^2} \qquad (9)$$

where $\hat{p}_a$ is the predicted proportion and p_a is the observed proportion at age a. The new sample size is then used in the model and the model is re-run. This process is repeated until the change in effective sample size is less than one percent between two consecutive runs. Because the sample size can differ substantially from year to year in a fishery, a linear regression of effective sample size versus observed sample size is used to obtain predicted effective sample size (MacCall 2003), which is then used in each iteration of the model run.

A prior for the steepness parameter in the stock-recruitment relations is also added in the likelihood functions (He at al. in review). The prior is based on a persistence principle that persistence of any species, given its life history and its exposure to recruitment variability, requires a minimum recruitment compensation that enables the species to rebound consistently from very low abundances. The prior curve for widow rockfish-like species has the following form:



A logistic equation that fits well with the curve is used in the likelihood function of the assessment model.

Model selection and evaluation

Initial model runs were performed using the same base model in the 2003 assessment (He et al. 2003), but with the new 2003 and 2004 data. After a series of sensitivity analysis and model examinations during the 2005 STAR Panel review, a final base model was selected (Model T2). It added new CPUE indices and used some new methods in the assessment model. These include:

- AFSC triennial bottom survey indices from 1977 to 2004 are included;
- Depletion rate is computed in the same way as in the 2003 rebuilding analysis (He et al. 2003);
- Power coefficient of midwater juvenile survey index is estimated instead of using a fixed value;
- An informative prior for recruitment steepness is included in the likelihood functions (He et al., in review);
- Sample sizes for age composition data are replaced by effective sample sizes.

Base model results

Results of the base model (Model T2) run are presented in Tables 13-14 and Figures 13-27. The resulting time series of total biomass, spawning biomass, spawning output, recruitment, and fishing mortality are presented in Table 13 and Figures 13-16. Estimated parameter values and their standard deviations are presented in Table 14. The fishery-specific selectivity curves are shown in Figure 17. The stock-recruitment relationship is shown in Figure 18. The fits to the landings are shown in Figures 19-20, and the fits to the various indices are shown in Figures 21-26. The fits of the age composition data are shown in Figure 27.

Uncertainty and sensitivity analysis

Sensitivity analysis was done by comparing results between base model and three other models. Key features for four models are listed below:

Model name	Recruitment steepness	Natural mortality	Selectivity
Model T1	0.45	0.125	Double logistic / logistic
Model M015	0.25	0.15	Double logistic
Model T2 (base model)	0.28	0.125	Double logistic
Model M011	0.32	0.11	Double logistic

These features were selected during the 2005 STAR Panel review to embrace uncertainties in model specifications and parameter estimates, especially for important parameter such as natural mortality. Biomass trends between the 2003 assessment base model and this assessment's base model were compared (Figure 28). It is noted that the 2003 assessment estimated lower biomass between 1975 and 2002 than this assessment, and that the 2003 assessment estimated continuous decline of biomass during recent years while this assessment estimated an increase of biomass from 2001 to 2002.

Table 15 and Figures 29-31 show results of comparisons between base model and three alternative models. Table 14 also shows comparisons of depletion rates using different computation methods between the 2003 assessment and this assessment. Model T1, which uses logistic selectivity for the Vancouver-Columbia and Eureka-Conception fisheries before 1983, had the least number of parameters. This model estimated that the population was most depleted (depletion = 25.28%), but with the highest recruitment steepness (h =0.4515). This model also estimated the lowest overall biomass and recruitments (Table 14, Figures 29 and 30). Model M015, which assumes natural mortality of 0.15 as used in previous assessments, estimated similar depletion (25.78%) as Model T1, but with the lowest recruitment steepness (h =0.2540). Model T2 (base model) has the same number of parameters as Model M015 and Model M011, and estimated intermediate depletion and recruitment steepness. Model M011, which assumes natural mortality of 0.11, estimated the population was least depleted (depletion = 38.49%), and with moderate high recruitment steepness (h =0.3161). Recruitments in recent years were very similar among Model T1, Model T2, and Model M015 (Figure 30). Historical depletion rates for all models are presented in Figure 31. It shows that the population was never depleted below the overfished threshold (25%) in Model T1, Model M011, and Model M015, but the population was overfished between 2001 and 2003. The depletion rates estimated by Model T1 were 23.4%, 23.0%, and 23.8% for 2001, 2002, and 2003, respectively.

Rebuilding parameters

Unfished spawning output (B_0) was calculated as an average from the first year (1958) to 1982, which is the same period used in the 2003 rebuilding analysis (He et al. 2003). Other rebuilding parameters were calculated in the same way as in the 2003 assessment. A separate C++ program was written (embedded in the ADMB program) to produce a data file (“rebuild.dat”) that can be directly inputted into the rebuilding program written by Punt (2005).

Status of the stock

The percentage ratio of spawning output in 2004 to B_0 is the population status. The point estimate, from the base model run, for the population status in 2004 is 31.09% (Table 15). Given that the population was declared as an overfished stock in previous assessments (Williams 2000, He et al. 2003), and the population status is within the precautionary zone (>25% and <40%), rebuilding analysis is needed to determine harvest projections and target fishing mortalities.

Management Recommendations

The stock has declined since fishing began in the later 1970’s. The 2003 assessment showed that the spawning output in 2002 was just below 25% of unfished spawning output. This assessment shows that the spawning output in 2004 was within the precautionary zone. Therefore, it is necessary to conduct rebuilding analysis to determine harvest levels and related risks of each harvest levels (He et al. 2003).

Future research

1. There are increasingly fewer reliable abundance indices for widow rockfish. Recent management measures have undermined the ability to continue fishery dependent time series of relative abundance from the Oregon bottom trawl fishery and Pacific whiting fishery since 1999. The constant flux of the management regime suggests that there is little likelihood that meaningful CPUE indices can be developed from these fisheries in the future. The triennial bottom trawl survey may be the only data that can provide abundance indices in the future. More analysis should be done to either calibrate or compare triennial survey results with those from the NWFSC Combined survey.
2. The long-term recruitment index is a key datum series in the stock assessment. Continuation of the midwater juvenile trawl survey and recent increases in sampling intensity and spatial coverage will improve estimation confidence and data quality. Comparison and possibly integration of the existing juvenile survey results with a recently initiated survey by the fishing industry (Vidar Wespestad, pers. comm.) could also broaden the spatial extent of this index. The ability to infer direct and indirect estimates of year class strengths from surveys and other sources, as well as to better understand the relationship between environmental conditions in the California Current System, should improve short-term forecasts of productivity, biomass levels and allowable catches from stock assessments.
3. Preliminary information from recent bycatch monitoring suggests that discards may have decreased substantially compared to the assumed 16% currently used. New discard data should be analysed and, if warranted, past discard estimates should be adjusted.
4. The utility of hydro-acoustic surveys on widow rockfish abundance should be evaluated in future assessments.
5. Sample sizes for existing age-collection programs (by fishery and survey) should be increased substantially.
6. The age-composition for the triennial survey should be determined by applying year-specific age-length keys to the survey length-frequencies, and included in future assessments as a basis for estimating survey selectivity.

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Literature Cited

Adams, P.B. 1987. The diet of widow rockfish *Sebastes entomelas* in northern California, pp. 37-41. *In*: W.H. Lenarz and D.R. Gunderson (eds.), Widow rockfish, proceedings of a workshop, Tiburon, California, December 11-12, 1980. NOAA Tech. Rep. NMFS 48.

Adams, P.B., editor. 1995. Progress in rockfish recruitment studies. Southwest Fisheries Science Center Administrative Report, Tiburon Laboratory, T-95-01.

Barss, W.H. and T.W. Echeverria. 1987. Maturity of widow rockfish *Sebastes entomelas* from the northeastern Pacific, 1977-82, pp. 13-18. *In*: W.H. Lenarz and D.R. Gunderson (eds.), Widow rockfish, proceedings of a workshop, Tiburon, California, December 11-12, 1980. NOAA Tech. Rep. NMFS 48.

Boehlert, G.W., W.H. Barss, and P.B. Lamberson. 1982. Fecundity of widow rockfish, *Sebastes entomelas*, off the coast of Oregon. Fish. Bull. 80:881-884.

Burnham, K.P. and D.R. Anderson. 1998. Model selection and inference a practical information-theoretic approach. Springer-Verlag New York Inc., NY.

Chong, E.K.P. and S.H. Zak. 1996. An introduction to optimization. John Wiley & Sons, Inc., New York.

Dorn, M.W., M.W. Saunders, C.D. Wilson, M.A. Guttormsen, K. Cooke, R. Kieser, and M.E. Wilkins. 1999. Status of the coastal Pacific hake/whiting stock in U.S. and Canada in 1998. *In*: Appendix to the status of the Pacific coast groundfish fishery through 1999 and recommended acceptable biological catches for 2000, stock assessment and fishery evaluation. Pacific Fishery Management Council, Portland, OR.

Eschmeyer, W.N., E.S. Herald, and H. Hammann. 1983. A field guide to Pacific coast fishes of North America. Houghton Mifflin Company, Boston, 336p.

Field, J.C. and S.V. Ralston. In press. Spatial variability in California current rockfish recruitment events. Can. J. Fish. Aquat. Sci.

Fournier, D. 1996. An introduction to AD Model Builder for use in nonlinear modeling and statistics. Otter Research Ltd., Sidney, British Columbia, Canada.

Greiwank, A. and G.F. Corliss, editors. 1991. Automatic differentiation of algorithms: theory, implementation and application. Proceedings of the SIAM Workshop on the Automatic Differentiation of Algorithms, Soc. Indust. And Applied Mathematics, Philadelphia.

Gunderson, D.R. 1984. The great widow rockfish hunt of 1980-82. N. Am. J. Fish. Man. 4:465-468.

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

He, X., A. Punt, A.D. MacCall, and S. Ralston. In preparation. Rebuilding analysis for widow rockfish in 2005.

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

He, X., M. Mangel, and A.D. MacCall. In review. A prior for steepness based on a persistence principle. Submitted to Fishery Bulletin.

Hightower, J.E. and W.H. Lenarz. 1990. Status of the widow rockfish stock in 1990. *In*: Status of the Pacific coast groundfish fishery through 1990 and recommended biological catches for 1991 (Appendix F, Volume 2). Pacific Fishery Management Council, Portland, OR.

Lenarz, W.H. 1987. Ageing and growth of widow rockfish, pp. 31-35. *In*: W.H. Lenarz and D.R. Gunderson (eds.), Widow rockfish, proceedings of a workshop, Tiburon, California, December 11-12, 1980. NOAA Tech. Rep. NMFS 48.

MacCall, A.D., S. Ralston, D. Pearson, and E.H. Williams. 1999. Status of bocaccio off California in 1999 and outlook for the next millennium. *In*: Appendix to the status of the Pacific coast groundfish fishery through 1999 and recommended acceptable biological catches for 2000, stock assessment and fishery evaluation. Pacific Fishery Management Council, Portland, OR.

MacCall, A.D. 2003. Status of bocaccio off California in 2003. Status of the Pacific coast groundfish through 2003, stock assessment and fishery evaluation, Volume I. Pacific Fisheries Management Council, August 2003.

Maunder, M.N. in preparation. Determing the effective sample size for over-dispersed multinomial data: Appliation to catch-at-age data used in stock assessment models. Inter-American Tropical Tuna Commission, La Jolla, California.

McAllister, M.K. and J.N. Ianelli. 1997. Bayesian stocak assessment using catch-at-age data and the sampling-importance resampling algorithm.. Can. J. Fish. Aquat. Sci. 52:284-300.

Methot, R.D. 1998. Technical description of the stock synthesis assessment program. Unpublished manuscript. NOAA, NMFS, Northwest Fisheries Science Center, Seattle, Washington. 48 p.

Pearson, D.E. 1996. Timing of hyaline-zone formation as related to sex, location, and year of capture in otoliths of the widow rockfish, *Sebastes entomelas*. Fish. Bull. 94:190-197.

Pearson, D.E. and J.E. Hightower. 1991. Spatial and temporal variability in growth of widow rockfish (*Sebastes entomelas*). NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFSC-167, 43 p.

Pearson, D.E. and B. Erwin. 1997. Documentation of California's commercial market sampling data entry and expansion programs. NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFSC-240, 62 p.

Pennington, M. 1986. Some statistical techniques for estimating abundance indices from trawl surveys. Fishery Bulletin, 84:519-525.

Pennington, M. 1996. Estimating the mean and variance from highly skewed marine data. Fishery Bulletin, 94:498-505.

Pikitch, E.K., D.L. Erickson, and J.R. Wallace. 1988. An evaluation of the effectiveness of trip limits as a management tool. Northwest and Alaska Fisheries Center, NWAFC Processed Rep. 88-27.

Punt, A.E. 2005. SSC default rebuilding analysis. Technical specifications and user manual. Version 2.8a, April 2005. University of Washington, Seattle, Washington.

Otter Reaserach Ltd. 2001. AD Model Builder. Otter Research Ltd, Sydney B.C., Canada.

Quinn, T.J., II and R.B. Deriso. 1999. Quantitative fish dynamics. Oxford University Press, Inc., New York.

Quirollo, L.F. 1987. Review of data on historical catches of widow rockfish in northern California, pp. 7-8. *In*: W.H. Lenarz and D.R. Gunderson (eds.), Widow rockfish, proceedings of a workshop, Tiburon, California, December 11-12, 1980. NOAA Tech. Rep. NMFS 48.

Ralston, S. 1999. Trends in standardized catch rate of some rockfishes (*Sebastes* spp.) from the California trawl logbook database. Southwest Fisheries Science Center, Administrative Report SC-99-01.

Ralston, S. and D.F. Howard. 1995. On the development of year-class strength and cohort variability in two northern California rockfishes Fish. Bull. 93:710-720.

Ralston, S., J.N. Ianelli, R.A. Miller, D.E. Pearson, D. Thomas, and M.E. Wilkins. 1996. Status of bocaccio in the Conception/Monterey/Eureka INPFC areas in 1996 and recommendations for management in 1997. *In*: Status of the Pacific coast groundfish fishery through 1996 and recommended acceptable biological catches for 1997, Pacific Fishery Management Council, Portland, OR.

Ralston, S. and D. Pearson. 1997. Status of the widow rockfish stock in 1997. *In*: Status of the Pacific coast groundfish fishery through 1997 and recommended acceptable biological catches for 1998. Pacific Fishery Management Council, Portland, OR.

Ralston, S., D.E. Pearson, and J.A. Reynolds. 1998. Status of the chilipepper rockfish stock in 1998. *In*: Appendix to the status of the Pacific coast groundfish fishery through 1998 and recommended acceptable biological catches for 1999, stock assessment and fishery evaluation. Pacific Fishery Management Council, Portland, OR.

Rogers, J.B. and W.H. Lenarz. 1993. Status of the widow rockfish stock in 1993. *In*: Status of the Pacific coast groundfish fishery through 1993 and recommended acceptable biological catches for 1994. Pacific Fishery Management Council, Portland, OR.

Rogers, J.B. 2003. Species allocation of Sebastes and Sebastolobus sp. Caught by foreign contries of Washington, Oregon, and California, U.S.A. in 1965-1976. NMFS, Northwest Science Center.

Sampson, D.B. and P.R. Crone, editors. 1997. Commercial fisheries data collection procedures for U.S. Pacific coast groundfish. NOAA Tech. Memo. NMFS, NMFS-NWFSC-31, 189 p.

STAR Panel Report. 2005. Widow rockfish. Submitted to the Pacific Fishery Management Council, Portland, OR. August 2005.

Stefansson, G. 1996. Analysis of groundfish survey abundance data: combining the GLM and delta approaches. ICES Journal of Marine Sciences, 53:577-588.

Wilkins, M.E. 1986. Development and evaluation of methodologies for assessing and monitoring the abundance of widow rockfish, *Sebastes entomelas*. Fish. Bull. 84(2):287-310.

Williams, E.H., S. Ralston, A.D. MacCall, D. Woodbury, and D.E. Pearson. 1999. Stock assessment of the canary rockfish resource in the waters off southern Oregon and California in 1999. *In*: Appendix to the status of the Pacific coast groundfish fishery through 1999 and recommended acceptable biological catches for 2000, stock assessment and fishery evaluation. Pacific Fishery Management Council, Portland, OR.

Williams, E.H., A.D. MacCall, S. Ralston, and D.E. Pearson. 2000. Status of the widow rockfish resource in Y2K. *In*: Appendix to the 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, Portland, OR.

Table 1. U.S. total landings (mt) of widow rockfish by four fisheries from 1966 to 2004.

Year	Vancouver, Columbia	Oregon Midwater Trawl	Oregon Bottom Trawl	Eureka, Monterey, and Conception	Total
1966	3670			96	3766
1967	3900			249	4149
1968	1693			336	2029
1969	356			21	377
1970	554			0	554
1971	701			0	701
1972	410			13	423
1973	617			207	824
1974	293			280	573
1975	454			358	812
1976	948			412	1360
1977	1318			883	2201
1978	605			502	1107
1979	966			2326	3292
1980	16190			5666	21856
1981	21779			5227	27007
1982	14802			11245	26047
1983	3222	1452	1488	4325	10487
1984	1450	3568	1334	3506	9858
1985	1537	3185	871	3570	9163
1986	2559	2977	1171	2800	9507
1987	3722	4985	1169	3035	12911
1988	3078	4102	1121	2183	10484
1989	3378	4871	1971	2266	12486
1990	2241	3235	2167	2579	10222
1991	1176	1846	1940	1369	6331
1992	946	1149	2624	1331	6051
1993	1747	1755	3386	1347	8235
1994	1074	1678	2382	1248	6384
1995	1087	1394	2278	1944	6703
1996	965	1464	2114	1529	6072
1997	1016	1523	2245	1707	6492
1998	563	758	1330	1304	3955
1999	525	1721	794	902	3943
2000	380	2276	16	1141	3813
2001	302	966	39	505	1812
2002	65	155	6	51	276
2003	16	8	0	5	28
2004	30	12	2	28	73

Table 2. Management performance in obtaining the harvest guideline for widow rockfish. Harvest guideline and allowable biological catch (ABC) are taken from Council documents.

Year	Harvest Guideline	Allowable Biological Catch	Landings
1989	12100	12400	12486
1990	12400	8900	10222
1991	7000	7000	6331
1992	7000	7000	6051
1993	7000	7000	8235
1994	6500	6500	6384
1995	6500	7700	6703
1996	6500	7700	6072
1997	6500	7700	6492
1998	5090	5750	3955
1999	5090	5750	3943
2000	5090	5750	3813
2001	2300	3727	1812
2002	856	3727	276
2003	832	3871	28
2004	284	3460	73
2005	284	3460	

Table 3. Chronology of the regulatory history of widow rockfish by the Pacific Fishery Management Council.

Date	Regulation
10/13/82	75,000 lb trip limit
1/30/83	30,000 lb trip limit
9/10/83	1,000 lb trip limit
1/1/84	50,000 lb trip limit once per week
5/6/84	40,000 lb trip limit once per week
8/1/84	closed fishery with 1,000 trip limit for incidental catch
9/9/84	closed fishery
1/10/85	30,000 lb trip limit once a week or 60,000 lb trip limit once per two weeks, unlimited trips of less than 3,000 lbs
4/28/85	dropped 60,000 lb biweekly option
7/21/85	3,000 lb trip limit, unlimited number of trips
1/1/86	30,000 lb trip limit, only one weekly landing greater than 3,000 lbs
9/28/86	3,000 lb trip limit, unlimited number of trips
1/1/87	30,000 lb trip limit, only one weekly landing greater than 3000 lbs
11/25/87	closed fishery
1/1/88	30,000 lb trip limit, only one weekly landing greater than 3000 lbs, unlimited number of trips less than 3,000 lbs
9/21/88	3,000 lb trip limit, unlimited number of trips
1/1/89	30,000 lb trip limit, only one weekly landing greater than 3,000 lbs
4/26/89	10,000 lb trip limit once per week
10/11/89	3,000 lb trip limit with unlimited number of trips
1/1/90	15,000 lb trip limit once per week or 25,000 lb trip limit once per two weeks with only one landing greater than 3,000 lbs each week
12/12/90	closed fishery
1/1/91	10,000 lb trip limit per week or 20,000 lb trip limit every two weeks with only one landing greater than 3,000 lbs per week
9/25/91	3,000 lb trip limit with unlimited number of trips
1/1/92	30,000 lbs cumulative landings every 4 weeks
5/9/92	change from 3" mesh to 4.5" mesh in codend for roller gear north of Point Arena
8/12/92	3,000 lb trip limit with unlimited number of trips
12/2/92	30,000 lb cumulative trip limit per 4 weeks
12/1/93	3,000 lb trip limit with unlimited number of trips
1/1/94	30,000 lb cumulative limit per calender month
12/1/94	3,000 lb trip limit with unlimited number of trips
1/1/95	30,000 lb cumulative limit per calender month
4/14/95	45,000 lb cumulative limit per calender month
9/8/95	4.5" mesh applies to entire net and bottom trawl
1/1/96	70,000 lb cumulative limit per two months
9/1/96	50,000 lb cumulative limit per two months
11/1/96	25,000 lb cumulative limit per two months
1/1/97	70,000 lb cumulative limit per two months
5/1/97	60,000 lb cumulative limit per two months
1/1/98	limited entry: 25,000 lb cumulative per two month period, open access: 12,500 lb cumulative per two month period
5/1/98	limited entry: 30,000 lb cumulative per two month period

Table 3 (continued). Chronology of the regulatory history of widow rockfish by the Pacific Fishery Management Council.

Date	Regulation
7/1/98	open access: 3,000 lb cumulative per month
10/1/98	limited entry: 19,000 cumulative per month
1/1/99	limited entry: cumulative limits: phase 1 - 70,000 lbs per period, phase 2 - 16,000 lbs per period, phase 3 - 30,000 lbs per period. Open access: 2,000 lbs per month
5/1/99	limited entry: decrease phase 2 and phase 3 limits to 11,000 lbs
7/2/99	open access: 8,000 lb cumulative limit per month
10/1/99	limited entry: vessels in Oregon and Washington using 30,000 lb cumulative monthly limit must have midwater trawl gear aboard or a state cumulative limit will be imposed
1/1/00	Widow rockfish classified as a shelf species for regulatory purposes, 30,000 lbs/2 months for limited entry trawl, 3,000 lbs/month for limited entry fixed gear and open access
1/1/01	20,000 lbs/2 months for months of Jan-Apr and Sep-Oct; otherwise 10,000 lbs/2 months for midwater limited entry. 1,000 lbs/months for small footrope limited entry. 3,000 lbs/month for fixed gear limited entry. Open access: north - 3,000 lbs/month, south - 3,000 lbs per month with some monthly closures in some areas.
7/1/01	North - limited entry midwater trawl limits: 1,000 lbs/month
10/1/01	closed fishery for all except midwater, which may land 2,000 lbs/month in north for October, then 25,000 lbs/2 months.
1/1/02	North - limited entry trawl: closed through November to midwater trawl except for small bycatch in whiting fishery, in November 13,000 lbs/2 month with no more than 2 trips, small footrope trawl1000 lbs/month through September, then closed Sept-Oct, then 500 lbs/month Nov-Dec. South - limited entry trawl: midwater closed year round except for a small bycatch in the whiting fishery, small footrope trawl 1,000 lbs/month through July, then closed
1/1/03	North - limited entry trawl: midwater trawl closed through November except for small amount of bycatch in whiting fishery, 12,000 lbs/2 months for Nov-Dec. small footrope trawl - 300 lbs/month Jan-Apr and Nov-Dec, 1000 lbs/month May-Oct. North - limited entry fixed gear: 200 lbs/month. North - open access gear: 200 lbs/month. South - limited entry trawl: same as north for midwater and small footrope trawl. South - limited entry fixed gear: closed Mar-Apr, then variable 100 lbs/2 months to 250 lbs/2 months. South - - open access gear: same as limited entry fixed gear.
1/1/04	North - limited entry trawl: midwater trawl closed through November except for small amount of bycatch in whiting fishery (500 lbs/month during primary whiting season; combined widow and yellowtail trip limit of 500 lbs/trip with trips of at least 10,000 lbs of whiting), 12,000 lbs/2 months for Nov-Dec. small footrope trawl - 300 lbs/month Jan-Apr and Nov-Dec, 1000 lbs/month May-Oct. North - limited entry fixed gear: 200 lbs/month. North - open access gear: 200 lbs/month. South - limited entry trawl: closed. South - limited entry fixed gear between 40°10' and 34°27' N lat.: 300 lbs/2 months Jan-Feb and Sep-Dec, closed Mar-Apr, 200 lbs/2 months May-Aug. South - limited entry fixed gear south of 34°27' N lat.: closed Jan-Feb, 2,000 lbs/2 months Mar-Dec. South - - open access gear between 40°10' and 34°27' N lat.: same as limited entry fixed gear. South – open access gear south of 34°27' N lat.: closed Jan-Feb, 500 lbs/2 months Mar-Dec.

Table 3 (continued). Chronology of the regulatory history of widow rockfish by the Pacific Fishery Management Council.

Date	Regulation
1/1/05 (regs. for 2005 and 2006)	North - limited entry trawl: large and small footrope trawl- 300 lbs/2 months; midwater trawl- closed except for small amount of bycatch in whiting fishery (500 lbs/month during primary whiting season; combined widow and yellowtail trip limit of 500 lbs/trip with trips of at least 10,000 lbs of whiting); selective flatfish trawl - 300 lbs/month Jan-Apr and Nov-Dec, 1000 lbs/month May-Oct. North - limited entry fixed gear: 200 lbs/month. North - open access gear: 200 lbs/month. South - limited entry trawl: large footrope and midwater trawl- closed; small footrope trawl- 300 lbs/month. South - limited entry fixed gear between 40°10’ and 34°27’ N lat.: 300 lbs/2 months Jan-Feb and Sep-Dec, closed Mar-Apr, 200 lbs/2 months May-Aug. South - limited entry fixed gear south of 34°27’ N lat.: 2,000 lbs/2 months Jan-Feb and May-Dec, closed Mar-Apr. South - - open access gear between 40°10’ and 34°27’ N lat.: same as limited entry fixed gear. South – open access gear south of 34°27’ N lat.: 500 lbs/2 months Jan-Feb and May-Dec, closed Mar-Apr.
7/1/05	South - limited entry fixed gear south of 34°27’ N lat.: 3,000 lbs/2 months Jul-Dec. South – open access gear south of 34°27’ N lat.: 750 lbs/2 months Jul-Dec.

Table 4a. Propotional age composition of males for the Vancouver-Columbia fishery with the sum across sexes equal to 1. Data are from 1980 to 2004.

	Age																
Year	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1980	0.000	0.000	0.009	0.022	0.020	0.056	0.096	0.111	0.046	0.029	0.012	0.013	0.006	0.004	0.002	0.002	0.001	0.003
1981	0.000	0.007	0.024	0.064	0.046	0.024	0.048	0.088	0.068	0.047	0.026	0.017	0.012	0.005	0.004	0.003	0.003	0.009
1982	0.000	0.008	0.030	0.084	0.031	0.045	0.021	0.021	0.033	0.072	0.045	0.034	0.035	0.021	0.014	0.009	0.005	0.017
1983	0.000	0.008	0.154	0.113	0.028	0.017	0.014	0.013	0.014	0.018	0.020	0.015	0.015	0.009	0.006	0.007	0.006	0.020
1984	0.000	0.003	0.054	0.161	0.083	0.033	0.014	0.004	0.006	0.007	0.008	0.013	0.013	0.011	0.007	0.008	0.008	0.029
1985	0.000	0.008	0.075	0.080	0.125	0.066	0.022	0.009	0.004	0.006	0.005	0.006	0.005	0.003	0.006	0.005	0.003	0.028
1986	0.000	0.007	0.060	0.174	0.075	0.049	0.014	0.006	0.005	0.005	0.003	0.003	0.005	0.006	0.003	0.002	0.002	0.029
1987	0.000	0.006	0.024	0.120	0.194	0.046	0.013	0.009	0.003	0.004	0.006	0.004	0.003	0.004	0.004	0.002	0.002	0.011
1988	0.000	0.000	0.015	0.060	0.137	0.199	0.035	0.013	0.005	0.002	0.001	0.003	0.003	0.001	0.000	0.001	0.001	0.014
1989	0.000	0.003	0.018	0.093	0.095	0.157	0.087	0.009	0.004	0.001	0.000	0.001	0.000	0.001	0.000	0.000	0.002	0.008
1990	0.000	0.000	0.025	0.077	0.153	0.068	0.097	0.030	0.011	0.005	0.001	0.000	0.000	0.000	0.001	0.001	0.001	0.007
1991	0.000	0.001	0.010	0.062	0.114	0.107	0.074	0.044	0.050	0.010	0.004	0.003	0.002	0.001	0.004	0.001	0.001	0.018
1992	0.000	0.003	0.020	0.031	0.072	0.077	0.082	0.049	0.052	0.029	0.020	0.008	0.005	0.003	0.002	0.000	0.001	0.012
1993	0.000	0.000	0.016	0.058	0.051	0.063	0.057	0.035	0.029	0.031	0.023	0.020	0.012	0.007	0.005	0.004	0.002	0.013
1994	0.000	0.001	0.011	0.041	0.087	0.057	0.045	0.037	0.028	0.023	0.026	0.016	0.013	0.011	0.005	0.004	0.003	0.017
1995	0.001	0.010	0.031	0.056	0.096	0.100	0.064	0.029	0.031	0.019	0.015	0.024	0.010	0.007	0.006	0.007	0.002	0.012
1996	0.001	0.012	0.059	0.112	0.104	0.058	0.033	0.018	0.013	0.010	0.008	0.006	0.008	0.002	0.003	0.003	0.002	0.008
1997	0.000	0.003	0.037	0.149	0.129	0.050	0.015	0.010	0.006	0.007	0.007	0.008	0.001	0.003	0.003	0.001	0.001	0.004
1998	0.000	0.001	0.014	0.043	0.146	0.110	0.040	0.015	0.007	0.009	0.008	0.003	0.002	0.002	0.007	0.001	0.000	0.006
1999	0.000	0.002	0.011	0.041	0.081	0.107	0.082	0.041	0.023	0.010	0.010	0.009	0.005	0.005	0.004	0.005	0.002	0.005
2000	0.000	0.000	0.005	0.058	0.113	0.071	0.073	0.073	0.038	0.013	0.012	0.005	0.002	0.009	0.006	0.003	0.002	0.005
2001	0.000	0.000	0.004	0.051	0.126	0.084	0.062	0.054	0.037	0.039	0.033	0.008	0.017	0.006	0.006	0.006	0.002	0.006
2002	0.000	0.002	0.020	0.025	0.057	0.097	0.063	0.052	0.024	0.025	0.011	0.014	0.002	0.002	0.005	0.002	0.002	0.003
2003	0.000	0.003	0.060	0.080	0.084	0.060	0.017	0.003	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.000	0.035	0.102	0.044	0.040	0.028	0.010	0.013	0.005	0.003	0.005	0.003	0.002	0.103	0.003	0.000	0.106

Table 4b. Propotional age composition of females for the Vancouver-Columbia fishery with the sum across sexes equal to 1. Data are from 1980 to 2004.

	Age																
Year	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1980	0.000	0.000	0.009	0.018	0.014	0.026	0.088	0.142	0.085	0.063	0.035	0.018	0.021	0.019	0.005	0.007	0.006	0.013
1981	0.000	0.007	0.017	0.047	0.044	0.020	0.020	0.062	0.078	0.071	0.037	0.028	0.019	0.010	0.005	0.006	0.005	0.027
1982	0.000	0.008	0.018	0.060	0.029	0.042	0.019	0.015	0.015	0.049	0.040	0.040	0.033	0.032	0.017	0.015	0.006	0.037
1983	0.000	0.006	0.153	0.114	0.040	0.021	0.009	0.014	0.013	0.016	0.029	0.023	0.022	0.013	0.010	0.007	0.005	0.028
1984	0.001	0.002	0.044	0.152	0.075	0.026	0.018	0.005	0.006	0.007	0.011	0.017	0.025	0.024	0.020	0.011	0.014	0.081
1985	0.000	0.008	0.071	0.081	0.117	0.058	0.028	0.009	0.007	0.005	0.008	0.005	0.012	0.010	0.011	0.007	0.008	0.099
1986	0.000	0.002	0.053	0.178	0.091	0.070	0.020	0.013	0.004	0.007	0.008	0.006	0.009	0.008	0.008	0.009	0.003	0.061
1987	0.000	0.004	0.014	0.095	0.224	0.057	0.037	0.026	0.009	0.007	0.004	0.002	0.007	0.008	0.005	0.008	0.004	0.035
1988	0.000	0.002	0.007	0.056	0.151	0.206	0.035	0.017	0.012	0.008	0.003	0.000	0.003	0.001	0.000	0.001	0.000	0.007
1989	0.000	0.003	0.007	0.076	0.093	0.184	0.104	0.009	0.010	0.006	0.001	0.001	0.001	0.002	0.000	0.001	0.004	0.020
1990	0.000	0.001	0.028	0.062	0.116	0.078	0.119	0.059	0.012	0.006	0.003	0.003	0.000	0.001	0.002	0.001	0.001	0.029
1991	0.000	0.000	0.004	0.054	0.084	0.099	0.066	0.057	0.054	0.011	0.009	0.005	0.004	0.002	0.001	0.003	0.002	0.040
1992	0.000	0.003	0.023	0.025	0.055	0.091	0.082	0.057	0.069	0.046	0.030	0.012	0.008	0.004	0.001	0.004	0.002	0.024
1993	0.000	0.001	0.008	0.059	0.038	0.068	0.070	0.054	0.050	0.085	0.048	0.030	0.015	0.009	0.003	0.005	0.002	0.029
1994	0.004	0.003	0.013	0.047	0.074	0.068	0.044	0.054	0.041	0.043	0.052	0.035	0.025	0.016	0.013	0.008	0.004	0.031
1995	0.001	0.009	0.032	0.050	0.078	0.082	0.055	0.037	0.023	0.027	0.017	0.021	0.010	0.007	0.011	0.005	0.002	0.014
1996	0.000	0.002	0.068	0.112	0.108	0.064	0.054	0.024	0.014	0.018	0.013	0.011	0.017	0.005	0.004	0.002	0.002	0.019
1997	0.000	0.001	0.029	0.167	0.142	0.053	0.033	0.024	0.017	0.018	0.017	0.010	0.007	0.011	0.005	0.002	0.003	0.029
1998	0.000	0.001	0.012	0.048	0.165	0.153	0.047	0.020	0.023	0.023	0.020	0.021	0.014	0.004	0.011	0.005	0.002	0.017
1999	0.000	0.001	0.012	0.046	0.067	0.127	0.105	0.053	0.033	0.023	0.015	0.013	0.014	0.009	0.006	0.011	0.005	0.018
2000	0.000	0.000	0.002	0.053	0.088	0.097	0.077	0.069	0.046	0.021	0.010	0.009	0.006	0.006	0.006	0.009	0.002	0.007
2001	0.000	0.000	0.002	0.025	0.053	0.090	0.057	0.014	0.031	0.025	0.048	0.035	0.017	0.019	0.004	0.006	0.008	0.023
2002	0.000	0.002	0.024	0.025	0.027	0.102	0.097	0.042	0.044	0.033	0.028	0.025	0.022	0.009	0.002	0.011	0.005	0.020
2003	0.003	0.013	0.101	0.054	0.047	0.057	0.040	0.010	0.027	0.007	0.007	0.007	0.003	0.003	0.000	0.000	0.003	0.003
2004	0.000	0.002	0.031	0.123	0.054	0.061	0.068	0.038	0.031	0.016	0.020	0.012	0.007	0.002	0.002	0.002	0.013	0.016

Table 5a. Propotional age composition of males for the Oregon midwater trawl fishery with the sum across sexes equal to 1. Data are from 1984 to 2004. Note that there were no 2003 ageing data.

	Age																
Year	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1984	0.000	0.001	0.018	0.174	0.113	0.009	0.019	0.007	0.009	0.008	0.016	0.023	0.002	0.008	0.004	0.002	0.001	0.012
1985	0.000	0.002	0.067	0.069	0.224	0.065	0.007	0.006	0.003	0.000	0.002	0.005	0.013	0.003	0.002	0.000	0.000	0.010
1986	0.000	0.000	0.005	0.104	0.074	0.195	0.060	0.005	0.005	0.004	0.000	0.000	0.001	0.013	0.004	0.003	0.001	0.008
1987	0.000	0.000	0.014	0.125	0.218	0.074	0.042	0.022	0.002	0.003	0.003	0.000	0.000	0.002	0.004	0.000	0.001	0.003
1988	0.000	0.001	0.014	0.077	0.244	0.129	0.034	0.020	0.008	0.000	0.001	0.000	0.001	0.000	0.003	0.002	0.000	0.003
1989	0.000	0.006	0.019	0.054	0.121	0.199	0.068	0.016	0.010	0.003	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.006
1990	0.000	0.003	0.028	0.029	0.057	0.099	0.133	0.067	0.032	0.015	0.007	0.004	0.000	0.001	0.000	0.002	0.000	0.004
1991	0.000	0.000	0.008	0.064	0.100	0.107	0.065	0.089	0.039	0.010	0.011	0.003	0.002	0.002	0.001	0.000	0.001	0.009
1992	0.000	0.000	0.036	0.040	0.087	0.083	0.080	0.041	0.086	0.030	0.022	0.014	0.002	0.004	0.000	0.000	0.001	0.013
1993	0.000	0.000	0.016	0.071	0.055	0.081	0.049	0.039	0.034	0.060	0.026	0.018	0.015	0.006	0.000	0.003	0.001	0.010
1994	0.000	0.002	0.009	0.076	0.156	0.080	0.047	0.041	0.012	0.020	0.031	0.000	0.002	0.005	0.000	0.000	0.000	0.009
1995	0.000	0.004	0.017	0.025	0.131	0.095	0.048	0.043	0.032	0.023	0.030	0.007	0.001	0.001	0.000	0.005	0.000	0.001
1996	0.000	0.008	0.073	0.093	0.071	0.065	0.049	0.034	0.014	0.008	0.024	0.009	0.017	0.008	0.003	0.000	0.005	0.005
1997	0.000	0.002	0.031	0.240	0.116	0.043	0.026	0.027	0.016	0.013	0.009	0.003	0.014	0.013	0.000	0.000	0.001	0.002
1998	0.000	0.000	0.012	0.081	0.194	0.112	0.054	0.015	0.025	0.015	0.003	0.007	0.001	0.001	0.009	0.002	0.001	0.004
1999	0.000	0.001	0.025	0.038	0.109	0.181	0.087	0.022	0.005	0.006	0.000	0.001	0.001	0.000	0.001	0.001	0.000	0.002
2000	0.000	0.000	0.005	0.032	0.072	0.085	0.107	0.083	0.045	0.030	0.004	0.007	0.009	0.003	0.000	0.000	0.000	0.000
2001	0.000	0.000	0.001	0.018	0.098	0.099	0.120	0.062	0.050	0.042	0.017	0.006	0.002	0.003	0.002	0.002	0.004	0.004
2002	0.000	0.009	0.009	0.044	0.090	0.148	0.118	0.033	0.013	0.009	0.010	0.007	0.000	0.009	0.005	0.000	0.007	0.002
2004	0.000	0.080	0.140	0.203	0.081	0.026	0.015	0.002	0.002	0.002	0.001	0.002	0.001	0.000	0.000	0.001	0.001	0.001

Table 5b. Propotional age composition of females for the Oregon midwater trawl fishery with the sum across sexes equal to 1. Data are from 1984 to 2004. Note that there were no 2003 ageing data.

	Age																	
Year	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1984	0.000	0.002	0.020	0.162	0.181	0.015	0.030	0.006	0.007	0.004	0.028	0.061	0.016	0.009	0.007	0.006	0.006	0.018
1985	0.000	0.000	0.053	0.067	0.252	0.086	0.011	0.011	0.009	0.000	0.001	0.007	0.017	0.002	0.001	0.001	0.002	0.005
1986	0.000	0.000	0.010	0.137	0.082	0.168	0.067	0.004	0.011	0.004	0.000	0.000	0.004	0.016	0.001	0.002	0.002	0.009
1987	0.000	0.001	0.017	0.113	0.198	0.080	0.038	0.020	0.002	0.005	0.002	0.000	0.001	0.002	0.003	0.001	0.000	0.002
1988	0.001	0.005	0.015	0.077	0.192	0.099	0.026	0.017	0.009	0.004	0.004	0.000	0.001	0.000	0.001	0.004	0.003	0.004
1989	0.000	0.004	0.026	0.036	0.079	0.197	0.086	0.024	0.011	0.006	0.004	0.002	0.000	0.001	0.001	0.002	0.001	0.007
1990	0.000	0.000	0.018	0.034	0.054	0.079	0.151	0.104	0.037	0.022	0.009	0.002	0.002	0.001	0.001	0.000	0.000	0.004
1991	0.000	0.000	0.010	0.062	0.096	0.061	0.069	0.098	0.043	0.014	0.010	0.004	0.003	0.001	0.000	0.000	0.002	0.015
1992	0.000	0.000	0.023	0.030	0.070	0.075	0.042	0.064	0.089	0.031	0.015	0.006	0.001	0.002	0.002	0.002	0.000	0.008
1993	0.000	0.001	0.010	0.068	0.036	0.080	0.065	0.036	0.046	0.067	0.034	0.024	0.020	0.010	0.004	0.005	0.002	0.007
1994	0.000	0.000	0.008	0.049	0.158	0.064	0.056	0.041	0.035	0.025	0.029	0.015	0.021	0.005	0.000	0.000	0.002	0.003
1995	0.000	0.005	0.005	0.031	0.059	0.088	0.089	0.057	0.043	0.039	0.032	0.046	0.013	0.007	0.014	0.001	0.000	0.009
1996	0.000	0.007	0.067	0.059	0.077	0.080	0.049	0.024	0.039	0.016	0.018	0.023	0.018	0.006	0.001	0.001	0.001	0.027
1997	0.000	0.003	0.012	0.170	0.082	0.038	0.038	0.017	0.014	0.012	0.013	0.013	0.007	0.017	0.001	0.002	0.000	0.005
1998	0.000	0.000	0.004	0.037	0.158	0.092	0.048	0.031	0.032	0.015	0.015	0.012	0.004	0.002	0.007	0.001	0.003	0.005
1999	0.000	0.000	0.023	0.036	0.081	0.186	0.093	0.041	0.020	0.008	0.011	0.007	0.001	0.007	0.004	0.001	0.000	0.001
2000	0.000	0.000	0.009	0.031	0.071	0.098	0.079	0.091	0.060	0.027	0.016	0.007	0.009	0.004	0.003	0.001	0.006	0.005
2001	0.000	0.000	0.000	0.013	0.067	0.067	0.071	0.069	0.049	0.060	0.016	0.010	0.008	0.008	0.014	0.008	0.006	0.004
2002	0.000	0.003	0.009	0.018	0.065	0.114	0.091	0.082	0.036	0.033	0.015	0.005	0.009	0.000	0.005	0.000	0.002	0.002
2004	0.005	0.111	0.075	0.152	0.071	0.023	0.006	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 6a. Propotional age composition of males for the Oregon bottom trawl fishery with the sum across sexes equal to 1. Data are from 1984 to 1999.

Year	Age 3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1984	0.000	0.002	0.034	0.158	0.115	0.018	0.017	0.004	0.004	0.002	0.021	0.015	0.011	0.009	0.007	0.003	0.001	0.010
1985	0.000	0.003	0.049	0.097	0.195	0.049	0.003	0.005	0.002	0.000	0.001	0.004	0.026	0.000	0.007	0.001	0.000	0.007
1986	0.000	0.002	0.014	0.200	0.081	0.085	0.058	0.003	0.018	0.005	0.002	0.000	0.001	0.018	0.002	0.001	0.003	0.016
1987	0.000	0.000	0.011	0.111	0.204	0.072	0.040	0.016	0.003	0.002	0.007	0.000	0.000	0.006	0.005	0.002	0.000	0.008
1988	0.002	0.011	0.017	0.080	0.208	0.102	0.022	0.011	0.007	0.003	0.000	0.000	0.001	0.000	0.002	0.004	0.001	0.006
1989	0.000	0.009	0.025	0.051	0.094	0.176	0.064	0.027	0.014	0.008	0.000	0.005	0.000	0.000	0.001	0.001	0.006	0.007
1990	0.000	0.004	0.047	0.045	0.056	0.068	0.116	0.058	0.021	0.020	0.010	0.004	0.001	0.003	0.000	0.000	0.000	0.012
1991	0.000	0.000	0.004	0.066	0.100	0.072	0.042	0.078	0.037	0.010	0.012	0.003	0.001	0.004	0.000	0.000	0.001	0.011
1992	0.000	0.000	0.017	0.022	0.084	0.073	0.059	0.034	0.048	0.018	0.029	0.016	0.004	0.004	0.006	0.002	0.003	0.017
1993	0.000	0.000	0.006	0.035	0.035	0.088	0.091	0.047	0.033	0.054	0.035	0.023	0.014	0.004	0.002	0.004	0.000	0.017
1994	0.000	0.003	0.014	0.057	0.107	0.069	0.042	0.017	0.021	0.029	0.024	0.008	0.006	0.005	0.009	0.002	0.000	0.011
1995	0.000	0.003	0.034	0.109	0.074	0.135	0.039	0.044	0.021	0.018	0.007	0.012	0.005	0.005	0.005	0.000	0.000	0.002
1996	0.000	0.002	0.079	0.082	0.059	0.058	0.022	0.017	0.017	0.020	0.016	0.002	0.017	0.005	0.002	0.011	0.001	0.007
1997	0.000	0.006	0.044	0.230	0.118	0.047	0.031	0.021	0.009	0.018	0.007	0.006	0.001	0.006	0.002	0.000	0.000	0.004
1998	0.000	0.000	0.008	0.051	0.183	0.116	0.035	0.022	0.017	0.020	0.006	0.009	0.000	0.002	0.007	0.000	0.003	0.008
1999	0.000	0.004	0.028	0.066	0.118	0.177	0.072	0.027	0.009	0.000	0.000	0.007	0.001	0.000	0.000	0.000	0.007	0.003

Table 6b. Propotional age composition of females for the Oregon bottom trawl fishery with the sum across sexes equal to 1. Data are from 1984 to 1999.

	Age																
Year	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1984	0.000	0.000	0.033	0.135	0.188	0.031	0.018	0.013	0.008	0.005	0.014	0.034	0.017	0.009	0.005	0.006	0.003	0.049
1985	0.001	0.000	0.023	0.062	0.199	0.121	0.016	0.007	0.007	0.000	0.001	0.026	0.038	0.006	0.006	0.004	0.004	0.030
1986	0.000	0.001	0.025	0.106	0.062	0.096	0.068	0.007	0.018	0.013	0.000	0.000	0.004	0.044	0.010	0.007	0.005	0.025
1987	0.000	0.002	0.010	0.119	0.167	0.060	0.051	0.030	0.004	0.004	0.002	0.003	0.000	0.005	0.017	0.014	0.003	0.023
1988	0.010	0.014	0.009	0.077	0.172	0.103	0.041	0.027	0.015	0.010	0.005	0.006	0.001	0.002	0.006	0.010	0.003	0.010
1989	0.000	0.001	0.027	0.028	0.068	0.146	0.090	0.038	0.041	0.016	0.006	0.004	0.004	0.004	0.006	0.004	0.010	0.018
1990	0.000	0.000	0.046	0.036	0.037	0.068	0.137	0.107	0.036	0.017	0.009	0.005	0.007	0.002	0.002	0.001	0.001	0.024
1991	0.000	0.000	0.007	0.055	0.060	0.065	0.074	0.109	0.058	0.034	0.034	0.007	0.005	0.005	0.002	0.001	0.003	0.037
1992	0.000	0.000	0.010	0.008	0.082	0.089	0.069	0.058	0.090	0.048	0.032	0.020	0.014	0.005	0.006	0.001	0.003	0.031
1993	0.000	0.000	0.000	0.025	0.025	0.076	0.073	0.044	0.040	0.066	0.043	0.029	0.017	0.021	0.006	0.009	0.006	0.032
1994	0.000	0.002	0.009	0.043	0.100	0.063	0.057	0.063	0.046	0.026	0.065	0.029	0.020	0.012	0.012	0.007	0.006	0.016
1995	0.000	0.005	0.013	0.037	0.109	0.084	0.051	0.039	0.045	0.026	0.017	0.025	0.004	0.002	0.013	0.002	0.000	0.015
1996	0.000	0.007	0.076	0.102	0.082	0.086	0.051	0.028	0.041	0.032	0.008	0.004	0.040	0.000	0.002	0.010	0.003	0.011
1997	0.000	0.008	0.031	0.104	0.094	0.030	0.047	0.031	0.019	0.015	0.008	0.013	0.010	0.016	0.005	0.001	0.005	0.014
1998	0.000	0.000	0.012	0.047	0.141	0.110	0.054	0.024	0.030	0.017	0.026	0.013	0.016	0.003	0.008	0.002	0.001	0.009
1999	0.000	0.000	0.023	0.058	0.068	0.147	0.063	0.042	0.039	0.009	0.012	0.006	0.008	0.002	0.000	0.001	0.001	0.001

Table 7a. Propotional age composition of males for the Eureka-Conception fishery with the sum across sexes equal to 1.   Data are from 1978 to 2004.

	Age																
Year	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1978	0.000	0.000	0.000	0.000	0.039	0.062	0.114	0.039	0.047	0.016	0.016	0.000	0.016	0.039	0.000	0.023	0.000	0.055
1979	0.000	0.000	0.000	0.000	0.011	0.012	0.049	0.017	0.020	0.016	0.009	0.017	0.002	0.019	0.011	0.020	0.000	0.048
1980	0.000	0.000	0.002	0.014	0.003	0.007	0.040	0.032	0.051	0.031	0.025	0.029	0.010	0.053	0.004	0.016	0.005	0.060
1981	0.001	0.008	0.010	0.027	0.025	0.028	0.026	0.030	0.043	0.047	0.024	0.033	0.016	0.029	0.012	0.004	0.014	0.025
1982	0.000	0.000	0.044	0.007	0.037	0.033	0.030	0.014	0.043	0.076	0.036	0.030	0.020	0.014	0.017	0.010	0.008	0.032
1983	0.000	0.000	0.023	0.140	0.032	0.033	0.013	0.005	0.008	0.009	0.020	0.020	0.012	0.012	0.005	0.023	0.002	0.027
1984	0.000	0.000	0.022	0.137	0.145	0.028	0.036	0.014	0.014	0.002	0.010	0.030	0.014	0.004	0.005	0.004	0.004	0.030
1985	0.000	0.000	0.009	0.062	0.163	0.145	0.013	0.025	0.011	0.002	0.003	0.010	0.022	0.002	0.005	0.003	0.003	0.027
1986	0.000	0.003	0.042	0.046	0.082	0.124	0.129	0.014	0.022	0.017	0.001	0.001	0.008	0.029	0.006	0.009	0.004	0.038
1987	0.001	0.000	0.055	0.114	0.044	0.060	0.091	0.112	0.020	0.030	0.021	0.003	0.000	0.019	0.015	0.003	0.011	0.026
1988	0.000	0.035	0.000	0.066	0.061	0.090	0.061	0.051	0.034	0.014	0.009	0.008	0.003	0.004	0.006	0.016	0.002	0.016
1989	0.000	0.005	0.109	0.073	0.078	0.119	0.046	0.050	0.020	0.012	0.020	0.016	0.008	0.000	0.000	0.007	0.006	0.009
1990	0.000	0.000	0.045	0.116	0.029	0.047	0.038	0.056	0.030	0.025	0.016	0.023	0.019	0.014	0.004	0.002	0.008	0.006
1991	0.000	0.002	0.015	0.119	0.120	0.049	0.038	0.065	0.022	0.016	0.020	0.012	0.002	0.004	0.004	0.003	0.003	0.017
1992	0.000	0.001	0.011	0.019	0.138	0.095	0.038	0.017	0.044	0.028	0.021	0.019	0.011	0.005	0.016	0.001	0.002	0.023
1993	0.000	0.000	0.085	0.163	0.096	0.078	0.010	0.002	0.009	0.007	0.011	0.001	0.021	0.005	0.002	0.004	0.001	0.033
1994	0.002	0.004	0.007	0.070	0.148	0.110	0.065	0.021	0.024	0.007	0.008	0.005	0.006	0.009	0.001	0.005	0.000	0.005
1995	0.000	0.033	0.039	0.034	0.056	0.197	0.045	0.066	0.058	0.003	0.028	0.007	0.021	0.001	0.004	0.008	0.000	0.003
1996	0.004	0.006	0.046	0.045	0.067	0.114	0.118	0.033	0.027	0.018	0.015	0.003	0.025	0.007	0.002	0.002	0.009	0.013
1997	0.000	0.002	0.008	0.108	0.041	0.051	0.052	0.048	0.050	0.036	0.027	0.023	0.013	0.005	0.004	0.012	0.006	0.012
1998	0.000	0.008	0.082	0.061	0.093	0.069	0.054	0.021	0.045	0.025	0.018	0.018	0.005	0.007	0.009	0.000	0.000	0.013
1999	0.001	0.001	0.019	0.072	0.059	0.101	0.069	0.051	0.027	0.022	0.030	0.016	0.006	0.006	0.006	0.012	0.005	0.031
2000	0.000	0.000	0.004	0.044	0.061	0.116	0.055	0.044	0.027	0.028	0.009	0.000	0.003	0.003	0.008	0.002	0.002	0.002
2001	0.000	0.000	0.000	0.010	0.073	0.012	0.064	0.092	0.035	0.040	0.032	0.030	0.042	0.021	0.004	0.003	0.000	0.007
2002	0.000	0.010	0.002	0.002	0.015	0.035	0.044	0.104	0.029	0.021	0.098	0.032	0.061	0.002	0.030	0.000	0.033	0.036
2003	0.000	0.279	0.013	0.009	0.009	0.035	0.040	0.040	0.000	0.018	0.000	0.004	0.013	0.013	0.000	0.000	0.000	0.004
2004	0.000	0.000	0.023	0.000	0.015	0.031	0.054	0.070	0.039	0.015	0.047	0.023	0.007	0.032	0.039	0.000	0.007	0.007

Table 7b. Propotional age composition of females for the Eureka-Conception fishery with the sum across sexes equal to 1.   Data are from 1978 to 2004.

	Age																
Year	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1978	0.000	0.000	0.000	0.000	0.124	0.206	0.041	0.041	0.018	0.000	0.062	0.000	0.000	0.000	0.000	0.000	0.000	0.042
1979	0.000	0.000	0.000	0.000	0.029	0.067	0.158	0.062	0.061	0.040	0.075	0.011	0.019	0.036	0.011	0.023	0.030	0.127
1980	0.000	0.000	0.001	0.006	0.004	0.024	0.063	0.098	0.097	0.039	0.051	0.062	0.018	0.013	0.029	0.040	0.007	0.066
1981	0.000	0.003	0.005	0.014	0.036	0.019	0.025	0.055	0.073	0.091	0.027	0.056	0.046	0.039	0.025	0.040	0.011	0.035
1982	0.000	0.000	0.032	0.009	0.035	0.031	0.024	0.008	0.036	0.102	0.051	0.036	0.034	0.032	0.023	0.025	0.017	0.052
1983	0.000	0.010	0.075	0.167	0.047	0.048	0.015	0.009	0.002	0.008	0.037	0.022	0.012	0.028	0.020	0.016	0.026	0.071
1984	0.000	0.000	0.025	0.124	0.113	0.027	0.029	0.012	0.007	0.003	0.020	0.045	0.010	0.011	0.007	0.007	0.010	0.050
1985	0.000	0.000	0.002	0.039	0.153	0.144	0.020	0.039	0.006	0.002	0.003	0.010	0.023	0.002	0.006	0.007	0.009	0.031
1986	0.000	0.001	0.032	0.027	0.073	0.082	0.100	0.007	0.021	0.009	0.005	0.002	0.002	0.028	0.003	0.004	0.004	0.026
1987	0.001	0.000	0.047	0.095	0.021	0.051	0.051	0.055	0.011	0.010	0.004	0.002	0.001	0.004	0.003	0.006	0.001	0.011
1988	0.000	0.086	0.037	0.076	0.072	0.055	0.033	0.037	0.021	0.004	0.014	0.020	0.004	0.007	0.004	0.006	0.009	0.039
1989	0.000	0.003	0.082	0.043	0.042	0.081	0.054	0.038	0.021	0.010	0.008	0.004	0.006	0.006	0.000	0.001	0.001	0.022
1990	0.000	0.003	0.051	0.109	0.056	0.037	0.089	0.071	0.037	0.024	0.010	0.008	0.006	0.001	0.003	0.001	0.002	0.012
1991	0.000	0.007	0.008	0.113	0.128	0.061	0.030	0.033	0.023	0.017	0.013	0.011	0.008	0.008	0.007	0.001	0.002	0.018
1992	0.000	0.000	0.015	0.031	0.108	0.086	0.039	0.030	0.037	0.026	0.026	0.044	0.015	0.000	0.001	0.001	0.006	0.042
1993	0.000	0.004	0.033	0.135	0.124	0.097	0.037	0.004	0.001	0.010	0.008	0.001	0.001	0.001	0.001	0.005	0.005	0.007
1994	0.002	0.002	0.022	0.067	0.161	0.066	0.051	0.020	0.026	0.017	0.015	0.007	0.009	0.008	0.006	0.000	0.002	0.023
1995	0.000	0.008	0.009	0.015	0.050	0.137	0.050	0.068	0.023	0.005	0.008	0.002	0.005	0.008	0.000	0.008	0.000	0.001
1996	0.005	0.007	0.040	0.043	0.042	0.081	0.058	0.050	0.038	0.030	0.011	0.010	0.012	0.003	0.001	0.007	0.005	0.004
1997	0.000	0.001	0.007	0.083	0.038	0.056	0.053	0.042	0.065	0.048	0.030	0.020	0.005	0.021	0.006	0.007	0.005	0.014
1998	0.000	0.002	0.054	0.029	0.076	0.030	0.046	0.045	0.053	0.060	0.028	0.008	0.010	0.006	0.007	0.002	0.003	0.013
1999	0.000	0.002	0.010	0.074	0.046	0.094	0.042	0.047	0.038	0.022	0.021	0.015	0.014	0.014	0.004	0.009	0.002	0.013
2000	0.000	0.000	0.007	0.033	0.099	0.073	0.075	0.057	0.039	0.027	0.059	0.033	0.033	0.021	0.002	0.001	0.024	0.007
2001	0.000	0.000	0.000	0.008	0.060	0.099	0.037	0.065	0.064	0.032	0.038	0.023	0.021	0.001	0.013	0.023	0.034	0.018
2002	0.000	0.010	0.002	0.001	0.031	0.015	0.038	0.112	0.049	0.074	0.004	0.034	0.031	0.033	0.004	0.003	0.000	0.008
2003	0.013	0.412	0.040	0.000	0.000	0.013	0.004	0.022	0.004	0.000	0.000	0.013	0.000	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.000	0.015	0.016	0.015	0.016	0.038	0.038	0.068	0.060	0.067	0.076	0.015	0.053	0.046	0.031	0.007	0.030

Table 8. Number of samples collected for each year and fishery of age composition data used in the widow rockfish assessment.

	Vancouver-Columbia	Oregon midwater trawl	Oregon bottom trawl	Eureka-Conception
1978				7
1979				11
1980	18			26
1981	31			44
1982	40			149
1983	25			189
1984	22	32	27	169
1985	16	53	23	175
1986	27	56	22	154
1987	36	68	34	135
1988	20	39	33	127
1989	30	65	45	170
1990	41	61	49	155
1991	35	59	78	95
1992	31	43	82	55
1993	34	50	61	22
1994	28	22	63	28
1995	33	30	43	11
1996	25	32	27	35
1997	29	47	40	61
1998	22	41	30	37
1999	29	62	26	31
2000	21	55		17
2001	10	39		7
2002	12	17		14
2003	5			3
2004	19	4		7

Table 9. Yearly index estimates from the Santa Cruz/Tiburon Laboratory midwater trawl pelagic juvenile survey from 1984 to 2004.

Year	Index value	CV
1984	4.456	0.415206
1985	14.319	0.457595
1986	0.153	0.434277
1987	4.810	0.203188
1988	3.758	0.259248
1989	0.206	0.381102
1990	0.230	0.392817
1991	1.452	0.296396
1992	0.068	0.443453
1993	0.879	0.246520
1994	0.135	0.443453
1995	0.230	0.450612
1996	0.068	0.443453
1997	0.283	0.372287
1998	0.068	0.443453
1999	0.297	0.456079
2000	0.288	0.309768
2001	1.311	0.244552
2002	6.561	0.293078
2003	1.742	0.262856
2004	2.379	0.266954

Table 10. Oregon bottom trawl logbook catch-per-unit-effort index from 1984 to 1999.

Year	CPUE (lbs./hr.)	CV
1984	331.47	0.2121
1985	100.88	0.1875
1986	227.08	0.2928
1987	169.08	0.2730
1988	93.97	0.2897
1989	164.10	0.1749
1990	78.49	0.1348
1991	73.59	0.1275
1992	83.16	0.1179
1993	53.58	0.1314
1994	100.34	0.1128
1995	109.96	0.1387
1996	94.81	0.1357
1997	97.23	0.1502
1998	56.56	0.1718
1999	84.46	0.1684

Table 11. Scaled indices of widow rockfish catches derived from bycatch in three sectors of the Pacific whiting fisheries. Note that index values after 1998 were not used in this assessment.

Year	Index	CV
Foreign		
1977	0.770	0.115
1978	1.205	0.112
1979	0.703	0.119
1980	1.993	0.131
1981	0.728	0.126
1982	0.243	0.247
1984	2.937	0.125
1985	0.407	0.107
1986	1.111	0.103
1987	0.390	0.088
1988	0.513	0.124
Joint venture		
1983	2.889	0.120
1985	0.776	0.117
1986	0.823	0.081
1987	0.320	0.087
1988	0.659	0.077
1989	0.824	0.064
1990	0.710	0.074
Domestic		
1991	1.264	0.125
1992	0.781	0.125
1993	0.801	0.104
1994	1.465	0.068
1995	0.455	0.106
1996	1.018	0.082
1997	0.886	0.077
1998	1.330	0.079

Table 12. Indices of widow rockfish catches derived from triennial surveys from 1977 to 2004. Detailed description of the analysis is in Appendix B.

Year	Index	CV
1977	0.506	0.247
1980	0.382	0.332
1983	0.565	0.289
1986	0.353	0.351
1989	0.390	0.477
1992	0.461	0.364
1995	0.305	0.317
1998	0.692	0.313
2001	0.112	0.350
2004	0.126	0.461

Table 13. Estimated age 3 recruits, age 3+ biomass, spawning biomass, spawning outputs, and annual fishing mortality of widow rockfish from 1958 to 2004 from the base model.

Year	Age 3 Recruits (10^3)	Age 3+ Biomass (mt)	Spawning Biomass (mt)	Spawning Output (10^6 eggs)	Fishing Mortality
1958	34509	230505	112557	44904	0.000000
1959	34836	231687	112605	44905	0.000000
1960	35136	233164	112810	44922	0.000000
1961	35165	234823	113245	44996	0.000000
1962	33910	236270	113913	45167	0.000000
1963	32742	237373	114767	45437	0.000000
1964	29178	237410	115613	45759	0.000000
1965	31197	237529	116318	46084	0.000000
1966	23706	235548	116668	46351	0.036478
1967	37325	232387	114581	45676	0.041365
1968	39173	229946	111871	44742	0.020479
1969	40117	230756	110524	44156	0.003965
1970	41811	234416	110755	43994	0.005849
1971	44367	239082	111610	44041	0.007160
1972	40465	243147	113225	44391	0.004135
1973	89101	259807	115804	45063	0.007511
1974	32175	265099	118443	45834	0.004858
1975	12357	264142	122871	46972	0.006616
1976	10108	259304	127278	48587	0.010256
1977	16332	253355	129633	50425	0.015891
1978	21601	246373	129096	51385	0.008418
1979	10251	236002	125712	51001	0.026238
1980	38902	229729	119518	49122	0.227006
1981	57581	210808	102378	42491	0.366297
1982	20936	181547	83887	34716	0.447040
1983	66060	167675	68401	27663	0.243075
1984	77951	175342	64412	25243	0.227238
1985	28033	173484	63490	24085	0.195050
1986	28601	172748	64592	23757	0.179788
1987	28770	170056	66833	24357	0.206849
1988	22500	160241	66979	24756	0.159942
1989	9961	148981	66048	24891	0.205760
1990	24253	137885	61694	23704	0.182916

Table 13 (continued). Estimated age 3 recruits, age 3+ biomass, spawning biomass, spawning outputs, and annual fishing mortality of widow rockfish from 1958 to 2004 from the base model.

Year	Age 3 Recruits (10^3)	Age 3+ Biomass (mt)	Spawning Biomass (mt)	Spawning Output (10^6 eggs)	Fishing Mortality
1991	15480	126761	57451	22427	0.121770
1992	15827	120069	54980	21659	0.125041
1993	29059	117532	52088	20622	0.191516
1994	43798	117761	47939	19016	0.163827
1995	13461	113199	45414	17847	0.183220
1996	15160	108431	43681	16805	0.169068
1997	12222	102959	43489	16474	0.163523
1998	6586	94966	43083	16406	0.095073
1999	7052	89754	42851	16566	0.104394
2000	9622	84787	41348	16306	0.112583
2001	25820	84098	39119	15663	0.058742
2002	23850	86603	37789	15241	0.009983
2003	17341	89936	37847	15137	0.000996
2004	17643	93685	39032	15337	0.002184

Table 14. Estimated parameter values and their standard deviations for the base model.

Parameter description	Estimated value	Estimated standard deviation
Mean recruitment	10.346000	0.110980
Recruitment steepness	0.280960	0.056704
Recruitment deviation in 1958	0.103250	0.866710
Recruitment deviation in 1959	0.112690	0.866190
Recruitment deviation in 1960	0.121250	0.863450
Recruitment deviation in 1961	0.122070	0.856240
Recruitment deviation in 1962	0.085718	0.842500
Recruitment deviation in 1963	0.050438	0.816640
Recruitment deviation in 1964	-0.065852	0.771830
Recruitment deviation in 1965	-0.001385	0.652600
Recruitment deviation in 1966	-0.279750	0.581210
Recruitment deviation in 1967	0.169660	0.398980
Recruitment deviation in 1968	0.213500	0.337660
Recruitment deviation in 1969	0.233650	0.283720
Recruitment deviation in 1970	0.284310	0.241720
Recruitment deviation in 1971	0.356820	0.208490
Recruitment deviation in 1972	0.273230	0.213420
Recruitment deviation in 1973	1.064900	0.131150
Recruitment deviation in 1974	0.045657	0.187050
Recruitment deviation in 1975	-0.916390	0.245910
Recruitment deviation in 1976	-1.126900	0.240130
Recruitment deviation in 1977	-0.657920	0.185950
Recruitment deviation in 1978	-0.393790	0.152700
Recruitment deviation in 1979	-1.160300	0.190180
Recruitment deviation in 1980	0.150440	0.107980
Recruitment deviation in 1981	0.531070	0.094079
Recruitment deviation in 1982	-0.476040	0.129460
Recruitment deviation in 1983	0.696080	0.081536
Recruitment deviation in 1984	0.953780	0.065616
Recruitment deviation in 1985	0.067473	0.092484
Recruitment deviation in 1986	0.251030	0.101160
Recruitment deviation in 1987	0.325680	0.104770
Recruitment deviation in 1988	0.115750	0.111920
Recruitment deviation in 1989	-0.688500	0.143700
Recruitment deviation in 1990	0.182170	0.108160
Recruitment deviation in 1991	-0.279230	0.120010
Recruitment deviation in 1992	-0.261240	0.124180
Recruitment deviation in 1993	0.383810	0.113160
Recruitment deviation in 1994	0.837030	0.113080
Recruitment deviation in 1995	-0.315470	0.155040
Recruitment deviation in 1996	-0.157750	0.154640
Recruitment deviation in 1997	-0.308220	0.181380

Table 14 (continued). Estimated parameter values and their standard deviations for the base model.

Parameter description	Estimated value	Estimated standard deviation
Recruitment deviation in 1998	-0.874970	0.230550
Recruitment deviation in 1999	-0.757190	0.264110
Recruitment deviation in 2000	-0.429960	0.286380
Recruitment deviation in 2001	0.560490	0.262490
Recruitment deviation in 2002	0.473040	0.429260
Recruitment deviation in 2003	0.167500	0.529180
Recruitment deviation in 2004	0.218260	0.515420
Selectivity parameter 1 for fishery 1	2.522700	0.141370
Selectivity parameter 2 for fishery 1	5.869900	0.058679
Selectivity parameter 3 for fishery 1	0.150240	0.013263
Selectivity parameter 4 for fishery 1	0.000000	0.001278
Selectivity parameter 1 for fishery 2	2.434400	0.151440
Selectivity parameter 2 for fishery 2	6.227300	0.085509
Selectivity parameter 3 for fishery 2	0.280000	0.030910
Selectivity parameter 4 for fishery 2	7.590900	2.229600
Selectivity parameter 1 for fishery 3	2.463900	0.186070
Selectivity parameter 2 for fishery 3	6.022500	0.090360
Selectivity parameter 3 for fishery 3	0.207510	0.041259
Selectivity parameter 4 for fishery 3	9.944900	3.609100
Selectivity parameter 1 for fishery 4	2.373300	0.285650
Selectivity parameter 2 for fishery 4	5.669900	0.118340
Selectivity parameter 3 for fishery 4	0.340740	0.093586
Selectivity parameter 4 for fishery 4	17.116000	1.300600
Average fishing mortality for fishery 1	-4.121100	0.120190
Average fishing mortality for fishery 2	-3.466400	0.146620
Average fishing mortality for fishery 3	-4.642600	0.157110
Average fishing mortality for fishery 4	-4.960500	0.133350
Deviation of fishing mortality for Fishery 1 in 1966	0.788240	0.154600
Deviation of fishing mortality for Fishery 1 in 1967	0.883650	0.138880
Deviation of fishing mortality for Fishery 1 in 1968	0.079480	0.123900
Deviation of fishing mortality for Fishery 1 in 1969	-1.457000	0.115770
Deviation of fishing mortality for Fishery 1 in 1970	-1.021900	0.105000
Deviation of fishing mortality for Fishery 1 in 1971	-0.819320	0.096131
Deviation of fishing mortality for Fishery 1 in 1972	-1.393900	0.089306
Deviation of fishing mortality for Fishery 1 in 1973	-1.024500	0.084202
Deviation of fishing mortality for Fishery 1 in 1974	-1.810100	0.081010
Deviation of fishing mortality for Fishery 1 in 1975	-1.419700	0.079876
Deviation of fishing mortality for Fishery 1 in 1976	-0.785150	0.079817
Deviation of fishing mortality for Fishery 1 in 1977	-0.488240	0.083886
Deviation of fishing mortality for Fishery 1 in 1978	-1.192400	0.088913

Table 14 (continued). Estimated parameter values and their standard deviations for the base model.

Parameter description	Estimated value	Estimated standard deviation
Deviation of fishing mortality for Fishery 1 in 1979	-0.604890	0.093628
Deviation of fishing mortality for Fishery 1 in 1980	2.396100	0.094136
Deviation of fishing mortality for Fishery 1 in 1981	2.947500	0.088638
Deviation of fishing mortality for Fishery 1 in 1982	2.857400	0.078267
Deviation of fishing mortality for Fishery 1 in 1983	1.544000	0.070693
Deviation of fishing mortality for Fishery 1 in 1984	0.630710	0.067596
Deviation of fishing mortality for Fishery 1 in 1985	0.645300	0.065048
Deviation of fishing mortality for Fishery 1 in 1986	1.022300	0.062900
Deviation of fishing mortality for Fishery 1 in 1987	1.225600	0.060763
Deviation of fishing mortality for Fishery 1 in 1988	1.024100	0.058616
Deviation of fishing mortality for Fishery 1 in 1989	1.204300	0.056619
Deviation of fishing mortality for Fishery 1 in 1990	0.891590	0.056282
Deviation of fishing mortality for Fishery 1 in 1991	0.328440	0.057213
Deviation of fishing mortality for Fishery 1 in 1992	0.213960	0.058394
Deviation of fishing mortality for Fishery 1 in 1993	0.920400	0.061520
Deviation of fishing mortality for Fishery 1 in 1994	0.525880	0.066658
Deviation of fishing mortality for Fishery 1 in 1995	0.618520	0.074207
Deviation of fishing mortality for Fishery 1 in 1996	0.480600	0.084697
Deviation of fishing mortality for Fishery 1 in 1997	0.425120	0.096282
Deviation of fishing mortality for Fishery 1 in 1998	-0.174240	0.105520
Deviation of fishing mortality for Fishery 1 in 1999	-0.183700	0.115370
Deviation of fishing mortality for Fishery 1 in 2000	-0.423110	0.127470
Deviation of fishing mortality for Fishery 1 in 2001	-0.546850	0.136790
Deviation of fishing mortality for Fishery 1 in 2002	-2.004900	0.139150
Deviation of fishing mortality for Fishery 1 in 2003	-3.427100	0.138720
Deviation of fishing mortality for Fishery 1 in 2004	-2.876100	0.144510
Deviation of fishing mortality for Fishery 2 in 1983	0.463790	0.100360
Deviation of fishing mortality for Fishery 2 in 1984	1.188700	0.093829
Deviation of fishing mortality for Fishery 2 in 1985	0.942000	0.089544
Deviation of fishing mortality for Fishery 2 in 1986	0.755480	0.086006
Deviation of fishing mortality for Fishery 2 in 1987	1.049400	0.081699
Deviation of fishing mortality for Fishery 2 in 1988	0.764860	0.078017
Deviation of fishing mortality for Fishery 2 in 1989	1.023600	0.072812
Deviation of fishing mortality for Fishery 2 in 1990	0.732680	0.066586
Deviation of fishing mortality for Fishery 2 in 1991	0.259910	0.062615
Deviation of fishing mortality for Fishery 2 in 1992	-0.103890	0.060155
Deviation of fishing mortality for Fishery 2 in 1993	0.454450	0.056682
Deviation of fishing mortality for Fishery 2 in 1994	0.503960	0.053895
Deviation of fishing mortality for Fishery 2 in 1995	0.417450	0.054159
Deviation of fishing mortality for Fishery 2 in 1996	0.474370	0.058122

Table 14 (continued). Estimated parameter values and their standard deviations for the base model.

Parameter description	Estimated value	Estimated standard deviation
Deviation of fishing mortality for Fishery 2 in 1997	0.384400	0.066420
Deviation of fishing mortality for Fishery 2 in 1998	-0.396970	0.076255
Deviation of fishing mortality for Fishery 2 in 1999	0.479580	0.083790
Deviation of fishing mortality for Fishery 2 in 2000	0.855620	0.094598
Deviation of fishing mortality for Fishery 2 in 2001	0.110840	0.103240
Deviation of fishing mortality for Fishery 2 in 2002	-1.615200	0.105160
Deviation of fishing mortality for Fishery 2 in 2003	-4.576400	0.105030
Deviation of fishing mortality for Fishery 2 in 2004	-4.168600	0.113130
Deviation of fishing mortality for Fishery 3 in 1983	1.287800	0.099723
Deviation of fishing mortality for Fishery 3 in 1984	1.087100	0.092506
Deviation of fishing mortality for Fishery 3 in 1985	0.601150	0.087699
Deviation of fishing mortality for Fishery 3 in 1986	0.788940	0.084355
Deviation of fishing mortality for Fishery 3 in 1987	0.609310	0.080487
Deviation of fishing mortality for Fishery 3 in 1988	0.519050	0.076711
Deviation of fishing mortality for Fishery 3 in 1989	1.154300	0.071588
Deviation of fishing mortality for Fishery 3 in 1990	1.340500	0.065599
Deviation of fishing mortality for Fishery 3 in 1991	1.301800	0.061705
Deviation of fishing mortality for Fishery 3 in 1992	1.696200	0.059167
Deviation of fishing mortality for Fishery 3 in 1993	2.053200	0.055838
Deviation of fishing mortality for Fishery 3 in 1994	1.792200	0.053282
Deviation of fishing mortality for Fishery 3 in 1995	1.837000	0.053338
Deviation of fishing mortality for Fishery 3 in 1996	1.771800	0.056995
Deviation of fishing mortality for Fishery 3 in 1997	1.736700	0.064832
Deviation of fishing mortality for Fishery 3 in 1998	1.176800	0.074658
Deviation of fishing mortality for Fishery 3 in 1999	0.707960	0.082197
Deviation of fishing mortality for Fishery 3 in 2000	-3.103100	0.092052
Deviation of fishing mortality for Fishery 3 in 2001	-2.140900	0.100350
Deviation of fishing mortality for Fishery 3 in 2002	-4.003600	0.102060
Deviation of fishing mortality for Fishery 3 in 2003	-7.309700	0.101720
Deviation of fishing mortality for Fishery 3 in 2004	-4.904500	0.108510
Deviation of fishing mortality for Fishery 4 in 1966	-2.185100	0.141070
Deviation of fishing mortality for Fishery 4 in 1967	-1.204200	0.129340
Deviation of fishing mortality for Fishery 4 in 1968	-0.878960	0.117580
Deviation of fishing mortality for Fishery 4 in 1969	-3.633600	0.110020
Deviation of fishing mortality for Fishery 4 in 1970	-6.681500	0.101810
Deviation of fishing mortality for Fishery 4 in 1971	-6.700500	0.094571
Deviation of fishing mortality for Fishery 4 in 1972	-4.161900	0.088972
Deviation of fishing mortality for Fishery 4 in 1973	-1.424900	0.084793
Deviation of fishing mortality for Fishery 4 in 1974	-1.157500	0.082052
Deviation of fishing mortality for Fishery 4 in 1975	-0.956770	0.080789

Table 14 (continued). Estimated parameter values and their standard deviations for the base model.

Parameter description	Estimated value	Estimated standard deviation
Deviation of fishing mortality for Fishery 4 in 1976	-0.897740	0.080601
Deviation of fishing mortality for Fishery 4 in 1977	-0.166740	0.083639
Deviation of fishing mortality for Fishery 4 in 1978	-0.696170	0.088076
Deviation of fishing mortality for Fishery 4 in 1979	0.907870	0.092465
Deviation of fishing mortality for Fishery 4 in 1980	1.941400	0.093744
Deviation of fishing mortality for Fishery 4 in 1981	2.096600	0.089573
Deviation of fishing mortality for Fishery 4 in 1982	3.155400	0.079800
Deviation of fishing mortality for Fishery 4 in 1983	2.465700	0.072923
Deviation of fishing mortality for Fishery 4 in 1984	2.237300	0.069269
Deviation of fishing mortality for Fishery 4 in 1985	2.249000	0.065978
Deviation of fishing mortality for Fishery 4 in 1986	1.903100	0.064633
Deviation of fishing mortality for Fishery 4 in 1987	1.852100	0.063103
Deviation of fishing mortality for Fishery 4 in 1988	1.501800	0.061701
Deviation of fishing mortality for Fishery 4 in 1989	1.584600	0.059767
Deviation of fishing mortality for Fishery 4 in 1990	1.779900	0.058793
Deviation of fishing mortality for Fishery 4 in 1991	1.202300	0.059224
Deviation of fishing mortality for Fishery 4 in 1992	1.241800	0.059778
Deviation of fishing mortality for Fishery 4 in 1993	1.330700	0.062227
Deviation of fishing mortality for Fishery 4 in 1994	1.343200	0.067397
Deviation of fishing mortality for Fishery 4 in 1995	1.864400	0.074459
Deviation of fishing mortality for Fishery 4 in 1996	1.636000	0.084537
Deviation of fishing mortality for Fishery 4 in 1997	1.693800	0.096173
Deviation of fishing mortality for Fishery 4 in 1998	1.426800	0.106910
Deviation of fishing mortality for Fishery 4 in 1999	1.092100	0.116820
Deviation of fishing mortality for Fishery 4 in 2000	1.386600	0.128640
Deviation of fishing mortality for Fishery 4 in 2001	0.642700	0.137520
Deviation of fishing mortality for Fishery 4 in 2002	-1.602100	0.139050
Deviation of fishing mortality for Fishery 4 in 2003	-3.904700	0.137450
Deviation of fishing mortality for Fishery 4 in 2004	-2.282800	0.139990
Power coefficient for SC Lab index	0.145890	0.096683
Catchbility for SC Lab index	-10.201000	0.226500
Catchbility for Oregon bottom trawl fishery	-6.405300	0.176410
Catchbility for whiting bycatch (foreign)	-11.462000	0.233930
Catchbility for whiting bycatch (joint venture)	-11.247000	0.319280
Catchbility for whiting bycatch (domestic)	-10.785000	0.187220
Catchbility for triennial trawl survey	-12.194000	0.206290

Table 15. Comparisons between base model (Model T2) and other models.

Parameter and estimate	Model T1	Model M015	Model T2 (base model)	Model M011
Number of parameters	196	198	198	198
Steepness (*h*)	0.4515	0.2540	0.2810	0.3161
Unfished spawning output (B_0) (million of eggs)	35564	46750	49676	52871
Current spawning output (B_t) (million of eggs)	8992	12051	15444	20350
Depletion ($100*B_t/B_0$)	25.28	25.78	31.09	38.49
Standard deviation of depletion	5.61	4.96	5.92	6.95
Depletion calculated as in 2003 assessment	26.96	30.14	34.16	40.77

Figure 1. U.S. landings (mt) of widow rockfish by four fisheries from 1966 to 2002. Four fisheries are defined by area and gear type.

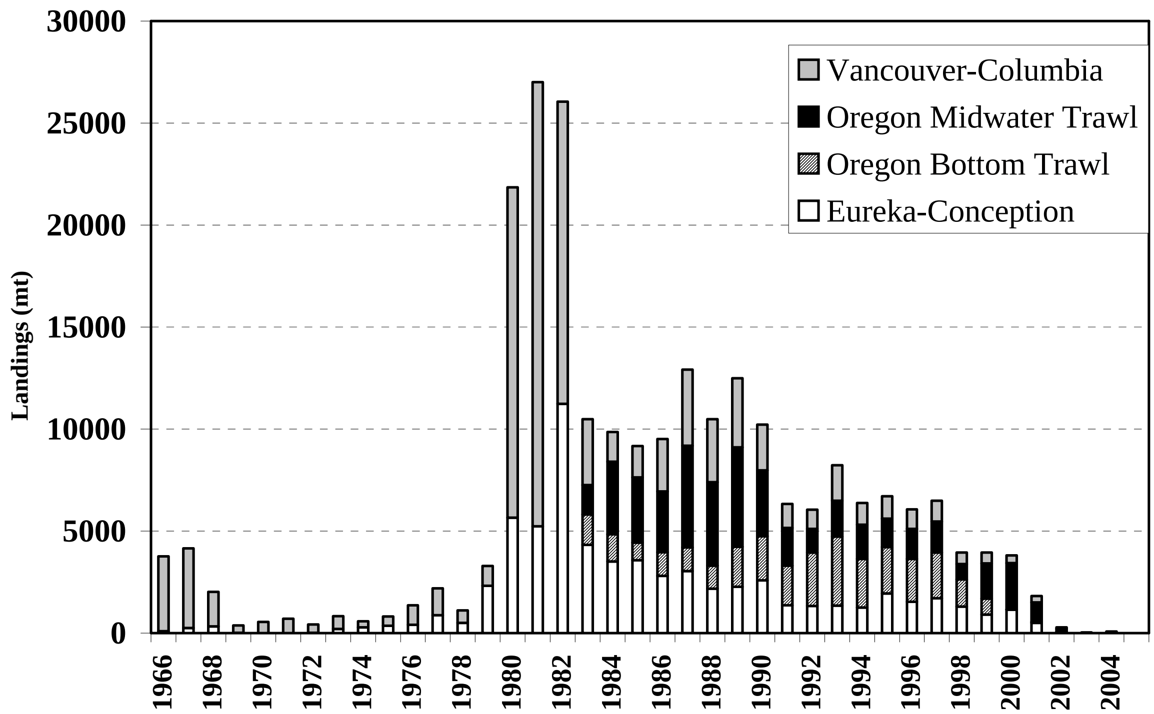


Figure 2. Growth functions for widow rockfish by sex from north and south of 43° latitude used in this assessment.

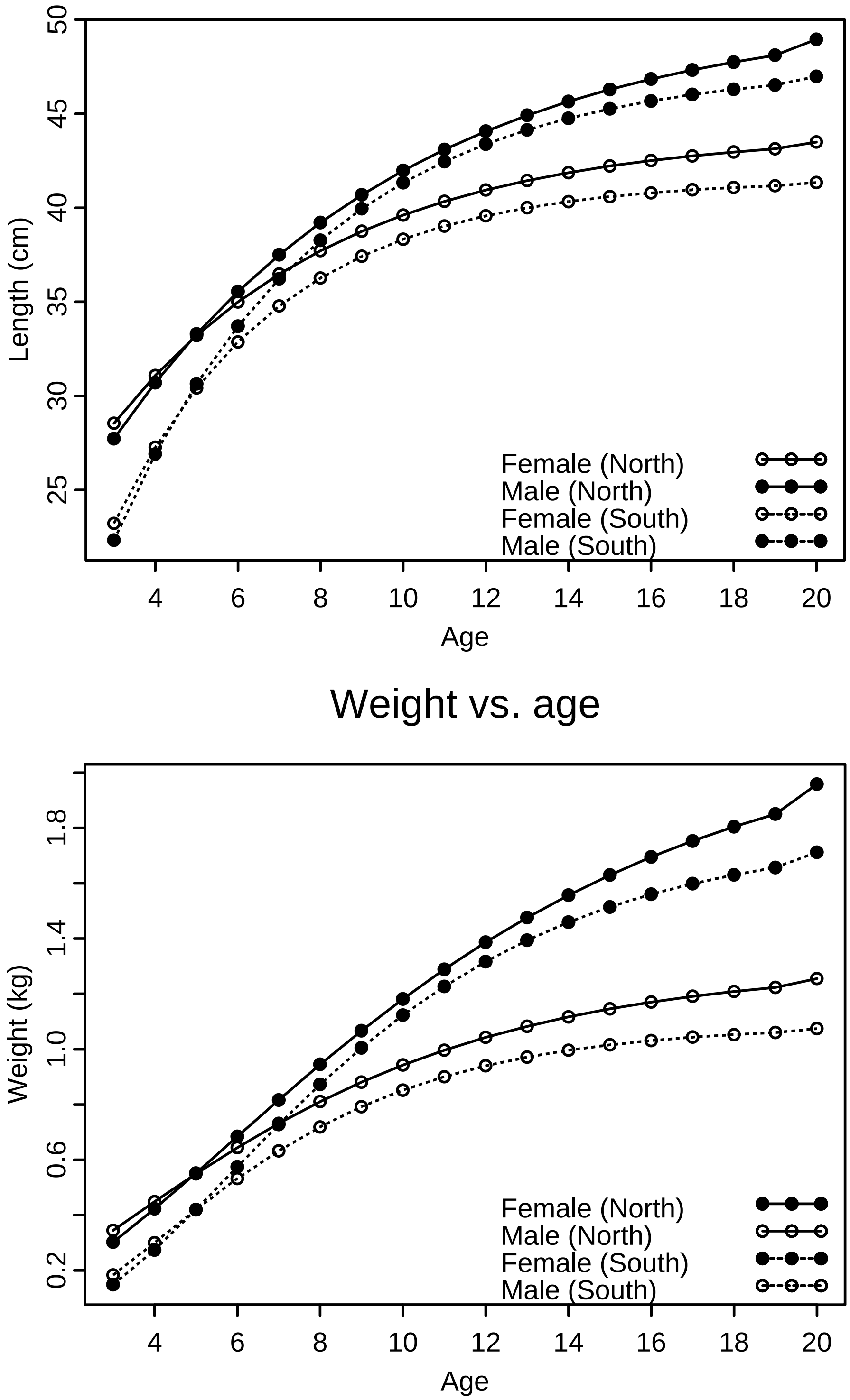
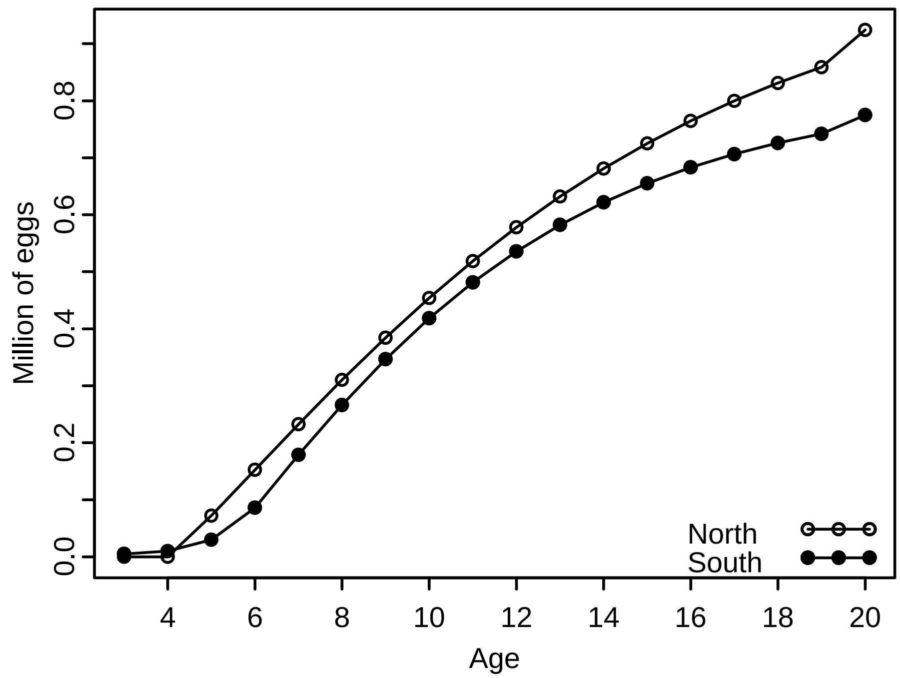


Figure 3. Fecundity and maturity for widow rockfish from north and south of 43° latitude used in this assessment.



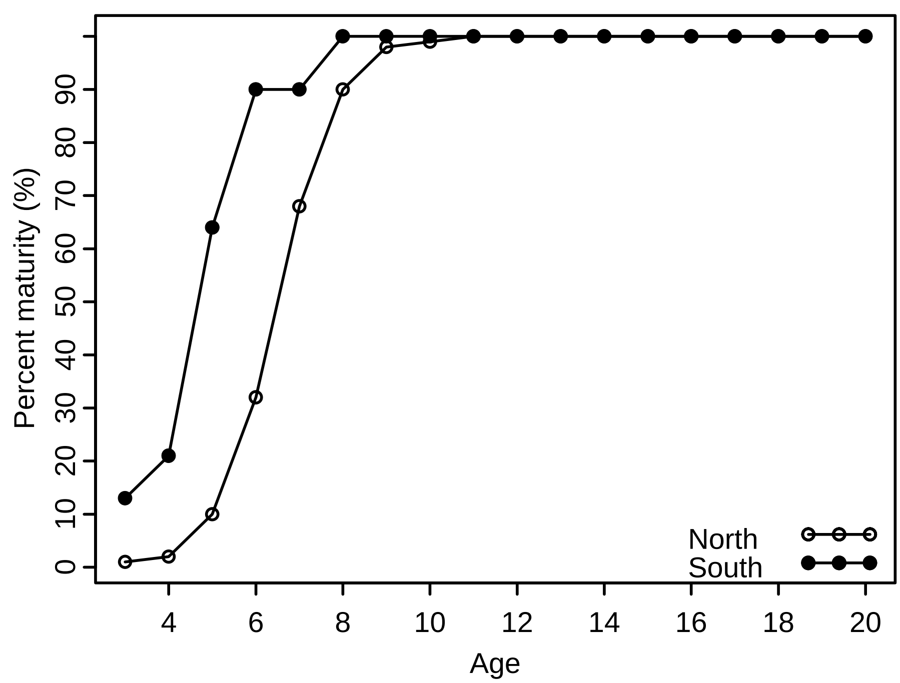


Figure 4. Proportional age composition data for the Vancouver-Columbia combined fishery, by sex and year with the sum across sexes equal to 1.

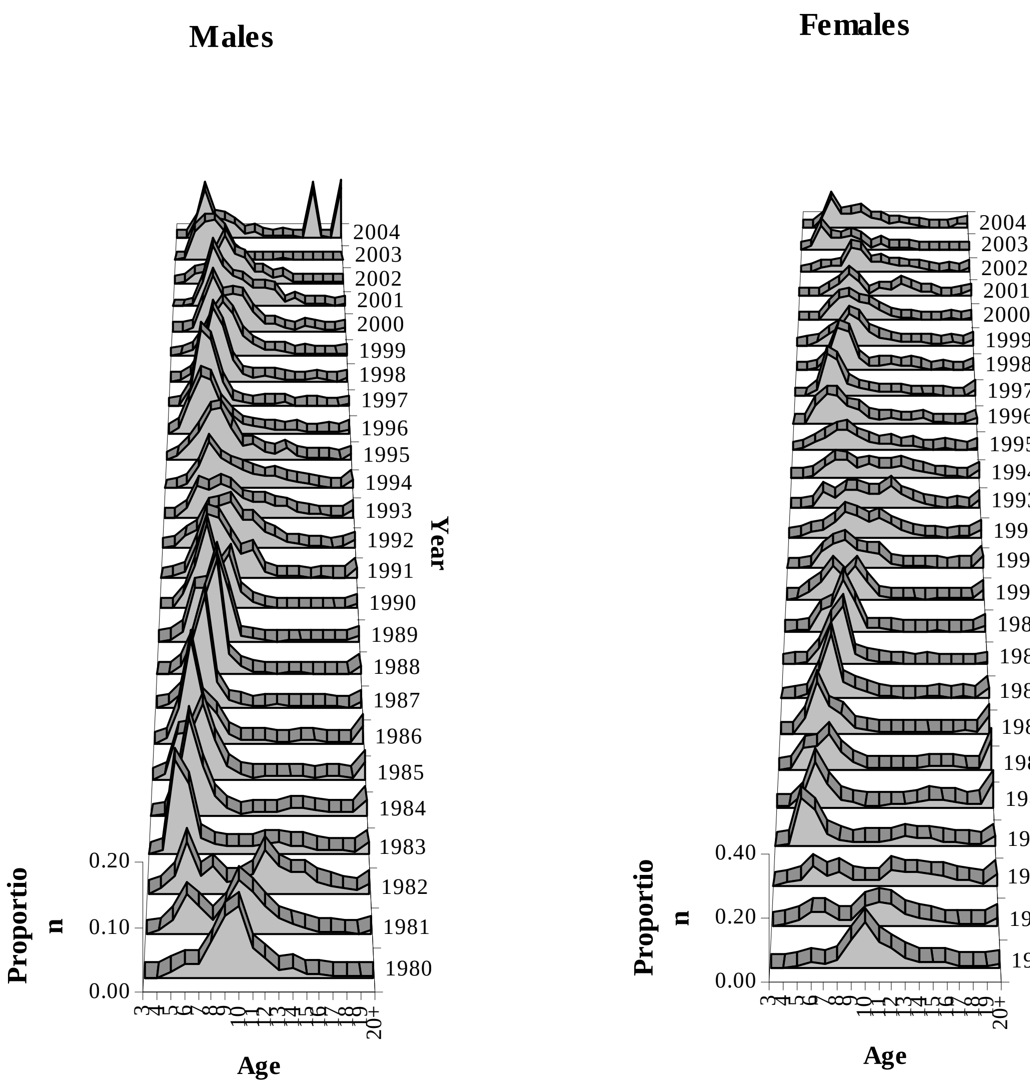


Figure 5. Proportional age composition data for the Oregon midwater trawl fishery, by sex and year with the sum across sexes equal to 1.

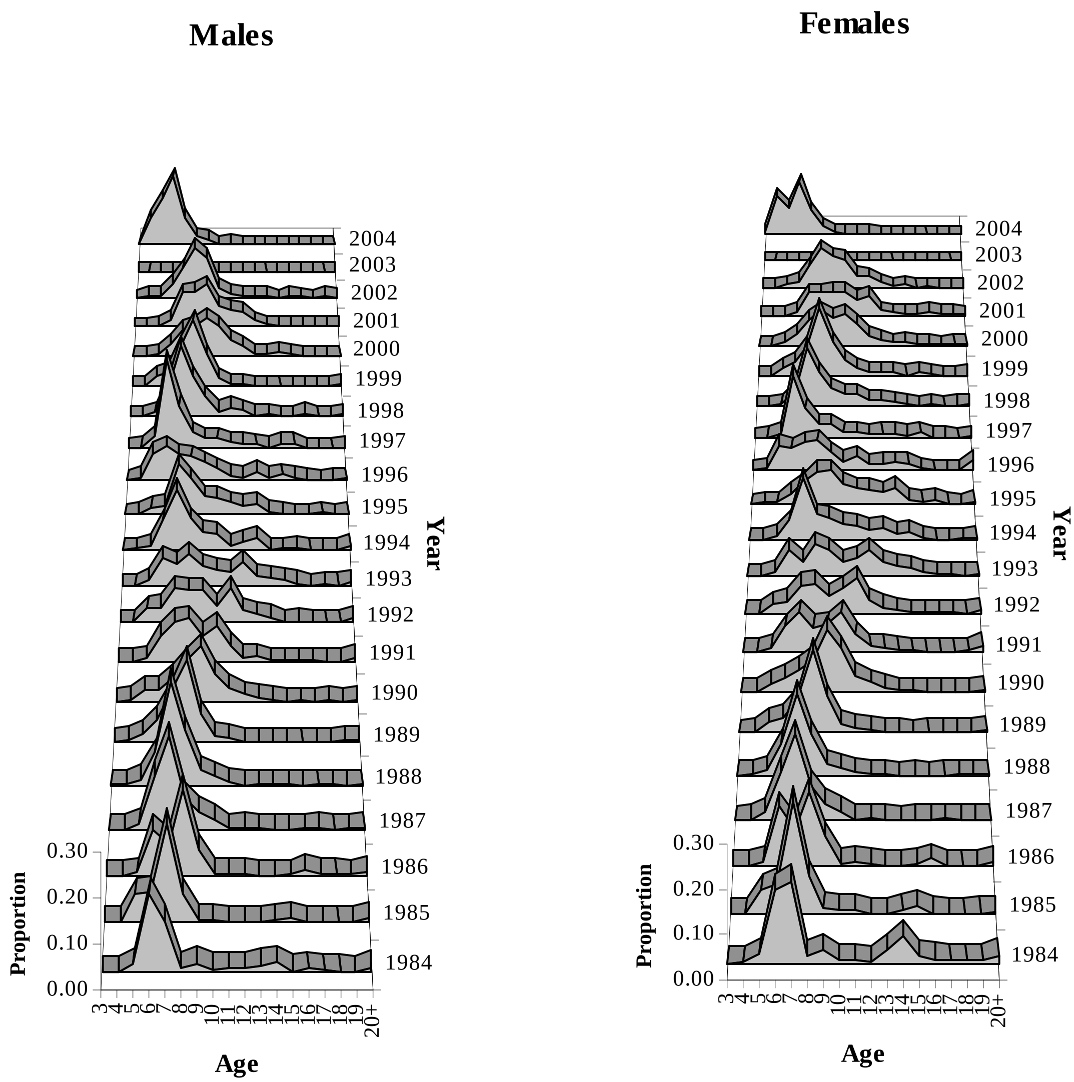


Figure 6. Proportional age composition data for the Oregon bottom trawl fishery, by sex and year with the sum across sexes equal to 1.

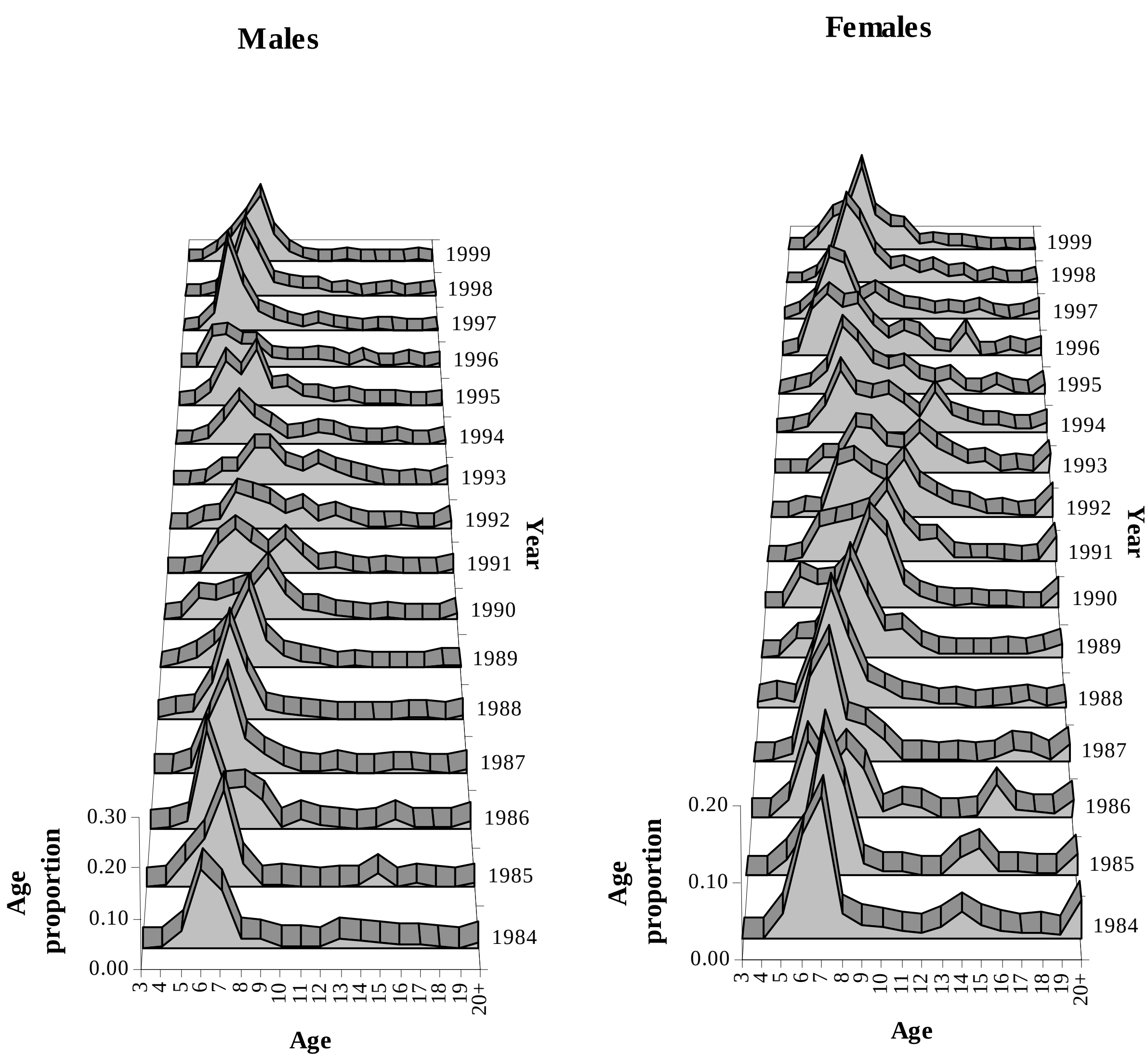
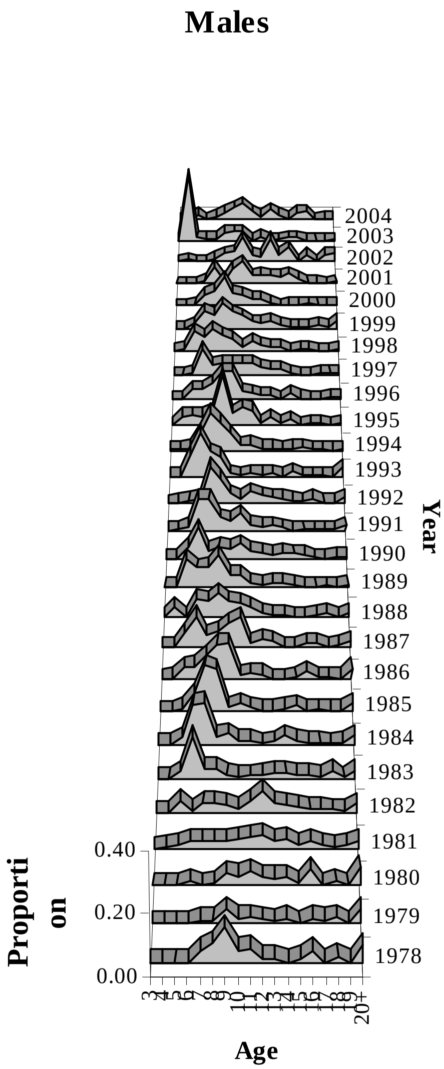


Figure 7. Proportional age composition data for the Eureka-Conception combined fishery, by sex and year with the sum across sexes equal to 1.



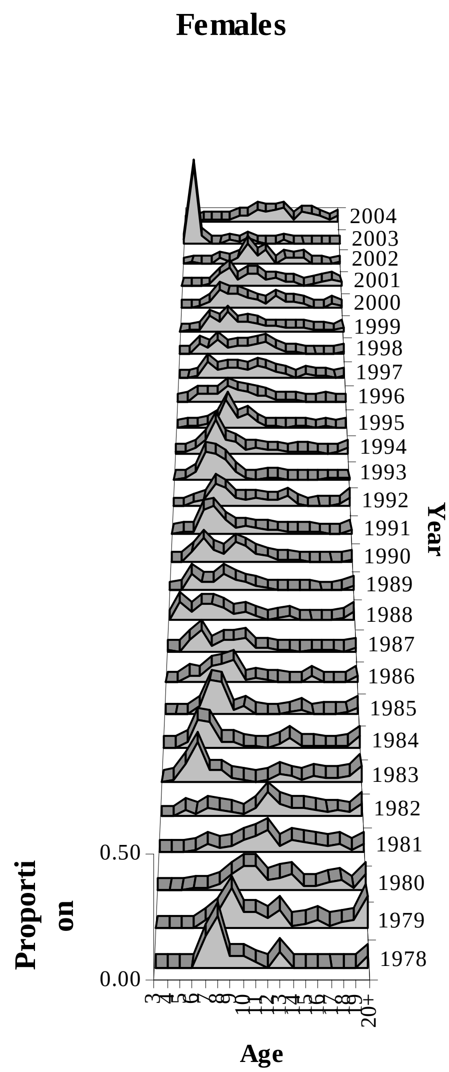


Figure 8. Yearly index estimates from the Santa Cruz/Tiburon Laboratory midwater juvenile trawl survey from 1984 to 2004.

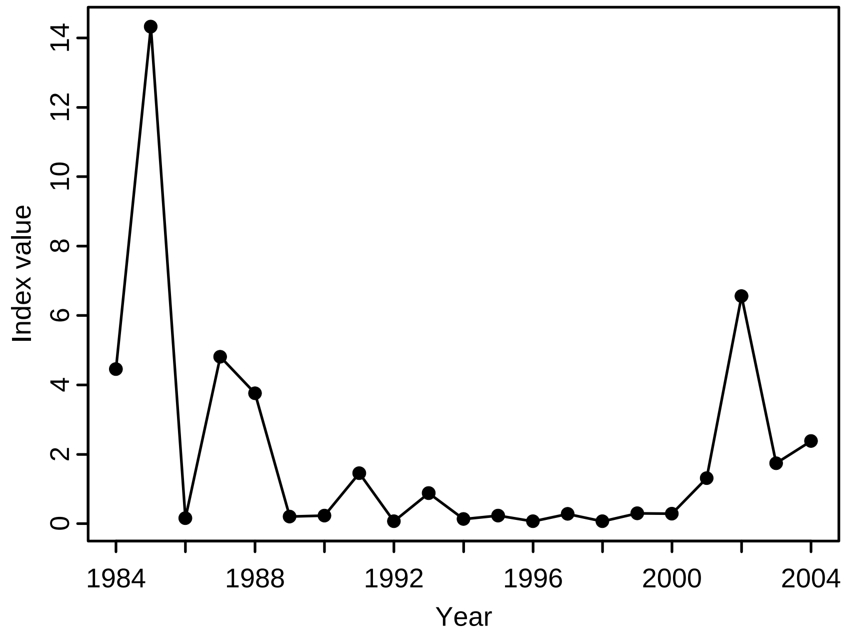


Figure 9. Catch per unit effort of widow rockfish from Oregon bottom trawl fishery from 1984 to 1999.

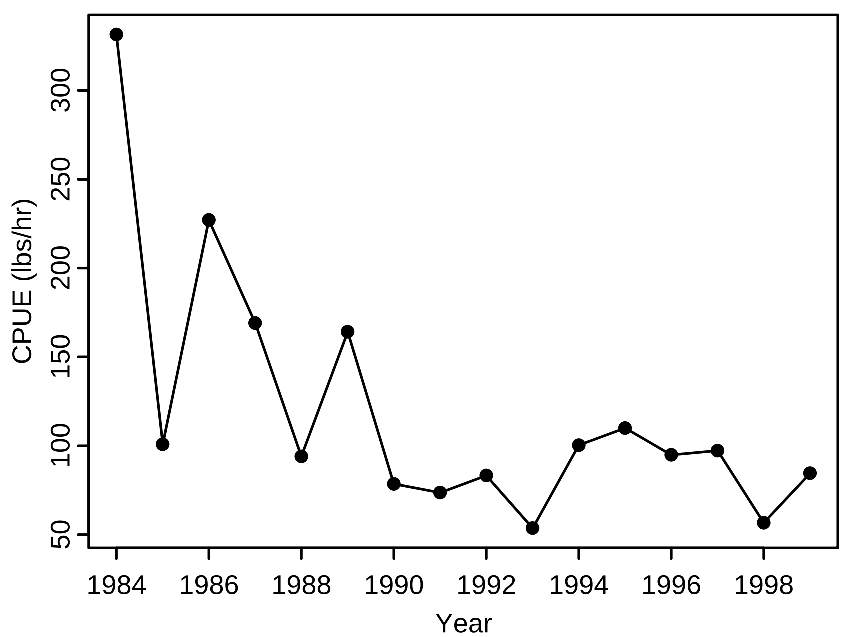


Figure 10. Scaled index values of catch per unit effort of widow rockfish abundance derived from bycatch in the Pacific whiting fisheries.

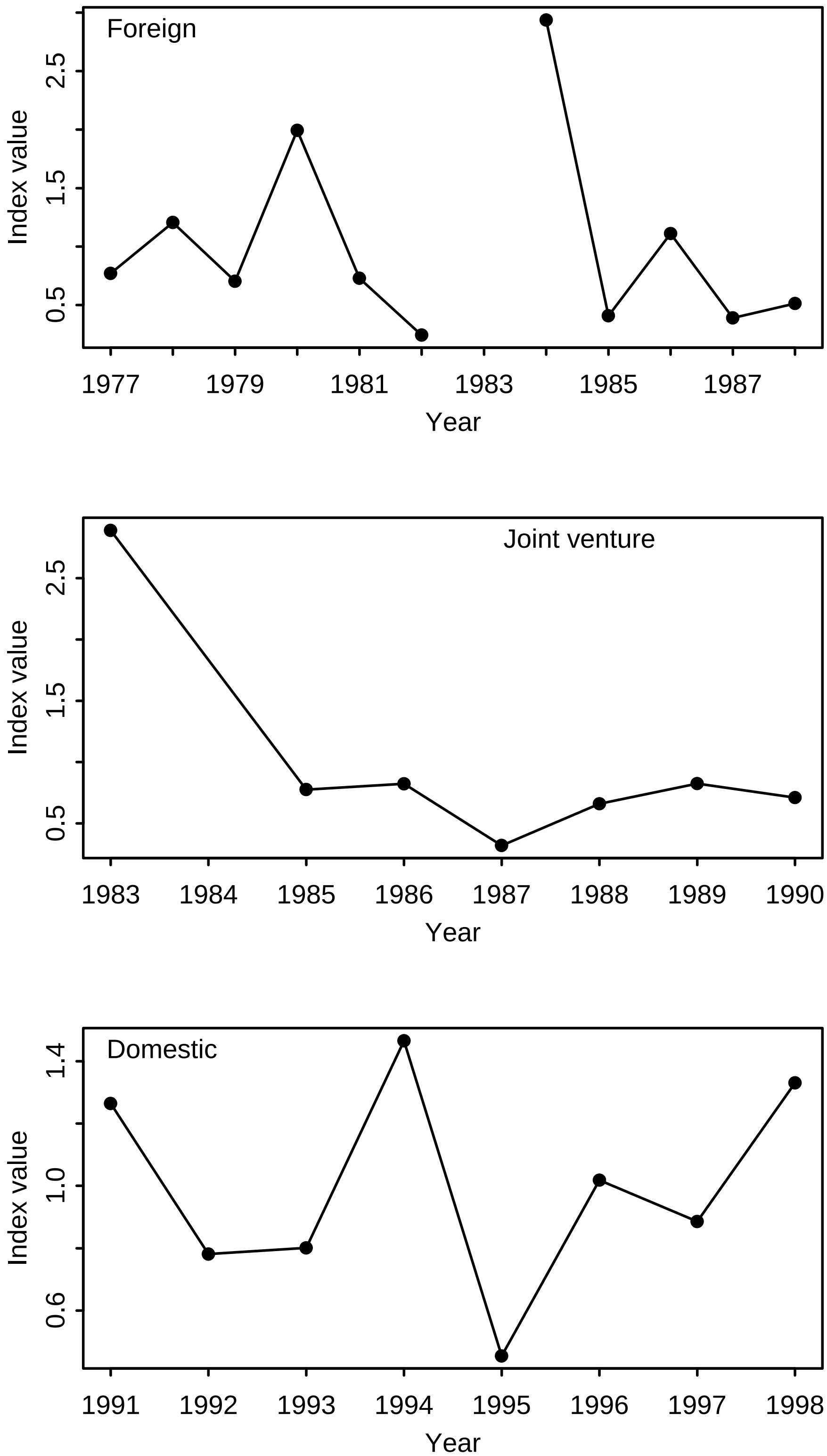


Figure 11. Index values of catch per unit effort of widow rockfish abundance derived from triennial surveys.

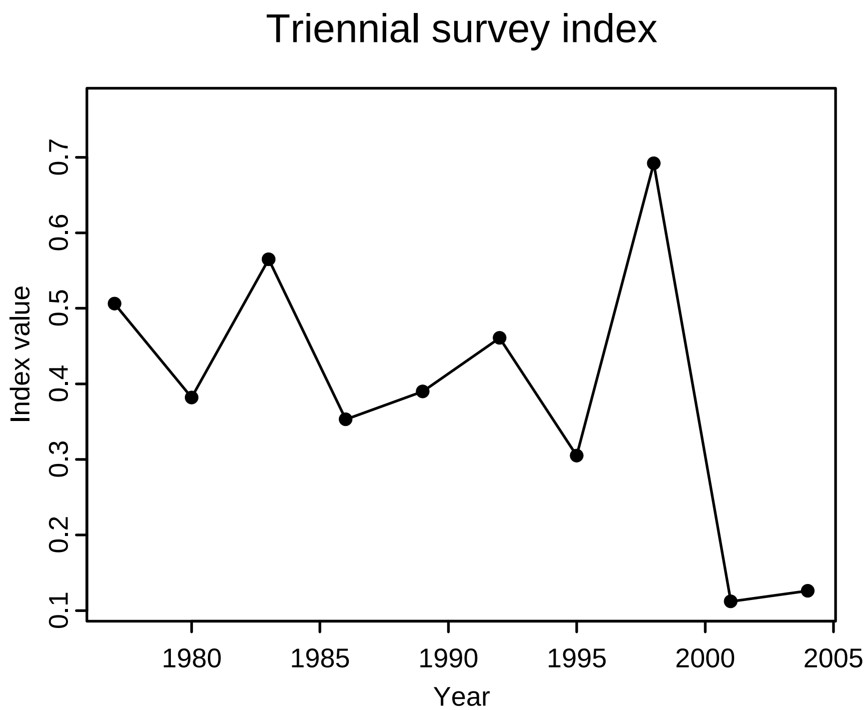


Figure 12. Fraction of landings in the north area, defined as the Vancouver-Columbia and Oregon trawl fisheries, with a 7-year moving average. Note that the fractions before 1977 were fixed at the value computed before the foreign landings (Rogers 2003) were added.

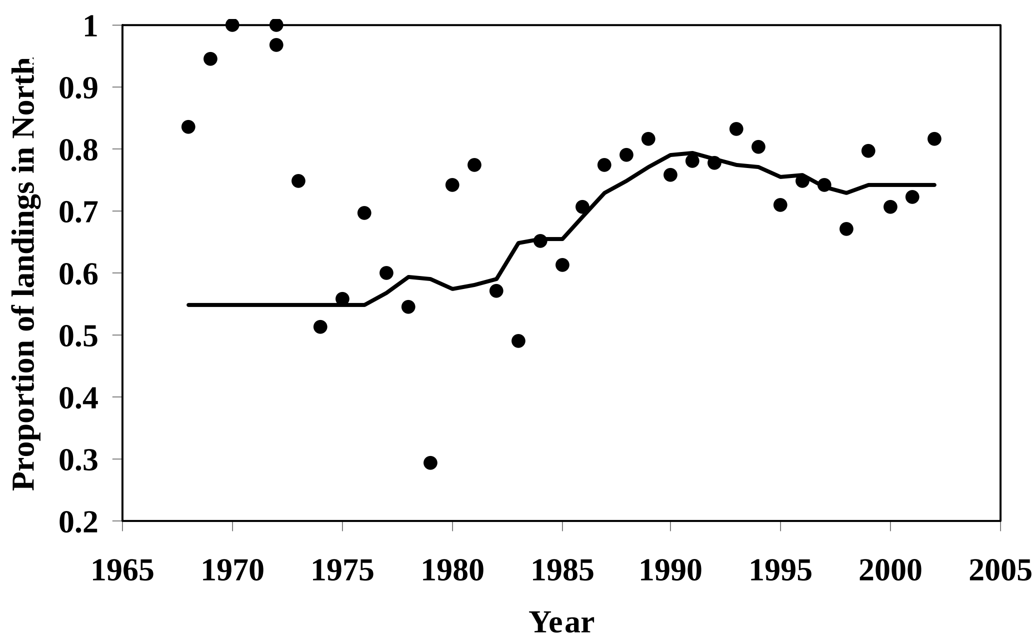


Figure 13. Age 3+ biomass (1000mt) and spawning biomass (1000mt) from 1958 to 2004 estimates from the base model.

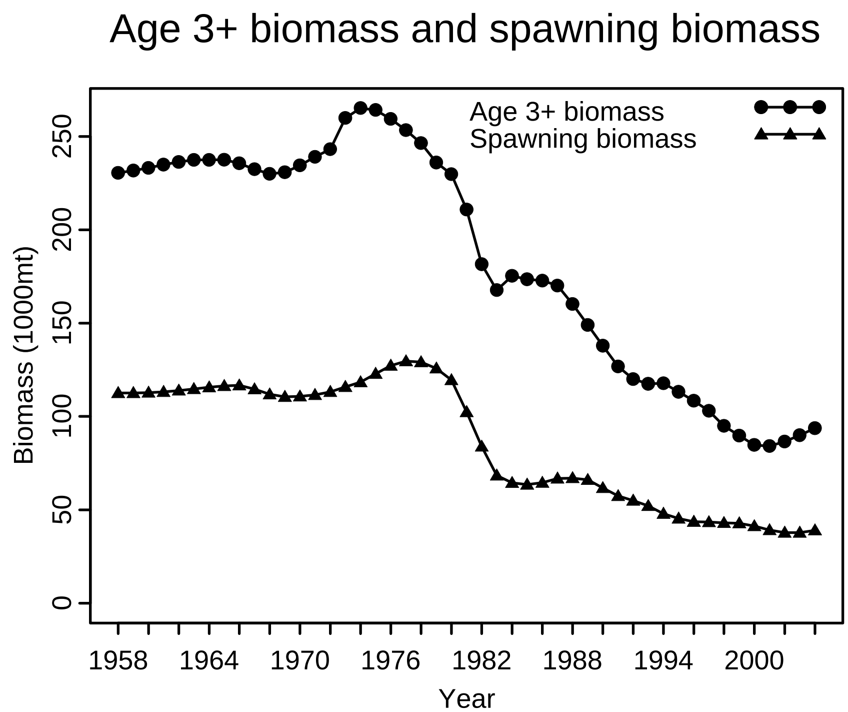


Figure 14. Spawning output (million of eggs) from 1958 to 2004 estimated from the base model.

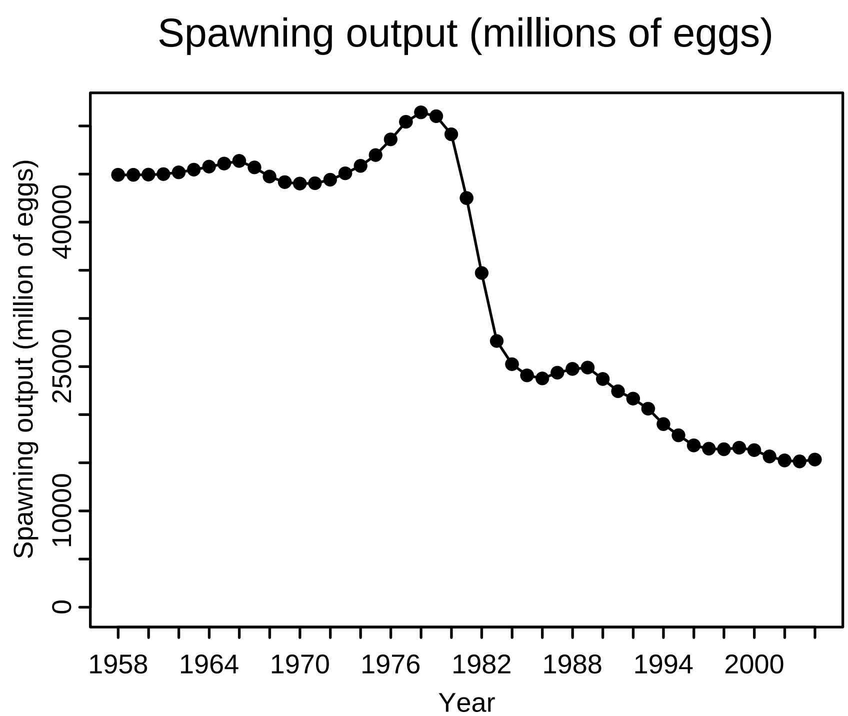


Figure 15. Age 3 recruits (*1000) from 1958 to 2004 estimates from the base model.

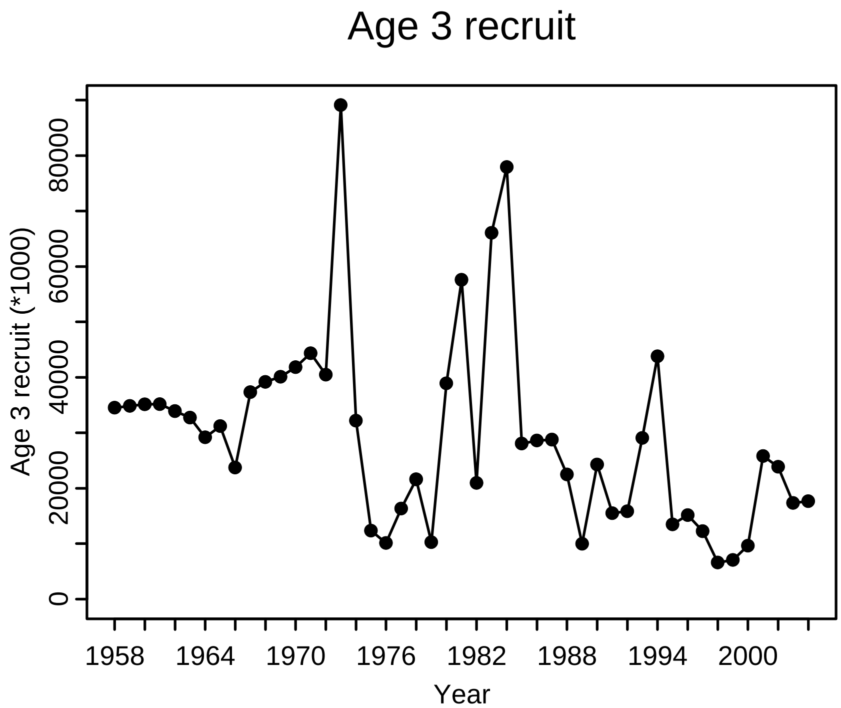


Figure 16. Fishing mortality by four fisheries from 1958 to 2002 estimates from the base model

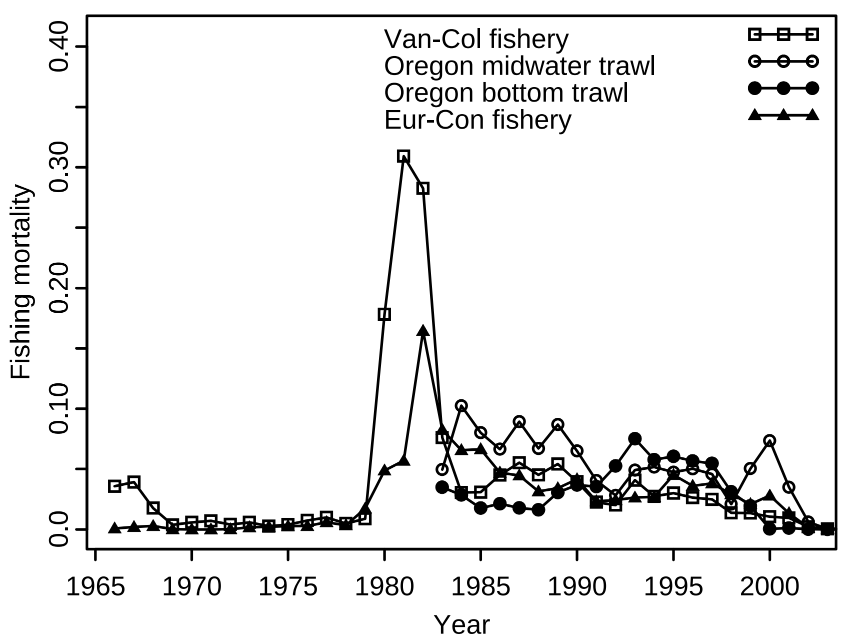


Figure 17. Fishery-specific selectivity estimates from the base model.

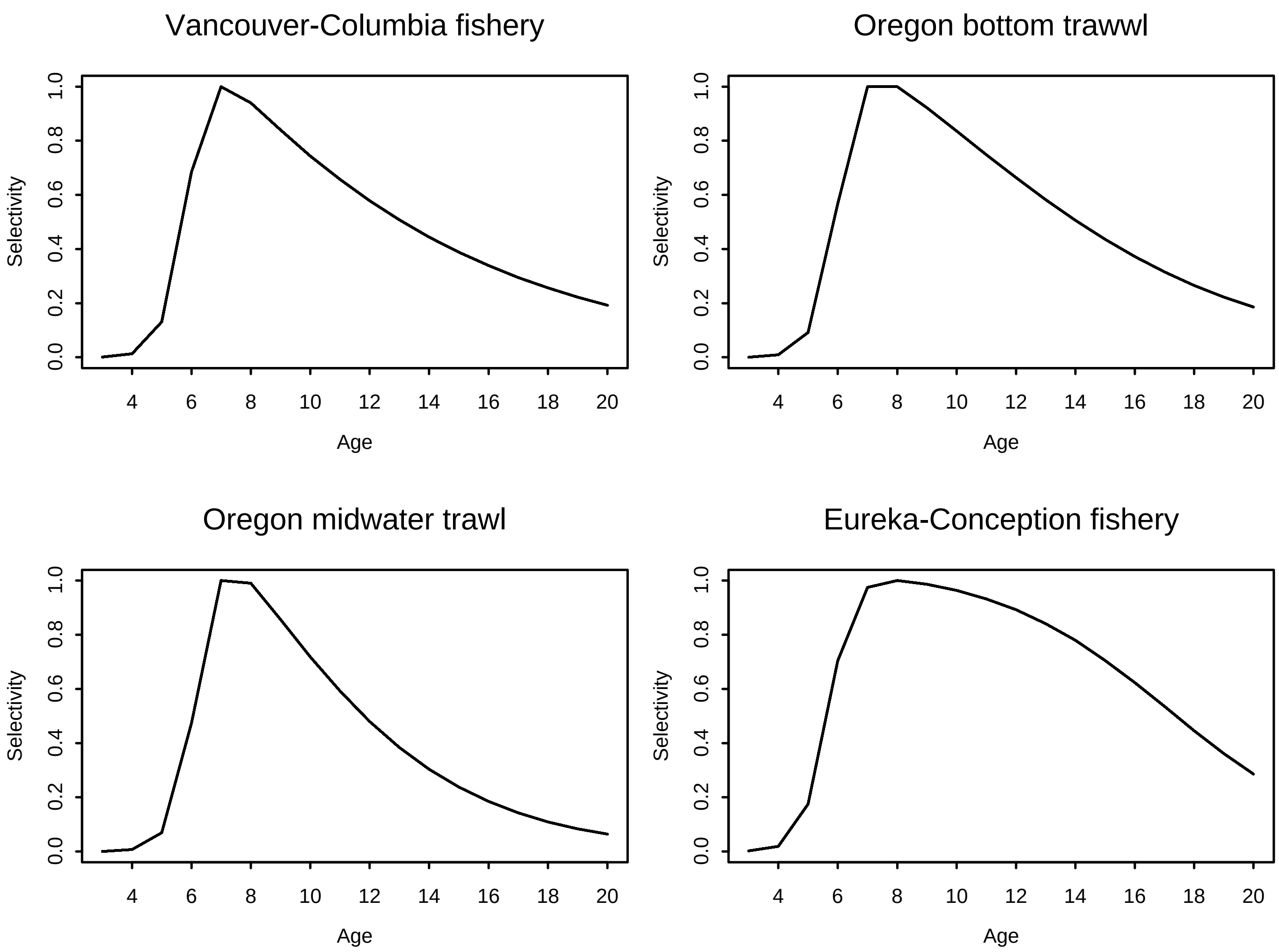


Figure 18. Stock-recruitment relationship from the base model. Estimated +Residual = predicted values plus annual recruitment residuals; Estimated = estimated values from stock-recruitment relationship.

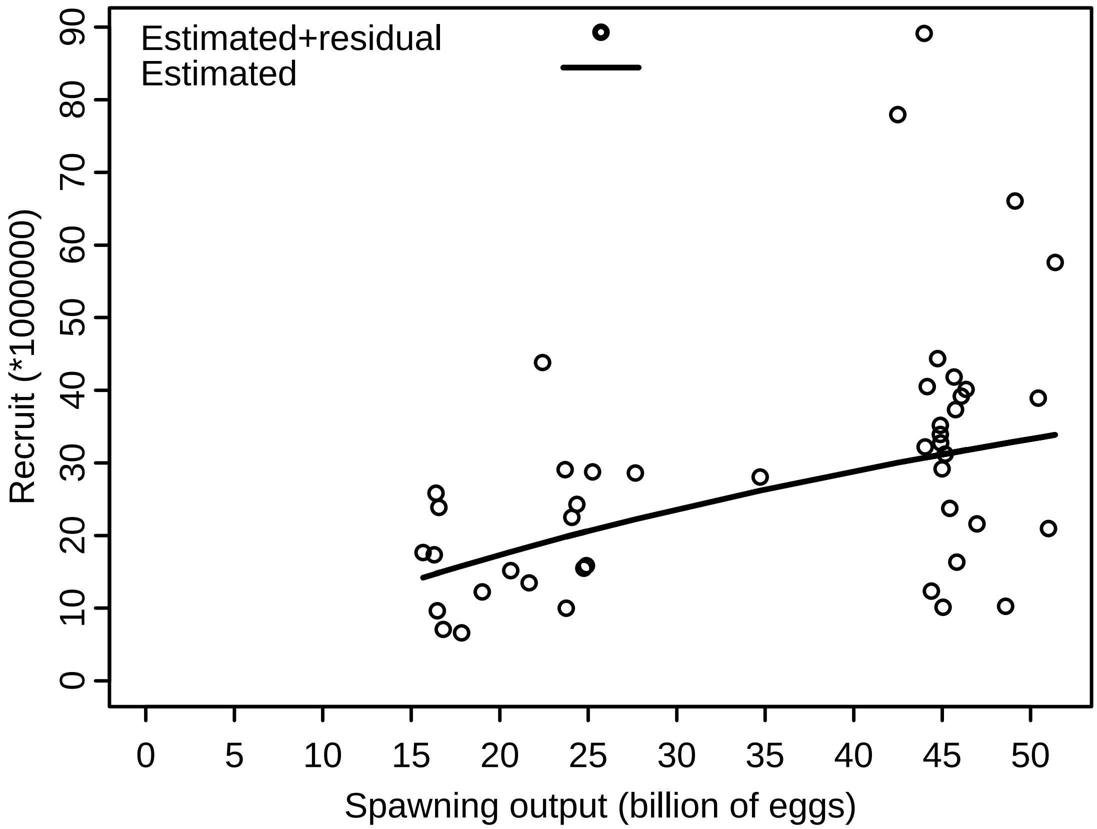


Figure 19. Model fits to the Vancouver-Columbia and Oregon midwater trawl fisheries landings data.

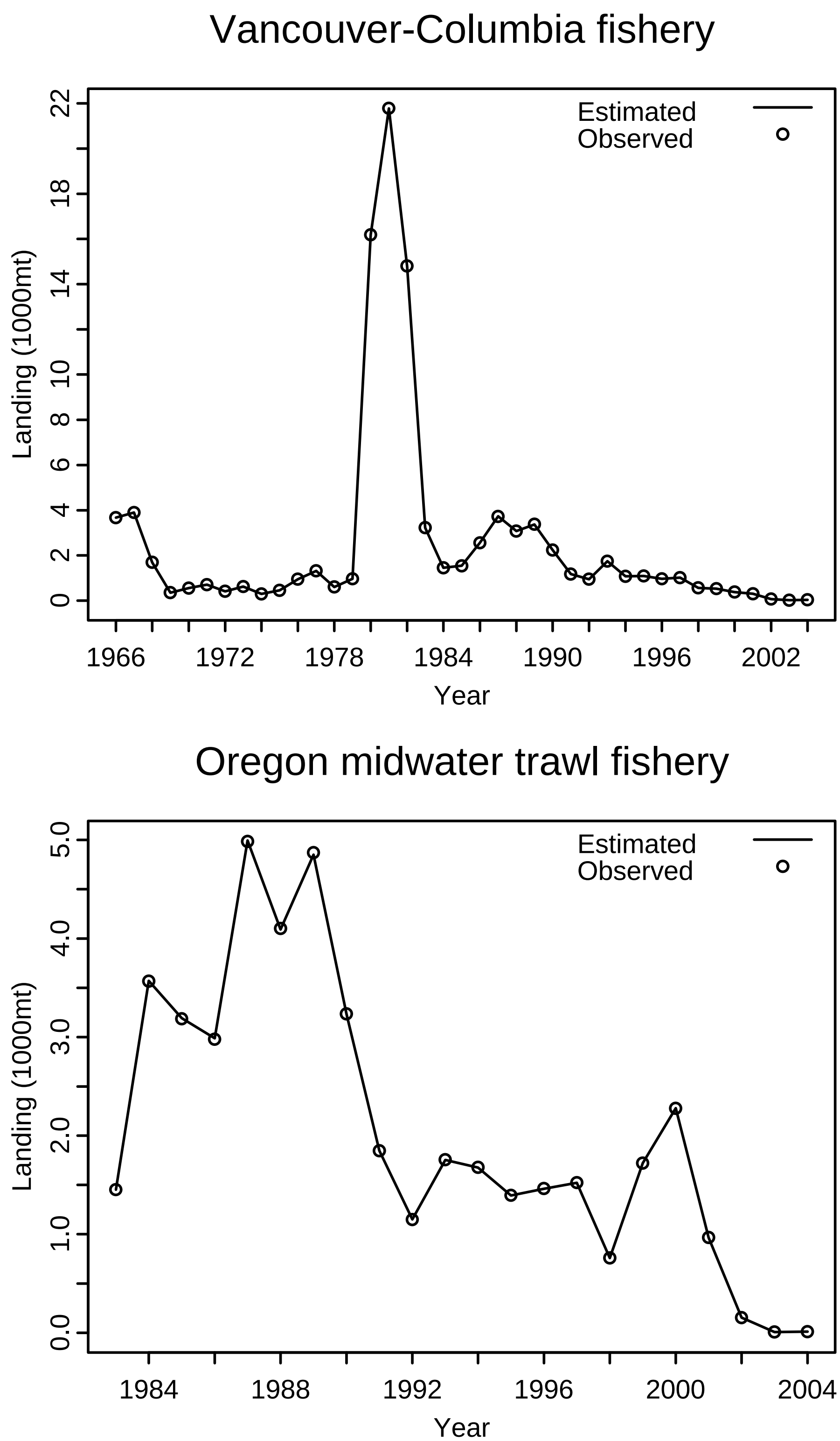


Figure 20. Model fits to the Oregon bottom trawl and Eureka-Conception fisheries landings data.

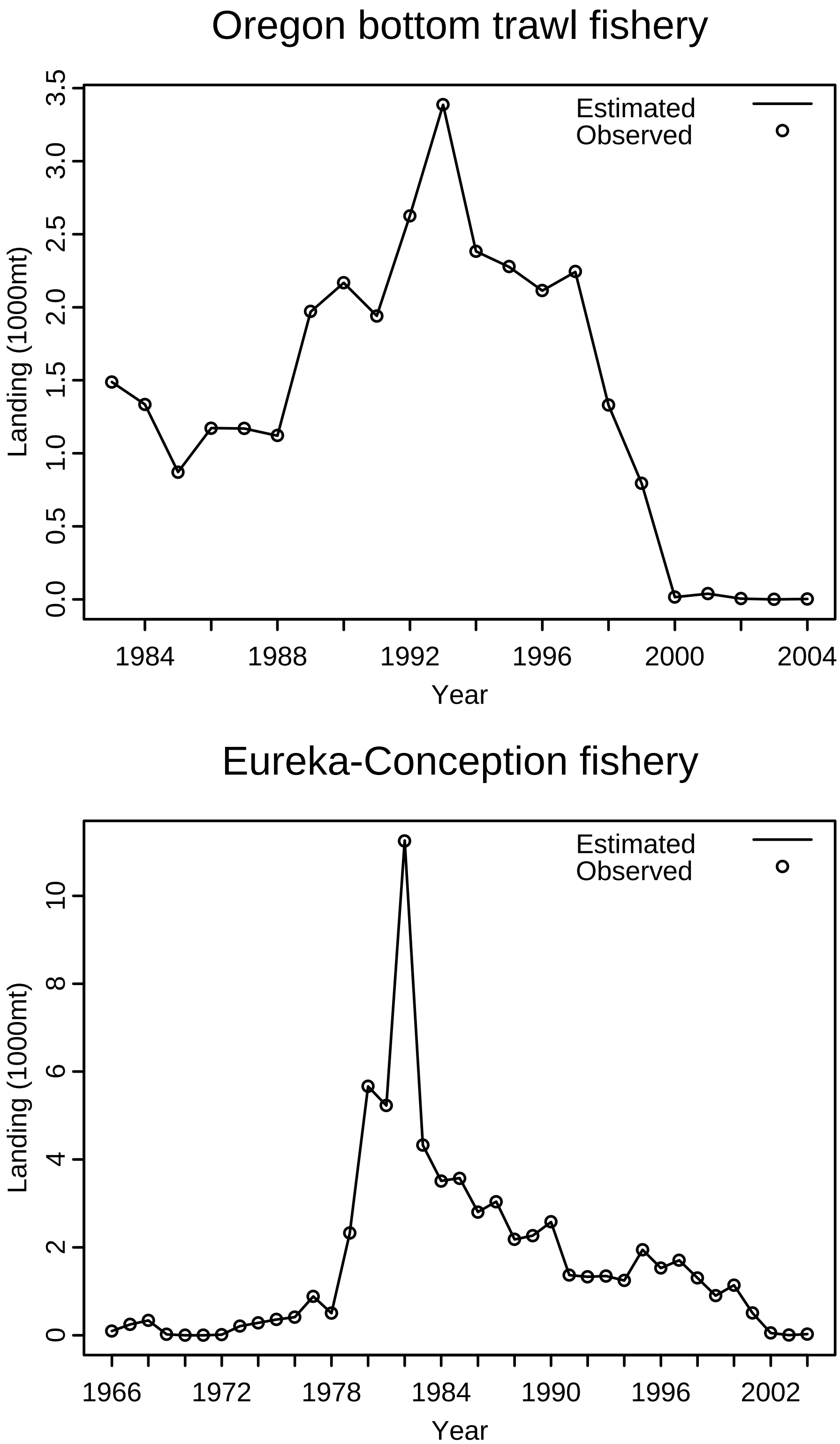


Figure 21. Model fits to the midwater trawl juvenile survey index.

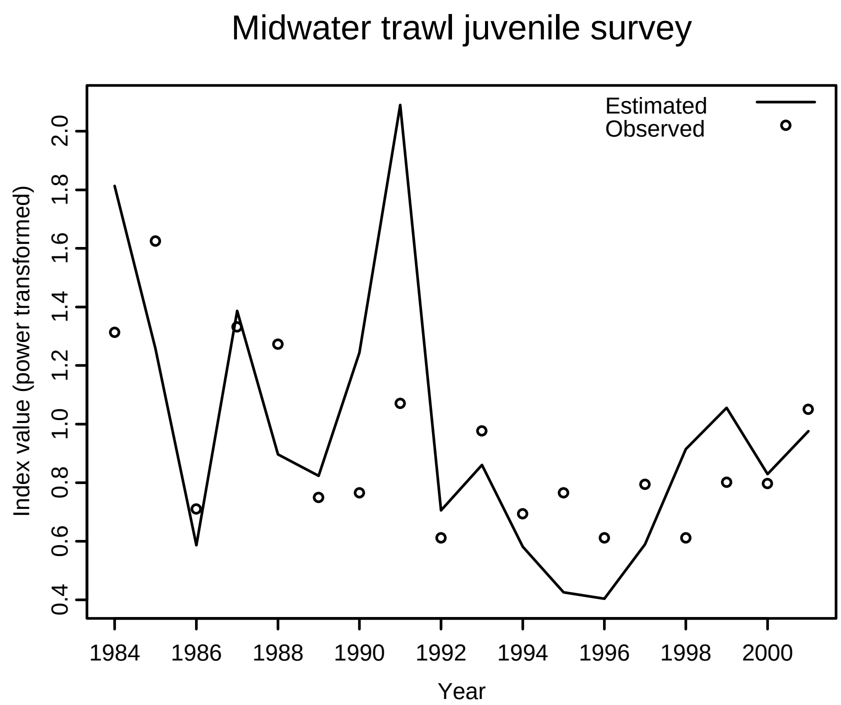


Figure 22. Model fits to the Oregon bottom trawl logbook index.

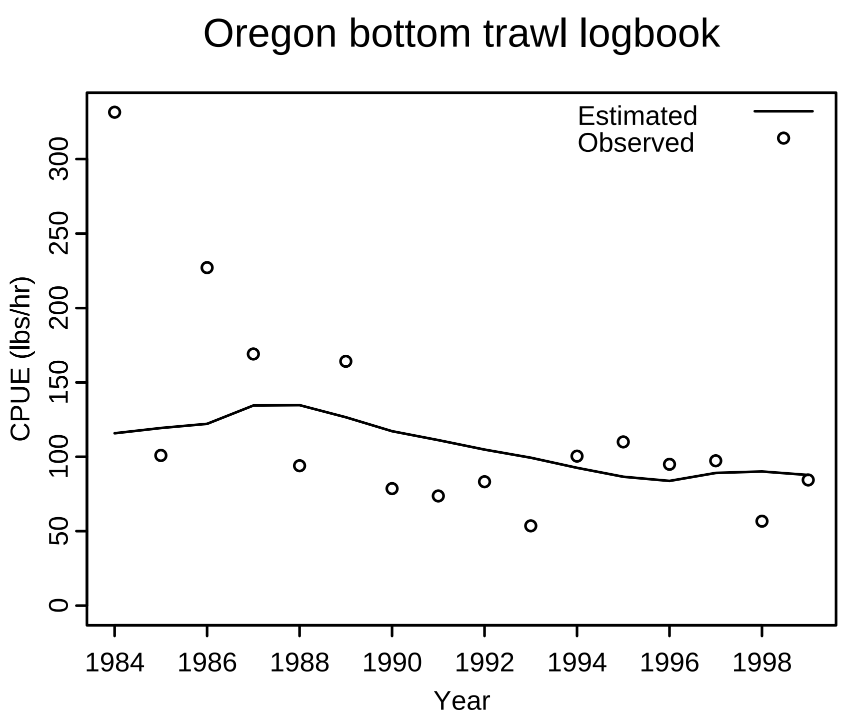


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Figure 23. Model fits to the Pacific whiting foreign fishery bycatch index.

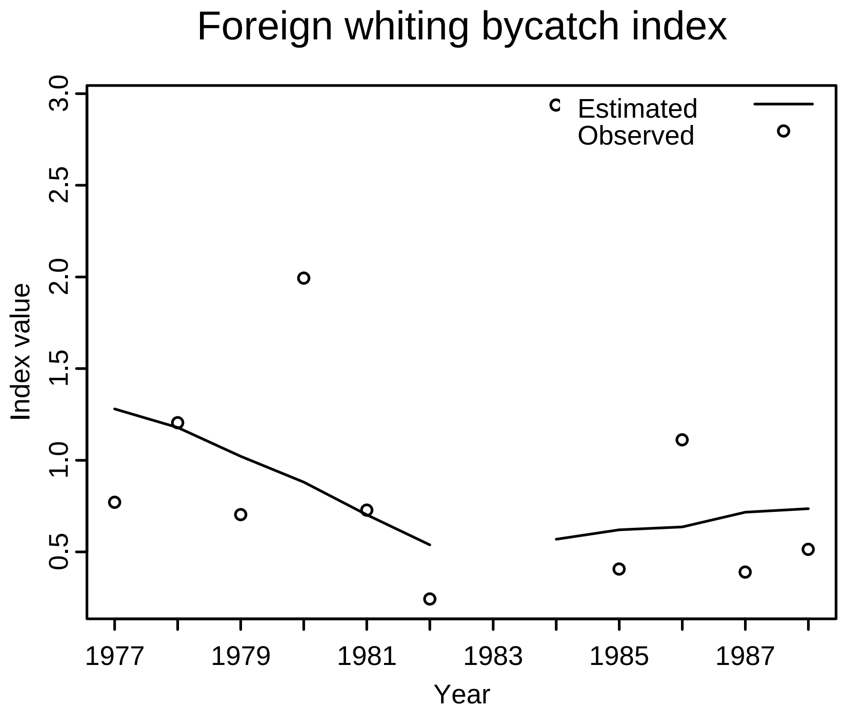

Figure 24. Model fits to the Pacific whiting joint venture (JV) fishery bycatch index.

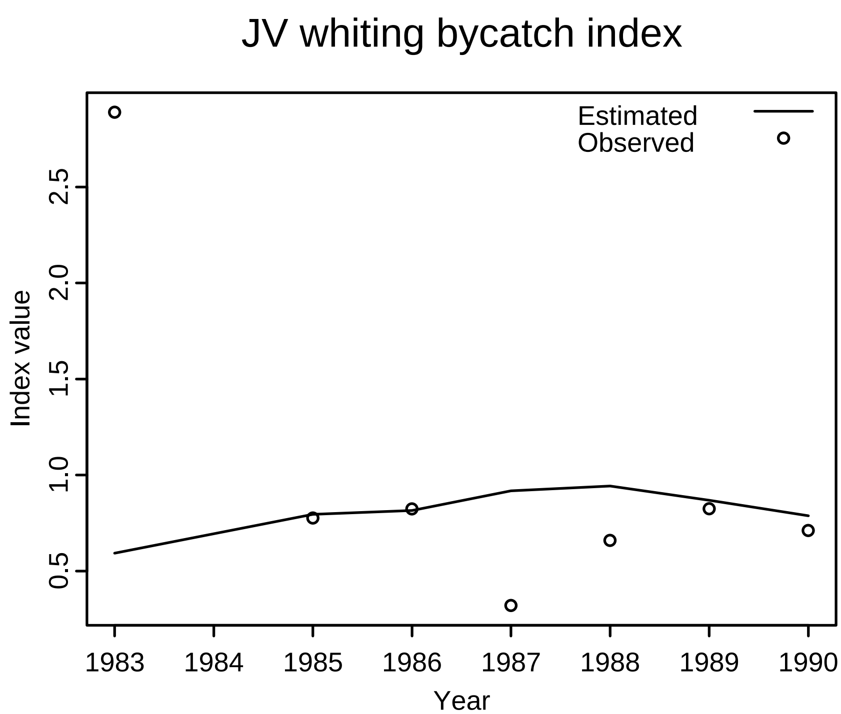

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Figure 25. Model fits to the Pacific whiting domestic fishery index.

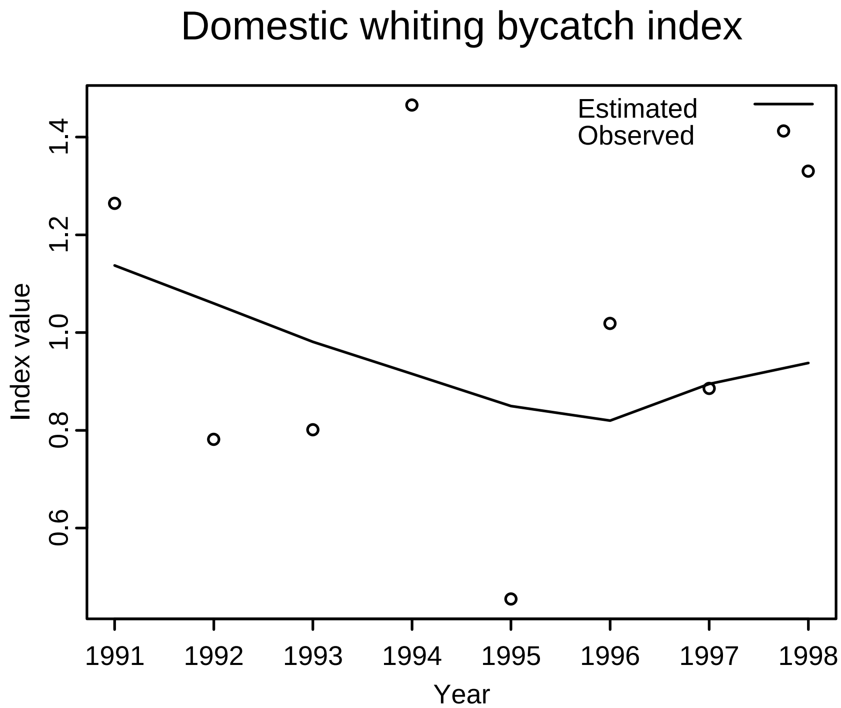


Figure 26. Model fits to triennial survey index.

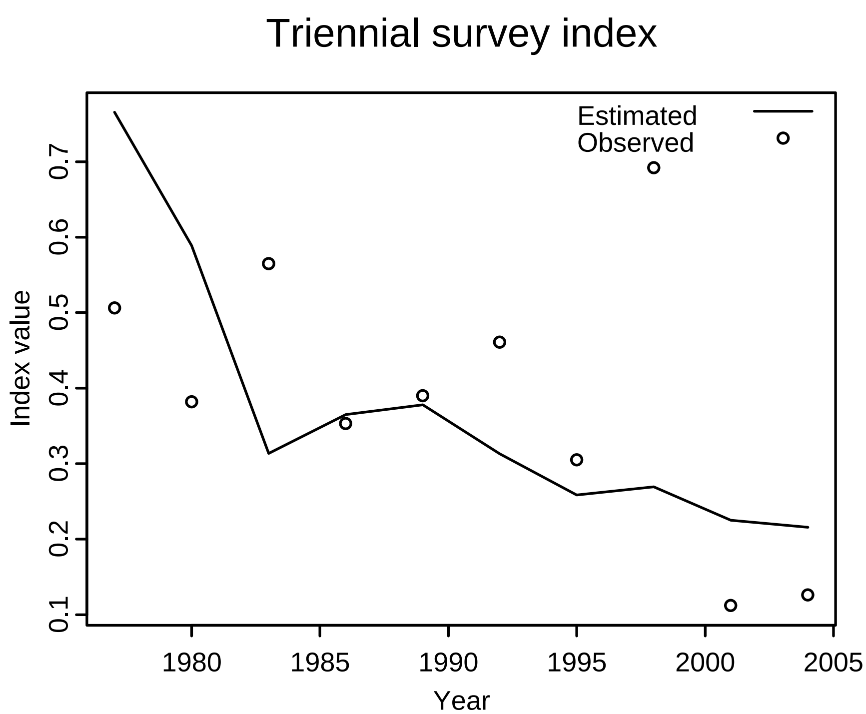
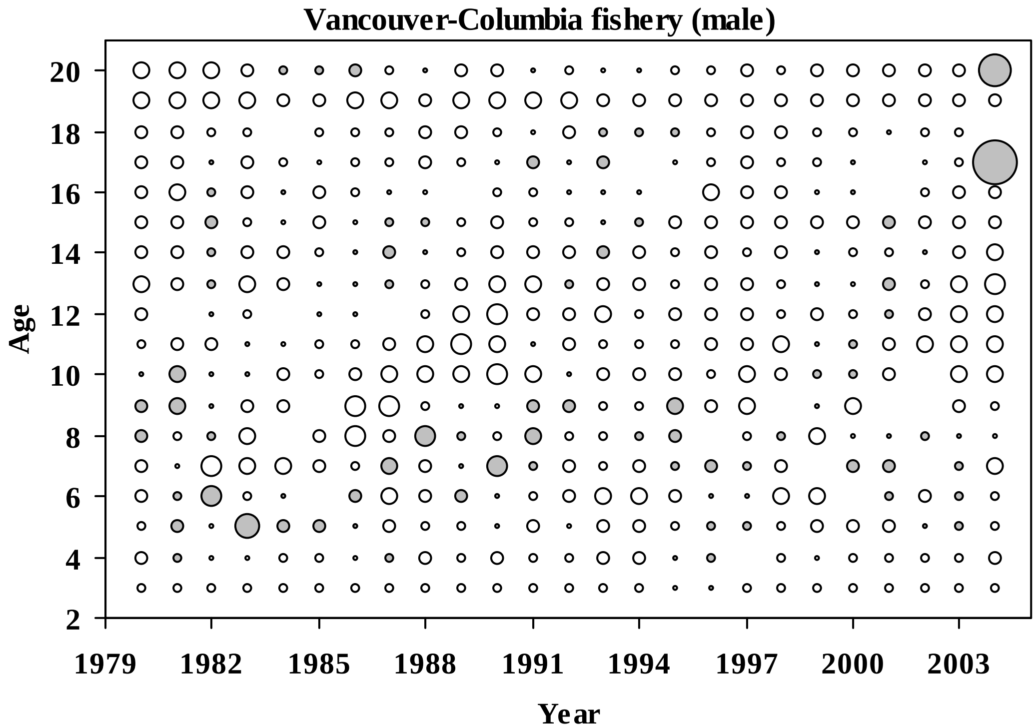


Figure 27a. Age composition residuals for the Vancouver-Columbia fishery from the base model. Residuals are standardized differences (observed – estimated). Dark circles are positive residuals and open circles are negative residuals.



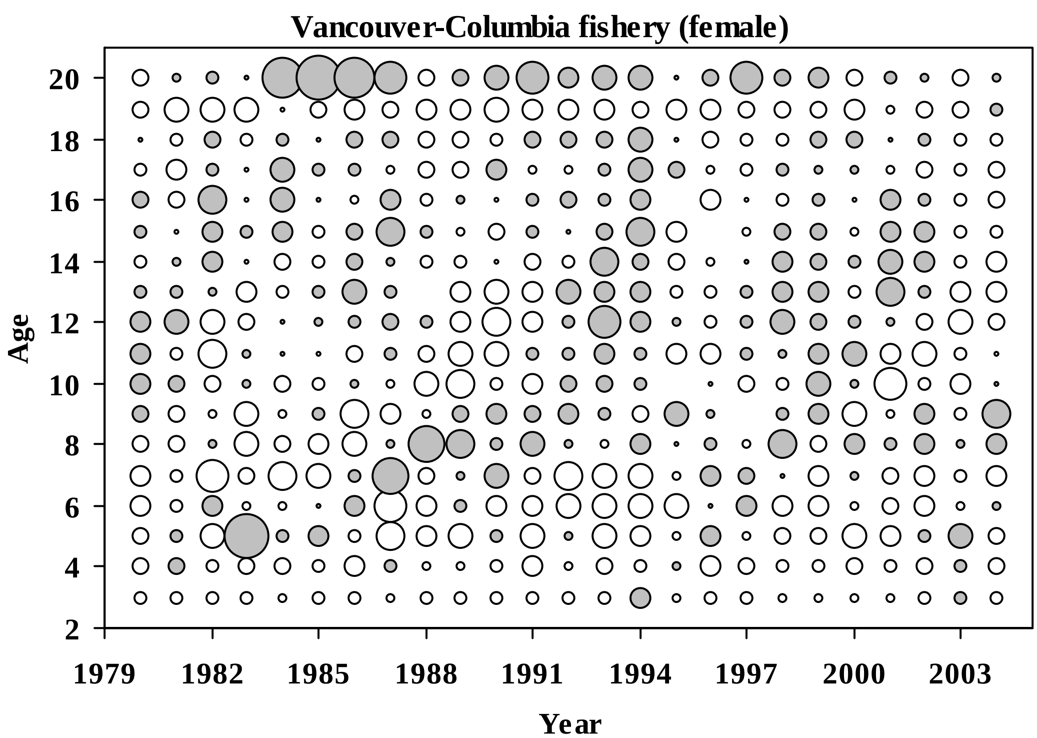
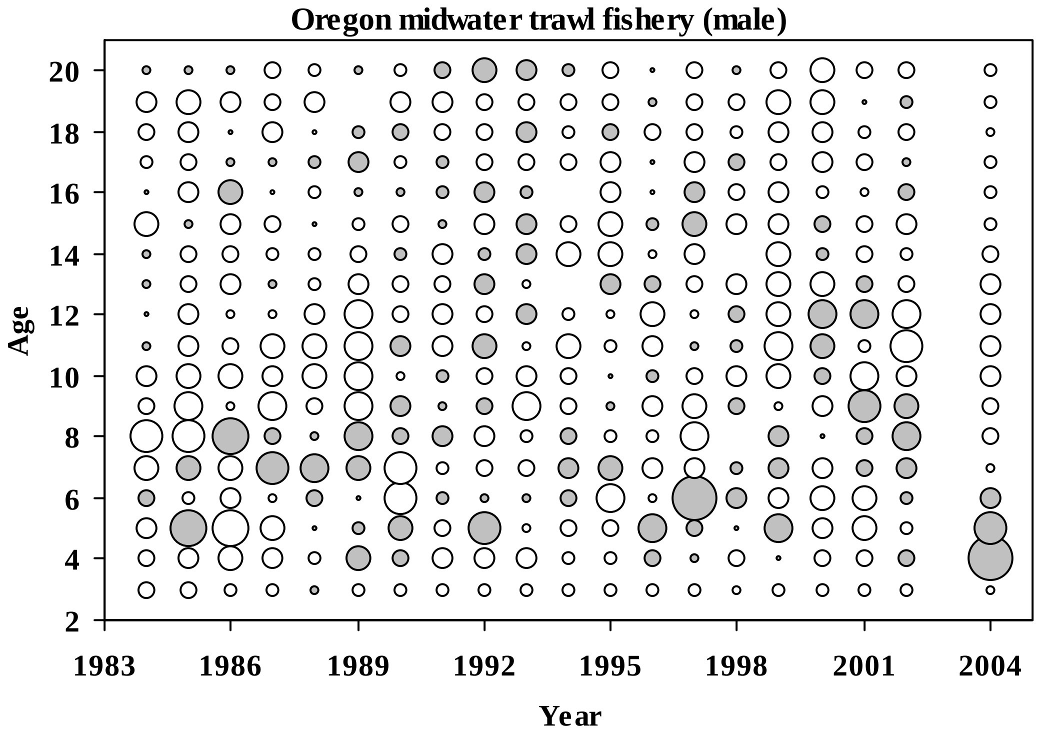


Figure 27b. Age composition residuals for the Oregon midwater trawl fishery from the base model. Residuals are standardized differences (observed – estimated). Dark circles are positive residuals and open circles are negative residuals.



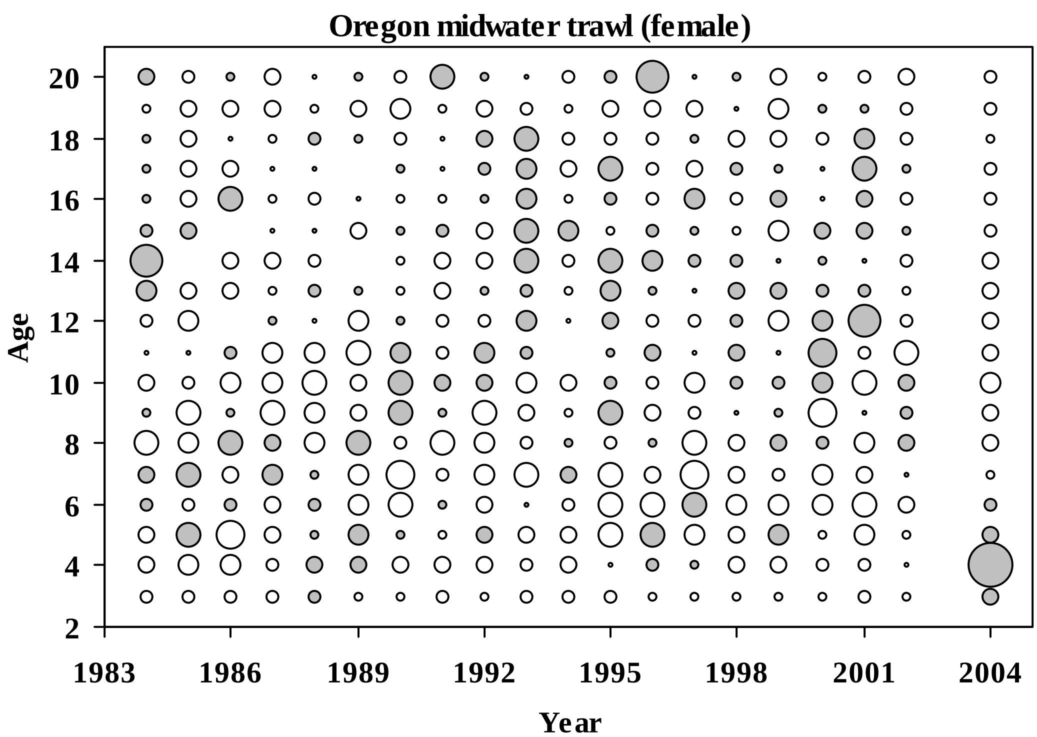
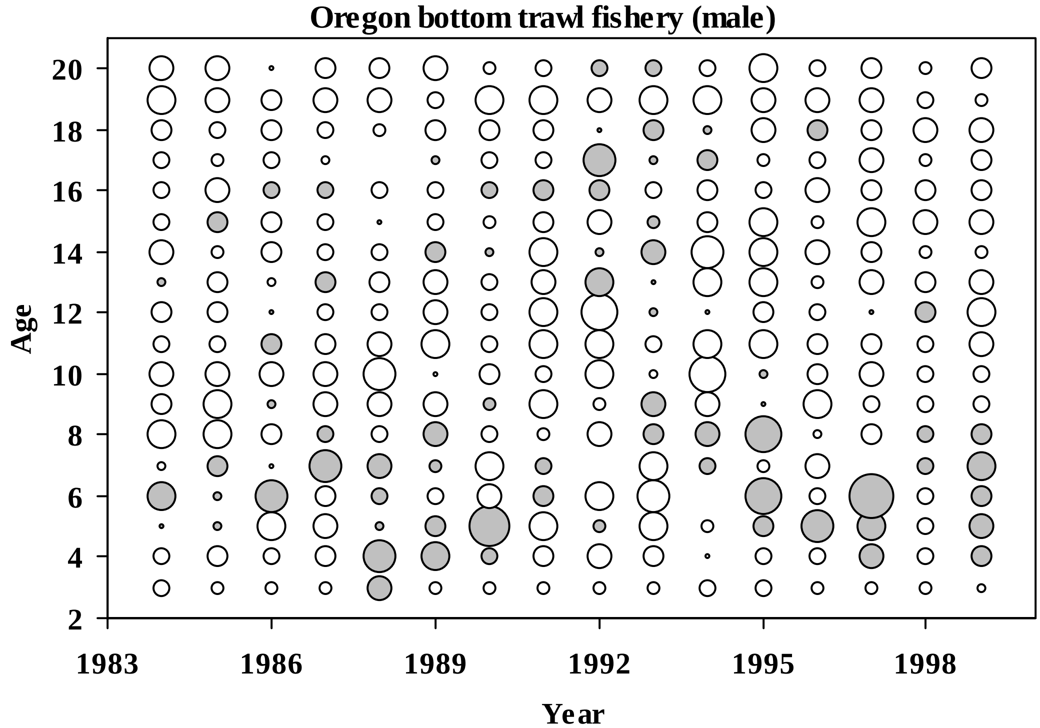


Figure 27c. Age composition residuals for the Oregon bottom trawl fishery from the base model. Residuals are standardized differences (observed – estimated). Dark circles are positive residuals and open circles are negative residuals.



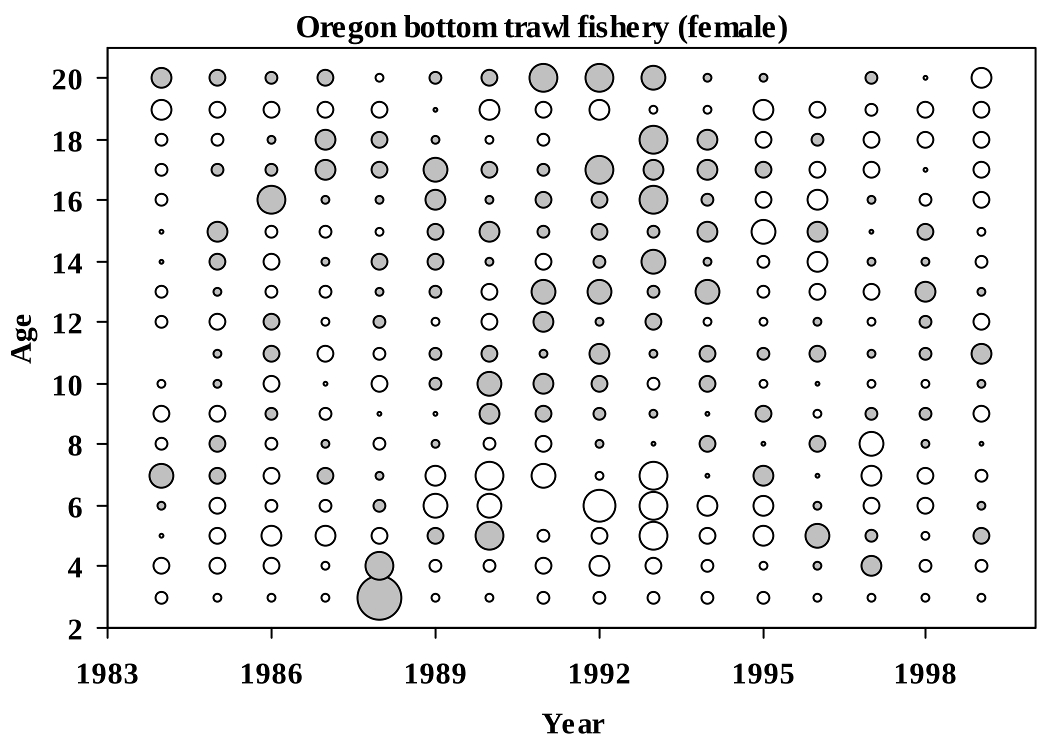
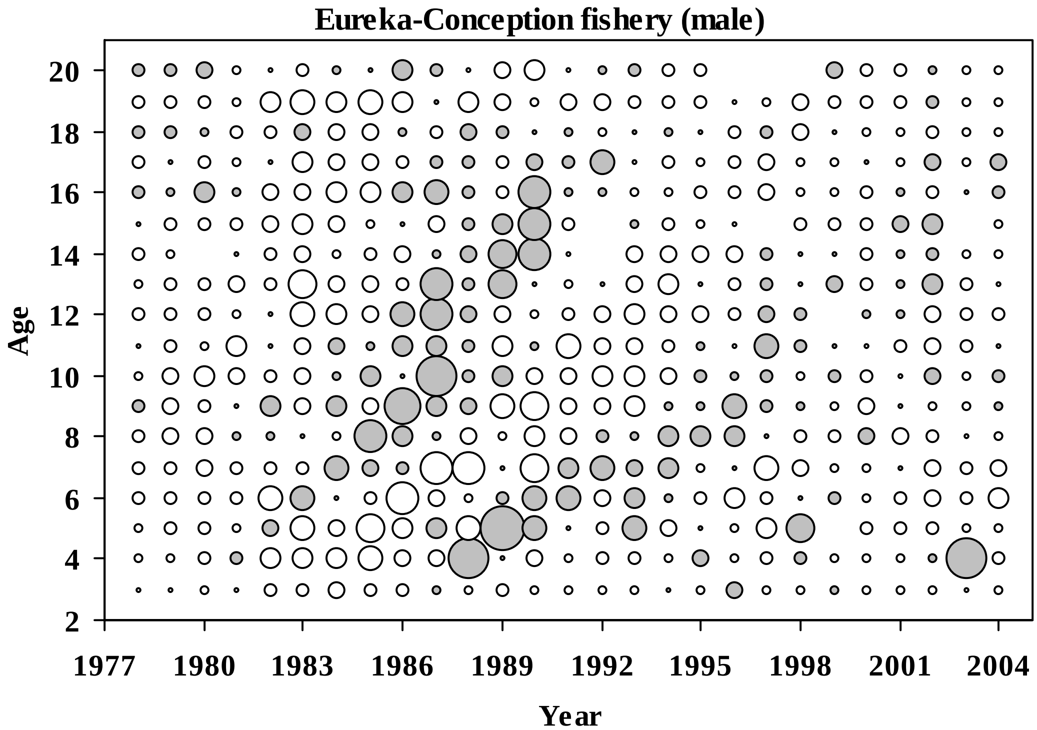


Figure 27d. Age composition residuals for the Eureka-Conception fishery from the base model. Residuals are standardized differences (observed – estimated). Dark circles are positive residuals and open circles are negative residuals.



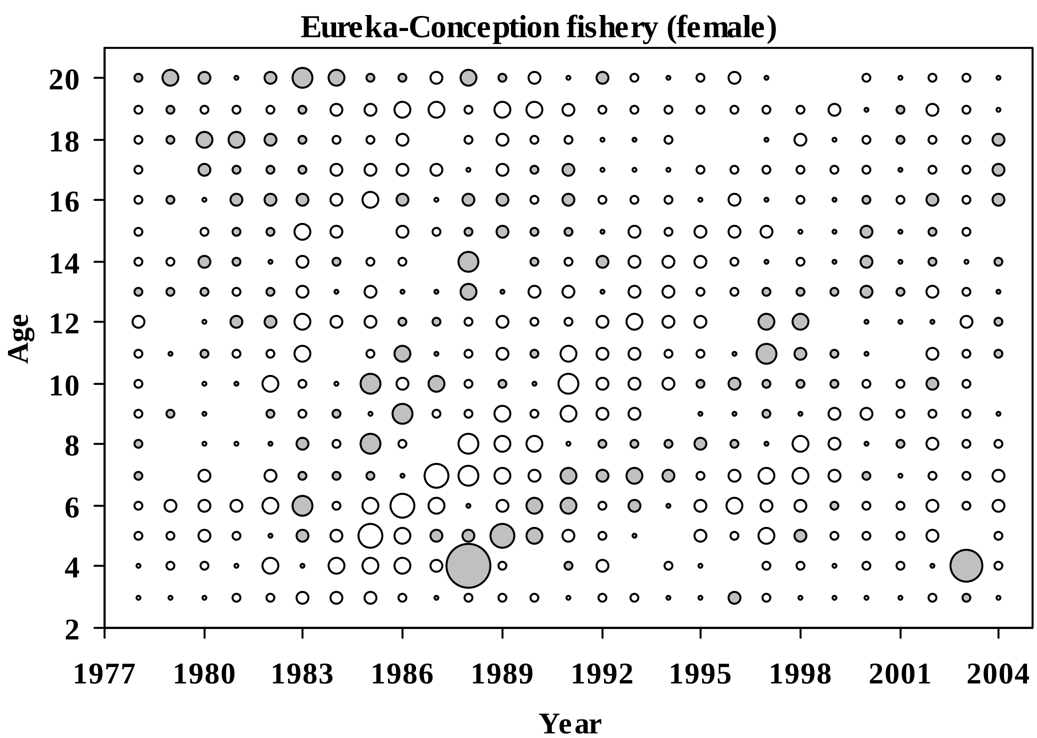


Figure 28. Comparisons of age 3+ biomass between base model of this assessment (2005 base model) and base model of the 2003 assessment.

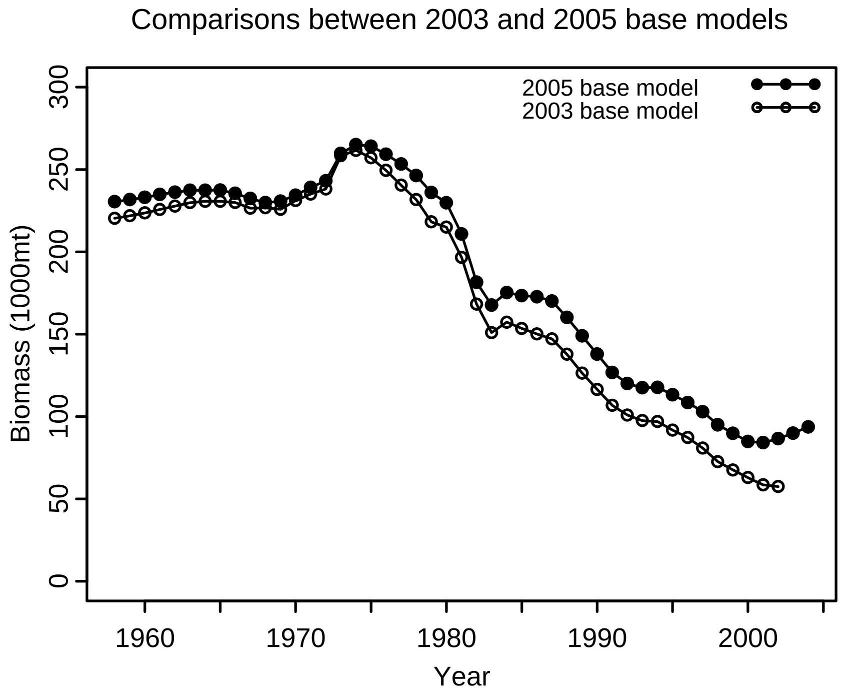


Figure 29. Comparisons of age 3+ biomass between base model (T2) and other models.

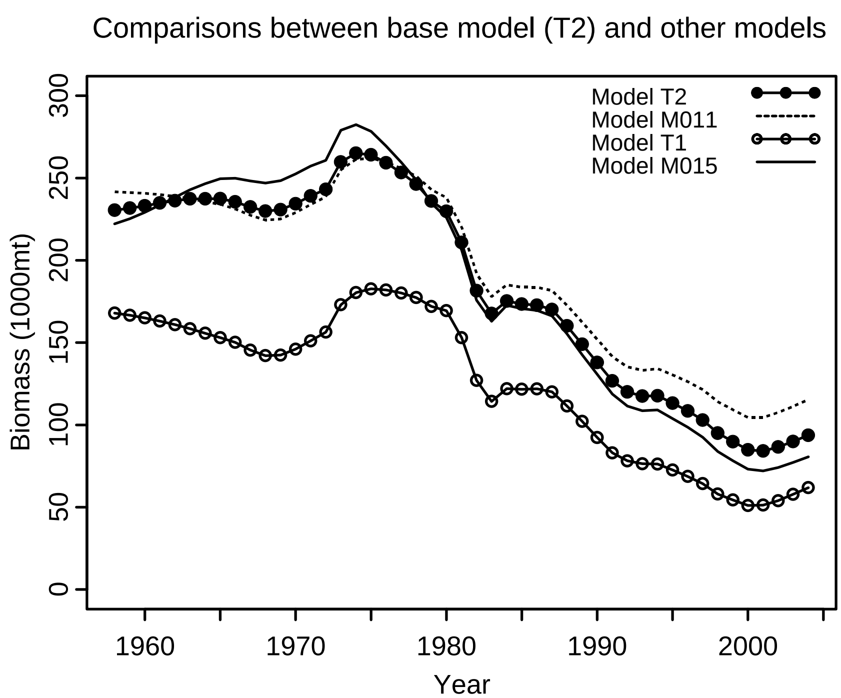


Figure 30. Comparisons of estimated age 3 recruitment between base model (T2) and other models.

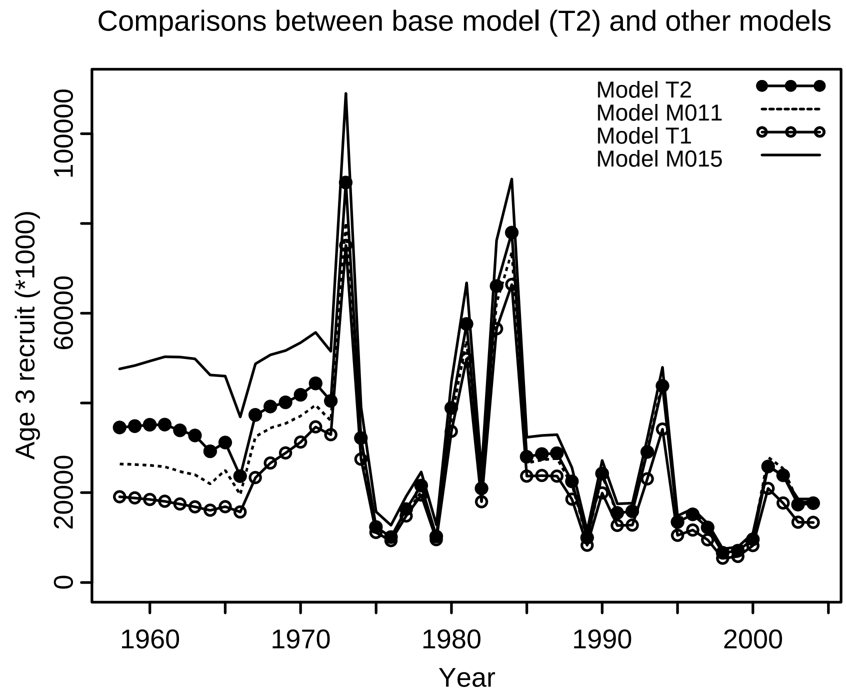
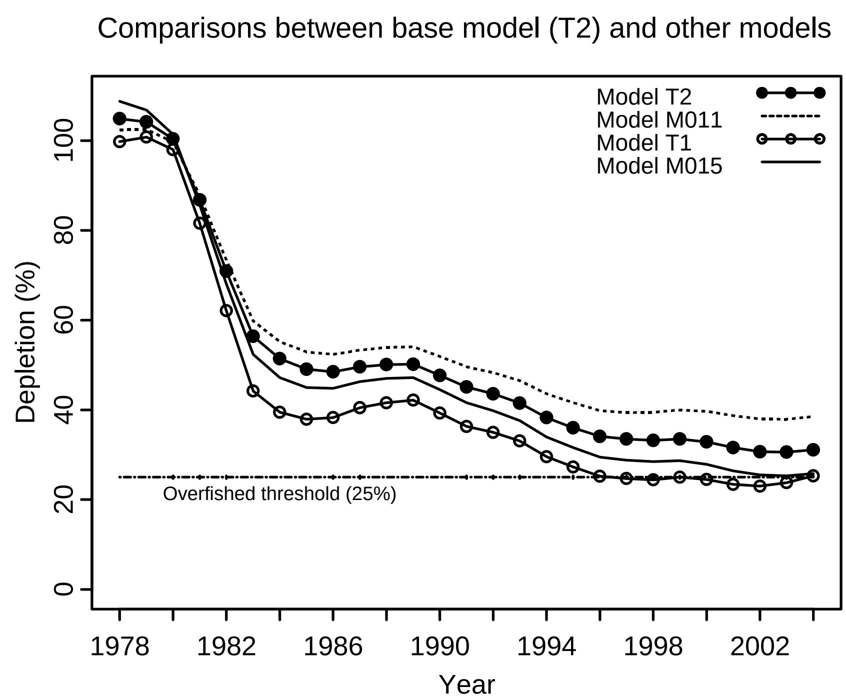


Figure 31. Comparisons of depletion rates (%) between base model (T2) and other models. Overfished threshold (25%) is also shown.



Appendix A. Widow bycatch indices from three Pacific Hake fisheries

E.J. Dick and Xi He
NMFS, Southwest Fisheries Science Center, Santa Cruz Laboratory

We computed indices of relative abundance based on incidental catch of widow rockfish in the Pacific Hake (*Merluccius productus*) fishery. As in the previous assessment (He et al., 2003), we recognized three periods of the fishery and treated them as independent indices in the model: ‘foreign’ (1977-88), ‘joint-venture’ (1983-90), and ‘domestic’ (1991-1998). The Widow rockfish STAR panel meeting report (PFMC, 2003) included specific recommendations regarding treatment of the data, which were adopted for all the analyses. Using the revised data sets, we present two indices for each fishery: one based on the model structure used in the 2003 assessment, and a second that attempts to addresses issues with the previous model specification. Assessment results between these two sets of indices were compared.

Data for the domestic fishery were obtained from the NORPAC database, and Martin Dorn (NMFS, AFSC) supplied data for the foreign and joint-venture fisheries. Several criteria were established for ‘valid’ tows (Table A1), based in part on spatial analyses described in Appendix A of the previous assessment (He et al., 2003). Following the recommendation of the 2003 STAR panel, we no longer excluded records with widow catches larger than 5 tons or those outside 2 standard deviations (PFMC, 2003).

Table A1. Characteristics of data used to compute indices of widow rockfish bycatch in three Pacific Hake fisheries.

	FISHERY		
FIELD	**Foreign**	**Joint-Venture (JV)**	**Domestic**
Year	1977-82, 1984-88	1983, 1985-90	1991-1998
Tow duration	>15 min. & <500 min.	>15 min. & <500 min.	>15 min. & <500 min.
Latitude	43° – 46°, 47° – 47.5°	43° – USA-Canada border	43° – USA-Canada border
Hake catch	< 50 tons/tow	< 150 tons/tow	< 150 tons/tow
Gear type (NORPAC code)	Pair trawl (4)	Pair trawl (4) Non-pelagic trawl (1)	Pelagic trawl (2)
Distance from 200m isobath	<= 5 nautical miles	<= 5 nautical miles	<= 5 nautical miles

Data from 1976 were excluded from the index for the foreign fishery due to indications of underreporting (Bailey et al., 1982). At the request of the 2003 STAR panel, we also excluded years after 1998 because the domestic fishery began actively avoiding widow rockfish in 1999.

We calculated CPUE per tow as the weight (kg) of widow rockfish divided by tow duration (minutes). Since a large percentage of tows (41% - 59%) did not catch widow rockfish, we calculated each bycatch index using the delta-GLM method (Stefánsson, 1996). The model structure in the previous assessment incorporated two generalized linear models (GLM): a binomial GLM with a logit link function and a Gaussian GLM for log(CPUE) with an identity link function. The linear predictors for both GLMs included year and latitude as categorical variables, binning latitudes into 1° increments. We present time series of relative abundance based on this model structure in Table A2. The precisions of the year effects for each index were estimated using a jackknife routine.

Following analysis of the revised data set and the model structure from the previous assessment, we identified different trends in CPUE among latitudes and determined that the distributions of CPUE in the foreign and joint-venture fisheries were not adequately approximated by the lognormal distribution. We therefore developed revised indices for all three fisheries to resolve issues of model misspecification.

Revised bycatch index for the domestic fishery

To account for trends in CPUE that vary with latitude, we fit separate delta-GLM indices for each region and then summed the indices with weights equal to the area of widow rockfish "habitat." As in the previous assessment, widow habitat was defined as being within 5 nautical miles of the 200-meter depth contour. Habitat area was calculated using ArcView 3.2a (ESRI). The model structure from the previous assessment had six latitude bins, so estimating delta-GLM indices for each bin would have resulted in a very highly parameterized index. We therefore defined broader spatial categories, based on plots of mean widow CPUE aggregated into 10-minute latitude bins (Figure A1).

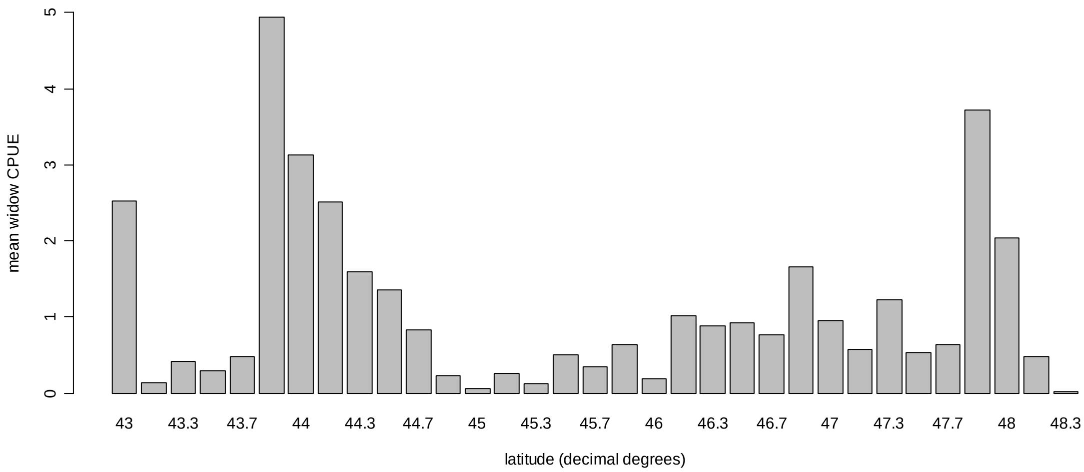


Figure A1. *Mean CPUE for incidental catch of widow rockfish in the domestic hake fishery (1991-1998), binned by 10-minutes of latitude.*

For the revised index, we defined a 'southern' region from 43º-45º N. latitude (1583 nm^2), and a 'northern' region from 45º to the USA-Canada boundary (3392 nm^2). Analysis of mean CPUE by latitude in individual years also shows southern and northern modes, with a minimum near 45º N. latitude.

We fit separate delta-GLM models for each region to account for different trends in CPUE among the northern and southern regions. Year and month were modeled as categorical explanatory variables in each GLM. The lognormal distribution appeared to be an adequate approximation for the distribution of CPUE in both regions.

The revised index for the domestic fishery in year i (I_i) is the area-weighted sum of the two regional (north/south) delta-GLM indices

$$I_i = \sum_{j=1}^{2} A_j Y_{ij} \tag{1}$$

where A_j is the area of widow habitat in region j, and Y_{ij} is the relative index of abundance for year i in region j. Assuming independence, the variance of the index is

$$Var(I_i) = \sum_{j=1}^{2} A_j^2 Var(Y_{ij}) \tag{2}$$

where $Var(Y_{ij})$ is estimated by a jackknife routine for each region. Figure A2 compares indices generated by the revised, area-weighted model and the model from the previous assessment. Point estimates and coefficients of variation for the indices are in Table A2.

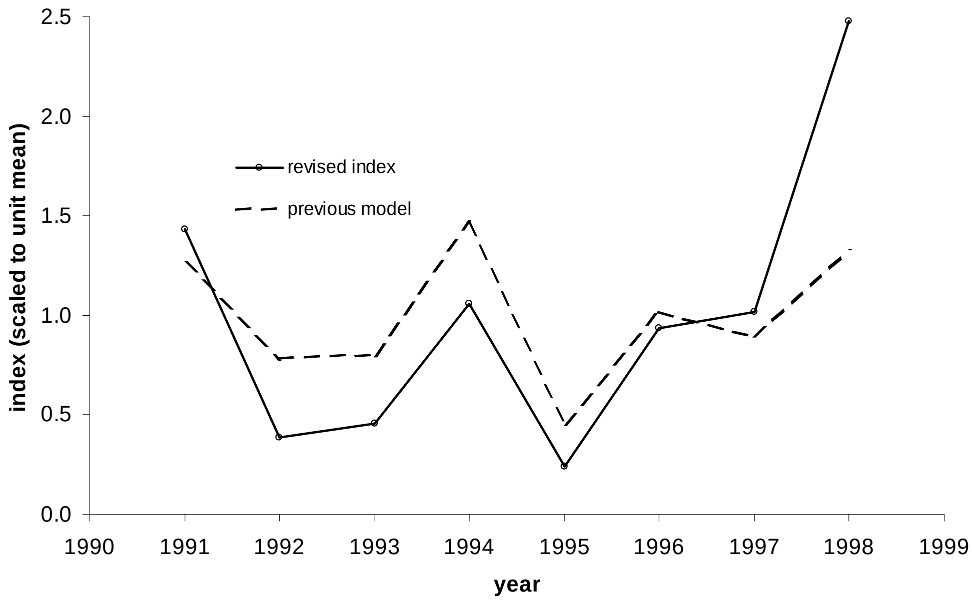


Figure A2. *Comparison of CPUE indices (scaled to unit mean) for incidental catch of widow rockfish in the domestic hake fishery.*

Revised bycatch index for the joint-venture fishery

We applied the recommendations of the 2003 STAR panel to data for the joint-venture fishery (1983-1990), and developed a revised time series of relative abundance. Using the model structure from the previous assessment we again found evidence that trends in CPUE differ with latitude (i.e. significant interactions exist between year and latitude). We therefore created a revised, area-weighted index similar to the one described for the domestic fishery. Time trends in CPUE for 'northern' and 'southern' regions were estimated using separate delta-GLM models with year and month effects.

Model diagnostics for the revised data also revealed that the lognormal distribution does not adequately approximate the distribution of CPUE in the joint-venture fishery. We fit models with two alternative distributions, gamma and inverse-Gaussian, and concluded that the inverse Gaussian distribution is a better choice for these data based on three criteria: the slope of a regression of log(variance) versus log(mean) for statistical cells with adequate sample size, quantile plots of standardized residuals, and Akaike's Information Criterion (AIC; Akaike, 1973). For example, data from the northern region generated a regression slope of 2.49 and AIC scores of –3272, –4029, and +992, corresponding to the lognormal, inverse-Gaussian, and gamma distributions, respectively. Quantile plots of standardized residuals from these three models are shown in Figure A3.

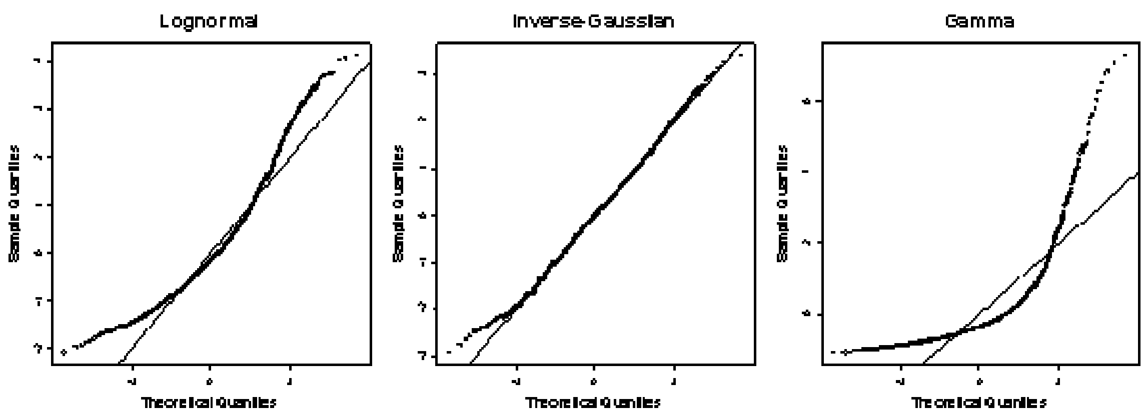


Figure A3. *Normal quantile plots of standardized residuals from models with different probability distributions (data from 'northern' region of joint-venture fishery).*

The choice of probability distribution has a strong effect on the index for the southern region (Figure A4). Diagnostics for the northern model also suggest a dramatic improvement in fit with the inverse-Gaussian model, but point estimates of annual trends are similar to those obtained using model structure from the previous assessment. Since the northern region has more widow habitat than the southern region, the revised (area-weighted) index was not dramatically different from the previous model (Figure A5). However, coefficients of variation estimated from the jackknife routine were generally larger for models that assumed inverse-Gaussian 'errors' (Table A2).

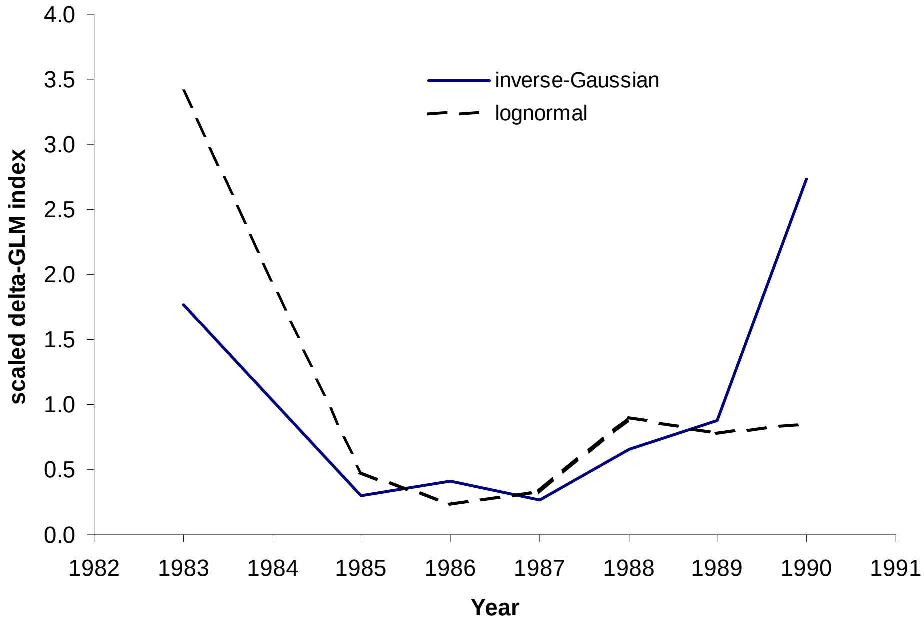


Figure A4. *CPUE indices (scaled to unit mean) based on different assumptions about the distribution of 'errors.' Data are widow bycatch in the joint-venture hake fishery, southern region (latitudes 43-45).*

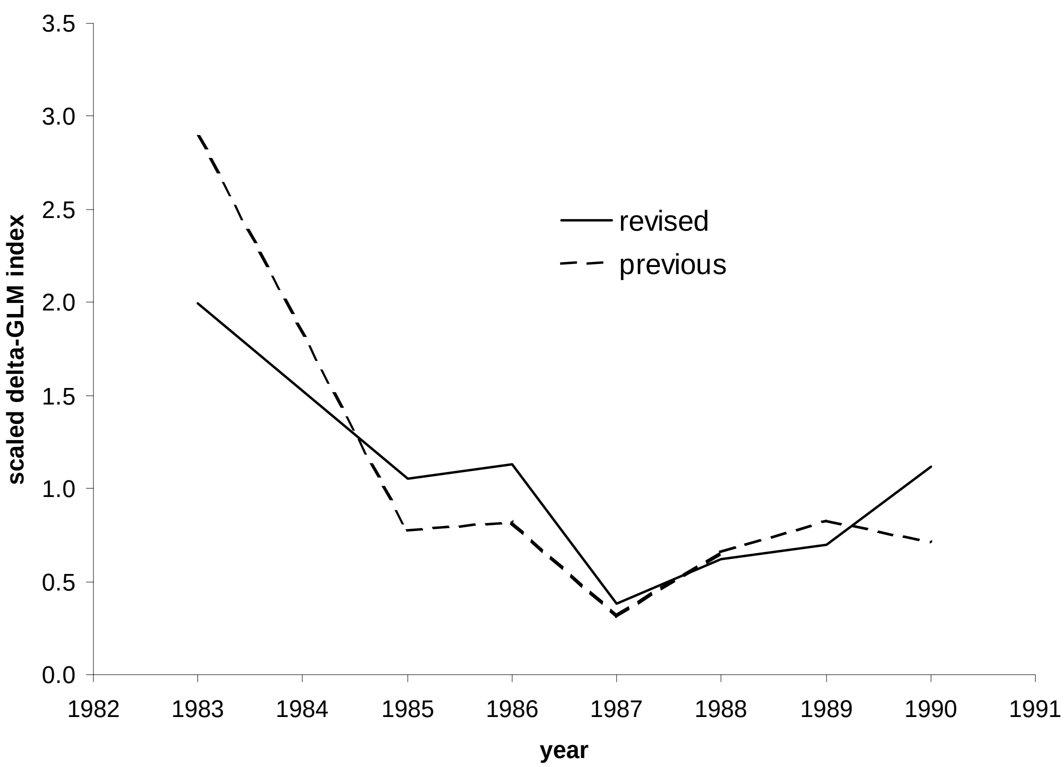


Figure A5. *CPUE indices (scaled to unit mean) for incidental catch of widow rockfish in the joint-venture hake fishery.*

Revised bycatch index for the foreign fishery

We applied the recommendations of the 2003 STAR panel to data for the foreign fishery (1977-1988), and estimated a revised time series of relative abundance. As mentioned above, data from 1976 are no longer included in the index due to indications of underreporting.

Spatial patterns in the distribution of effort for the foreign fishery are notably different from the joint-venture and domestic fisheries due to management measures that include several closed areas (PFMC, 2004). Closed areas relevant to this index include 1) 47°30' N. latitude to the U.S.-Canada boundary, 2) area landward of 12 nm, and 3) the "Columbia River Pot and Recreational Fishery Sanctuary" (roughly 46°-47° N. latitude). Sample sizes north of 45° are considerably smaller than those between 43°-45°, probably due to the closed areas. In particular, there are no observations in 1982 north of 45° and only 2 observations in 1984. We found minor evidence that annual trends differ among regions, but given the small sample sizes we chose to exclude area effects.

The revised index is a single delta-GLM with year and month effects. We assume that the positive observations follow an inverse-Gaussian distribution, based on the same set of criteria used for the joint-venture fishery. Figure A6 compares the revised index and the model used in the previous assessment.

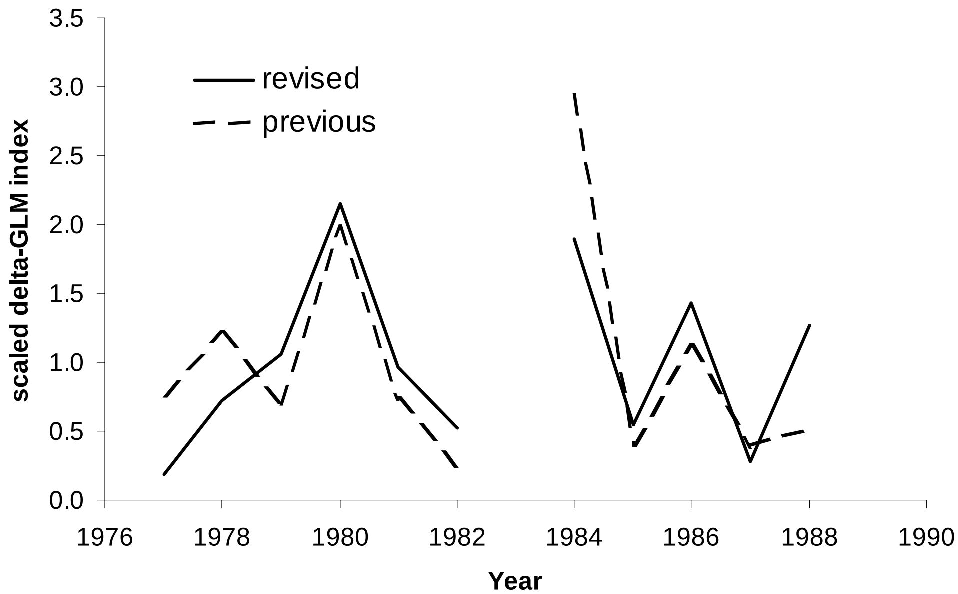


Figure A6. *CPUE indices (scaled to unit mean) for incidental catch of widow rockfish in the foreign hake fishery.*

Table A2. *Indices of relative abundance based on incidental catch of widow rockfish in three Pacific Hake fisheries. Indices scaled to unit mean.*

Fishery	**2003 Model Structure**		**Revised Model Structure**	
	Scaled Index	**CV**	**Scaled Index**	**CV**
Domestic				
1991	1.264	0.125	1.433	0.170
1992	0.781	0.125	0.386	0.139
1993	0.801	0.104	0.457	0.204
1994	1.465	0.068	1.057	0.155
1995	0.455	0.106	0.239	0.145
1996	1.018	0.082	0.935	0.190
1997	0.886	0.077	1.016	0.158
1998	1.330	0.079	2.478	0.187
Joint-Venture				
1983	2.889	0.120	1.995	0.332
1985	0.776	0.117	1.052	0.443
1986	0.823	0.081	1.132	0.294
1987	0.320	0.087	0.382	0.302
1988	0.659	0.077	0.621	0.337
1989	0.824	0.064	0.698	0.270
1990	0.710	0.074	1.120	0.306
Foreign				
1977	0.770	0.115	0.186	0.409
1978	1.205	0.112	0.726	0.582
1979	0.703	0.119	1.062	0.630
1980	1.993	0.131	2.148	0.985
1981	0.728	0.126	0.962	0.523
1982	0.243	0.247	0.520	0.933
1984	2.937	0.125	1.891	0.464
1985	0.407	0.107	0.543	0.572
1986	1.111	0.103	1.425	0.508
1987	0.390	0.088	0.273	0.283
1988	0.513	0.124	1.264	0.603

Comparisons of assessment results between two indices

We applied two sets of indices to the Model 4 assessment model (see main document), and compared the assessment results between them. Overall, the results were very similar, including trends in biomass, spawning outputs, and recruitments. Graphic comparisons of the assessment results are not presented because they are similar. Comparisons of key assessment results are presented in Table A3.

Table A3. *Comparisons of key assessment results between two indices.*

Parameter and estimate	Previous index	Revised index
Steepness (*h*)	0.2810	0.2814
Unfished spawning output (B_0) (million of eggs)	49676	49442
Current spawning output (B_t) (million of eggs)	15444	15264
Depletion ($100*B_t/B_0$)	31.09	30.87

References

Akaike, H., 1973. Information theory as an extension of the maximum likelihood principle. In: Petrov, B., Csaki, F. (Eds.), Second International Symposium on Information Theory. Akademiai Kiado, Budapest, pp. 267–281.

Bailey, K., R. C. Francis, and P. R. Stevens. 1982. The life history and fishery of Pacific whiting, *Merluccius productus*. California Cooperative Oceanic Fisheries Investigations Reports 23:81-98.

Environmental Systems Research Institute (ESRI). Redlands, CA. http://www.esri.com.

He, X., S. Ralston, A. MacCall, D. Pearson, and E. Dick. 2003. Status of the widow rockfish resource in 2003. Pacific Fishery Management Council, Portland, Oregon.

Pacific Fishery Management Council. 2003. Widow rockfish STAR panel meeting report. Pacific Fishery Management Council, Portland, OR.

Pacific Fishery Management Council. 2004. Pacific Coast Groundfish Fishery Management Plan for the California, Oregon, and Washington Groundfish Fishery as Amended through Amendment 17. Pacific Fishery Management Council, Portland, OR.

Stefánsson, G. 1996. Analysis of groundfish survey abundance data: Combining the GLM and delta approaches. ICES Journal of Marine Science 53(3):577-588.

Appendix B: Triennial trawl survey estimates of widow rockfish abundance

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Introduction

Widow rockfish are poorly sampled by the West Coast triennial trawl survey due to a combination of factors. These include their tendency to form dense midwater schools from dusk until dawn, often over irregular bottom habitat, and to often disperse or move closer to the bottom during daylight (Wilkins 1986, Stanley et al. 2000). Although the habitat associations of most *Sebastes* species present problems that are faced in estimating relative abundance time series from the triennial survey (Jagielo et al. 2003, Zimmerman et al. 2003), widow rockfish pose particular challenges. For example Millar and Methot (2002) performed a hierarchical analysis of survey catchabilities for six *Sebastes* stocks using traditional swept-area biomass estimates in the triennial survey, and found strong evidence that widow rockfish have a considerably lower catchability than other *Sebastes* stocks (on the order of 0.05, as opposed to 0.2 for several other species). As a consequence of these problems, triennial survey data have only sporadically been included in past widow rockfish assessments, generally with poor results and little to no improvement in model behavior. For example, Williams (2000) found that the triennial trawl survey data appeared to be in conflict with both the midwater trawl survey and the Oregon logbook index. However as the ability to use fishery-dependent indices of abundance has become problematic in recent years, as a result bias introduced by regulatory changes, the need to develop fishery-independent time series of abundance has become greater.

The patchiness of widow rockfish catches in the triennial trawl survey is particularly problematic. Table 1 and Figure 1 show the area-swept biomass estimates of widow rockfish over time using the traditional method of estimation (M. Wilkins, pers. com.). Figure 2 shows the expanded length-frequency compositions from the survey. These estimates suggest very low biomass levels in the early part of the time series, increasing to a peak level of abundance in 1992, and declining thereafter; and are inconsistent with time series trends from alternative indices of abundance and from recent stock assessments. However of the 4025 tows done between 55 and 366 meters depth (excluding tows in Canadian waters), half of the total biomass of widow rockfish caught in the survey were caught in only five, with the largest tow in 1992 (almost solely responsible for the tremendously high area-swept biomass index in that year, as this tow occurred in a strata with a large area) and the second and third largest in 1989. Over 65% of the total catches of widow rockfish were in just ten tows. Figure 3 shows the relative distribution of CPUE values for the 4025 triennial survey tows used in this analysis. By contrast, for yellowtail rockfish (*S flavidus*) there were 41 tows with catches greater than 100 kg, and 163 tows with between 10 and 100 kg of catch. Figure 4 shows the distribution of triennial survey tows and corresponding catches of widow rockfish for the years 1977-2004, within the 55 to 366 meter depth strata.

Data and Methods

In order to respond to the 2003 STAR Panel request that the widow rockfish assessment try to incorporate data from the triennial survey, we evaluated whether a more appropriate time series could be generated using the triennial survey data using a delta-GLM modeling approach. We obtained haul-specific triennial survey data from 1977 to 2004 from M. Wilkins (AFSC), and removed both bad performance tows and tows that were retrospectively labeled as "waterhauls" in the analysis by Zimmerman et al. (2001). We included all subsequent tows that occurred between depths of 55 to 366 meters for all years, with the exception of a small number of tows made south of 34˚ 30 in 1977, and all tows north of 48˚ 20' (Canadian waters). A cumulative frequency plot showing both positive tows and cumulative total survey catch (CPUE) by latitude for this region is presented as Figure 5a, which demonstrate that widow rockfish are widely dispersed along the coastline of the area sampled by the survey. Figure 5b shows the same tow data, with the cumulative frequency of CPUE and the number of positive tows by depth.

As these data are characterized by a large proportion (~88%) of zero observations and highly skewed positive observations, they are appropriate candidates for the delta-GLM method, which has become an increasingly accepted means for generating relative abundance time series for other fish populations (Lo et al. 1992, Dick 2004, Maunder and Punt 2004). This method is based on the product of fitted values from two GLMs; a binomial GLM that estimates the probability of a positive observation, $\boldsymbol{p}$, and a second GLM that estimates the mean, $\boldsymbol{\mu}$, of all positive observations. The framework allows for both the evaluation of alternative link functions (logit, probit) for the binomial model, and alternative error distributions (lognormal, gamma) to be evaluated from the positive data. The final index of abundance is the product of the year effects from these two models, $\boldsymbol{p\mu}$. The model used here was developed in the R programming language by Dick (2004), and has been referred to earlier in both this assessment and previous assessments (He et al. 2003). Akaike's information criterion (AIC) is used to assess whether the various factors (year, strata) are able to explain the variability in the data, such that the model with the smallest AIC is best supported by the data.

A series of models were run to evaluate both alternative factors and alternative link functions and error distributions. The prime candidates for factors included the traditional triennial survey strata (55 to 183 m; 184-366 meters, in different latitudinal configurations along the coast, see Weinberg et al. 2002), independent depth and latitude factors created using 50 meter depth and 2° latitude bins (similar to Ralston et al. 1998), and categorizing tows as being either within five nautical miles (inshore or offshore) of the shelf break (as with the Pacific whiting fishery index described earlier). Additionally, models were explored that used either finer or courser depth and latitude bins, that either included or excluded deeper (>300m) and/or shallow (<100m) tows, that weighted data with relative areas of their strata, that used sea surface temperature (SST) data as a covariate, that evaluated the interaction between El Niño and widow rockfish catchability, and that excluded the 1977 survey data. Although stock assessment authors were cautioned against using 1977 triennial survey data, due to the fact that this first survey fished only depths greater than 90 meters (NWFSC, unpublished report), the results here (including Figures 4a and 8a) strongly suggests that widow rockfish are very rarely encountered shallower than 100 meters. This result is consistent with Reynolds (2003) who used Oregon commercial logbook data to demonstrate that widow rockfish were strongly associated with habitats between 136 and 298 meters depth. Consequently we believe that the inclusion of the 1977 survey data is appropriate for this stock.

Results

Survey indices

In all configurations, both the binomial and the positive components of the Delta-GLM explained a very modest proportion of the variability in the data. However, the resulting trends for both year effects and spatial factors (latitude, depth, strata) were consistent across models. The lognormal distribution was determined to be appropriate based on a comparison of AIC scores with the gamma distribution (the latter was nearly 200 points greater); the inverse gaussian model for positives was unable to converge. Evaluation of the link functions for the binomial model using AIC criteria did not suggest a meaningful distinction among the three possibilities (logit, probit, or cloglog), in all instances the differences were less than 1 AIC point (and generally less than 0.5 points) apart. The logit was used as the default link function for all subsequent models.

For simplicity, only select results are shown here. These include a base model that uses coastwide data with 2° latitude and 50m depth bins, and an alternative model that excludes the 50 to 100 m depth range, and only considers data north of 41° latitude (both of these are presented with and without inclusion of the 1977 data). The latter model is shown as an example of the models that "best" fit the data, which were those that excluded both the shallow, nearshore tows (which had very few positives), and those that excluded tows south of 41° latitude. Table 2 shows the year effects for all four models, with standard errors estimated by a jackknife routine and coefficients of variation for the first model in each of the two cases. Differences in the standard errors for the models excluding 1977 were negligible. Figure 6 shows the results from Table 2 for the two base models.

While the SST data from the survey were uninformative, both the published literature (Woodbury 1999, Reynolds 2003) and the observation that catches and catch rates tended to be higher during strong El Niño events (1982-83, 1992-94 and 1997-98; based on the multivariate El Niño index, or MEI; http://www.cdc.noaa.gov/people/klaus.wolter/MEI/table.html) led us to evaluate potential interactions with widow rockfish availability and the MEI. First, we show the apparent relationship between the base model and the MEI (Figure 6), in which the R^2 value between the detrended index and the average MEI in the 12 month period immediately preceding the survey is 0.547 (P=0.015). Accounting for this relationship in the Delta-GLM model was compromised by the fact that these events were (essentially) on an annual scale. However, by running the model without year effects, but with a "dummy" variable for El Niño effects (e.g., either positive or negative), we found that a reasonable amount of the variance in the data could be explained by this factor (improvement of approximately 2 AIC points for the positives model, 9 AIC points for the binomial model). Moreover, the effect was to roughly double the abundance index during El Niño years (a ratio of 1.87 for El Niño versus non- El Niño years). There were insufficient data to evaluate fish were less available during strong La Niña events, as only one triennial survey (1989) occurred during strongly negative MEI (eg., La Niña) conditions.

Consequently, we present two alternative models in which the consequences of El Niño are accounted for in what is admittedly an imperfect manner. We considered two ways of approaching this issue. In the first, the model is simply run without the years of a strong MEI (e.g., excluding 1983, 1992 and 1998). The results are only slightly different from the base model for the remaining years. In the second approach, we modified the year index for years with a strong positive MEI by scaling these years by the reciprocal of the El Niño factor (e.g., 1/1.87) to account for increased availability during warm years. The results of these two models are presented in Table 3 and Figure 7 (note that alternative model 3 values in Table 3 are simply the same as the base model, but scaled by El Nino years). With respect to the depth and latitude effects, Table 4 shows the indices for the base model, and Figures 8a and 8b show these results graphically.

Table 5 shows the AIC scores for both the binomial and the positive components of the two models, with sequentially added combinations of model factors. The improvement in AIC is modest in the first base model, using depth and latitude bins, particularly for the year effects in the binomial model and all effects in the positives model. In the alternative model 1, the improvement in AIC is considerably greater for the positive model, and roughly similar for the binomial model. For all models, when Bayes Information Criteria (BIC) is used rather than AIC, including the year effects as explanatory variables are not supported by the data, although the latitude and depth factors remain acceptable. Although BIC selects more parsimonious models than AIC for large datasets, the relatively small number of parameters and the *a priori* expectation that the data will not be well explained by any model, make interpretation of these results somewhat subjective. These models were also tested for interactions among year and area effects, none of which were apparent in these models (including the model that was used to estimate the El Niño effect). Finally, diagnostic plots for the goodness of fit of each of the positive models for the base model are presented as Figures 9.

Comparisons of assessment results

Table 6 shows comparisons of key assessment results between base model and alternative model 1. The results of base model seem to be more comparable to results of other models in the main document (Table 14, Model 1, 2, 3, and 5), in terms of stock depletion rate. The base model also had better fits in the assessment model (negative log likelihood value = 188.17) than the alternative model (negative log likelihood value = 191.71).

Discussion and Conclusions

There is no doubt that the ability of the triennial trawl survey to provide a reliable index of relative abundance for widow rockfish is severely compromised, largely as a result of the atypical patterns of habitat preferences and aggregation demonstrated by the species, as well as a result of anomalous behavior during El Niño conditions. As suggested earlier, Reynolds (2003) used Oregon trawl logbook data to describe widow rockfish habitat; she found significant habitat associations included bottom depths of 136 to 298 meters, vertical depths of 101 to 197 meters, and temperatures between 7.1 and 8.1°C. Importantly, she also found that 1992 and 1997 were two years for which significant bottom depth associations were not detected, and no significant vertical depth association was detected in 1998 (her analysis did not cover the 1982-1983 El Niño period). She contemplated the possibility that distribution and behavior is altered during warm or El Niño conditions, such that widow rockfish were easier to catch in these years, consistent with the results suggested here.

El Niño years are well accepted to be associated with a warming of the water column and a substantial to severe decline in the availability of zooplankton and other forage (Wooster and Fluharty 1985, Pearcy and Schoener 1987, McGowan et al. 1998). Widow rockfish are known to forage primarily on pelagic macrozooplankton, particularly gelatinous zooplankton (salps, ctenophores and hydromedusae), euphausiids, pelagic shrimp, juvenile hake, and forage fishes (Adams 1987, Lee 2002). Consequently, it is sensible to consider that the distribution of widow rockfish is altered during El Niño years as a result of a lack of available food in the water column. Supporting this, Woodbury (1999) found that widow rockfish had atypically narrow annuli during the 1982-83 El Niño period, which could represent poor growth as a result of low food availability and/or elevated water temperatures. This in turn suggests that a reasonable mechanism to explain an increased vulnerability of widow rockfish to bottom trawl gear is a shift in distribution to cooler and/or deeper waters (e.g., closer to the bottom) as a result of either (or both) of these conditions.

Potentially supporting this argument is the observation that the NWFSC 2003 West Coast Trawl Survey suggests that the index for this year (also a year with a positive MEI) was substantially higher than either the 2001 or 2004 surveys, and higher than the overall average. As the differences in survey methods between the NWFSC surveys and the traditional (triennial) survey have yet to be formally evaluated, the use of these data in this index is not reported. However as the two surveys are calibrated in the future, the potential interaction between widow rockfish catchability and the environment can be more closely evaluated. By beginning to account for habitat preferences and variability in a manner consistent with what is known about the species, the problems associated with the survey methods are lessened, albeit far from eliminated. We believe that the indices developed here should be of utility in this current assessment, and should be valuable elements of future assessments, particularly if associated with further research and analyses of habitat associations.

Sources

Adams, P.B. 1987. Diet of widow rockfish (*Sebastes entomelas*) in northern California. In W.H. Lenarz and D.R. Gunderson (editors) Widow rockfish: proceedings of a workshop. NOAA Technical Report NMFS 48.

Dick, E.J. 2004. Beyond 'lognormal versus gamma': discrimination among error distributions for generalized linear models. Fisheries Research 70: 351-366.

He, X., S.V. Ralston, A.D. MacCall, D.E. Pearson, and E.J. Dick. 2003. Status of the widow rockfish resource in 2003. in Volume I: Status of the Pacific Coast Groundfish Fishery Through 2003 Stock Assessment and Fishery Evaluation Pacific Fishery Management Council: Portland OR.

Jagielo, T., A. Hoffman, J. Tagart and M. Zimmermann. 2003. Demersal groundfish densities in trawlable and untrawlable habitats off Washington: implications for the estimation of habitat bias in trawl surveys. Fishery Bulletin 101: 545-565.

Lee, Y.W. 2002. Oceanographic effect on the dynamics of food habits and growth conditions of some groundfish species of the Pacific Northwest. Doctoral Dissertation, Oregon State University.

Lo, N.C., Jacobson, L.D., and Squires, J.L. 1992. Indices of relative abundance for fish spotter data based on delta-lognormal models. Canadian Journal of Fisheries and Aquatic Sciences 49: 2515-2526.

Maunder, M.N. and A.E. Punt. 2004. Standardizing catch and effort data: a review of recent approaches. Fisheries Research 70: 141-159.

McGowan, J.A., D.R. Cayan and L.M. Dorman. 1998. Climate, ocean variability and ecosystem response in the Northeast Pacific. Science 281: 210-217.

Millar, R.B. and R.D. Methot. 2002. Age-structured meta-analysis of U.S. West Coast rockfish (*Scorpaenidae*) populations and hierarchical modeling of trawl survey catchabilities. Canadian Journal of Fisheries and Aquatic Sciences 59: 383-392.

Northwest Fisheries Science Center. Unpublished report. A summary report from the West Coast groundfish data workshop held July 26-30, 2004 in Seattle, WA.

Pearcy, W.G.and A. Schoener. 1987. Changes in the marine biota coincident with the 1982-1983 El Nino in the northeastern Subarctic Pacific Ocean. Journal of Geophysical Research 92: 14417-14428.

Philips, J.B. 1964. Life history studies on ten species of rockfish (genus *Sebastodes*). California Department of Fish and Game Fish Bulletin 126. 63 p.

Ralston, S.V., D. Pearson, J. Reynolds. 1998. Status of the chilipepper rockfish in 1998. In Appendix to Status of the Pacific Coast Groundfish Fishery through 1998 and recommended acceptable biological catches for 1999. Stock Assessment and Fishery Evaluation. Pacific Fishery Management Council: Portland OR.

Reynolds, J.A. 2003. Quantifying habitat associations in marine fisheries: a generalization of the Kolmogorov-Smirnov statistic using commercial logbook records linked to archived environmental data. Canadian Journal of Fisheries and Aquatic Sciences 60: 370-378.

Stanley, R.D., R. Kieser, K. Cooke, A.M. Surry, and B. Mose. 2000. Estimation of a widow rockfish (*Sebastes entomelas*) shoal off British Columbia, Canada as a joint exercise between stock assessment staff and the fishing industry. ICES Journal of Marine Science 57: 1035-1049.

Weinberg, K.L., M.E. Wilkins, F.R. Shaw, and M. Zimmerman. 2002. The 2001 Pacific West Coast bottom trawl survey of groundfish resources: Estimates of distribution, abundance, and length and age composition. NOAA Technical Memorandum NMFS-AFSC-128.

Wilkins, M.E. 1986. Development and evaluation of methodologies for assessing and monitoring the abundance of widow rockfish, *Sebastes entomelas*. Fishery Bulletin 84: 287-310.

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 the status of the Pacific coast groundfish fishery through 2001 and acceptable biological catches for 2002: Stock assessment and fishery evaluation. Pacific Fishery Management Council: Portland, Oregon.

Woodbury, D. 1999. Reduction of growth in otoliths of widow and yellowtail rockfish (*Sebastes entomelas* and *S. flavidus*) during the 1983 El Niño. Fishery Bulletin 97: 680-689.

Wooster, W.S. and D.L. Fluharty (editors) El Niño North: Niño Effects in the Eastern Subarctic Pacific Ocean. Washington Sea Grant: Seattle.

Zimmerman, M., M.E. Wilkins, K.L. Weinberg, R.R. Lauth, and F.R. Shaw. 2001. Retrospective analysis of suspiciously small catches in the National Marine Fisheries Service West Coast triennial bottom trawl survey. AFSC Processed Report 2001-03.

Zimmerman, M., M.E. Wilkins, K.L. Weinberg, R.R. Lauth, and F.R. Shaw. 2003. Influence of improved performance monitoring on the consistency of a bottom trawl survey. ICES Journal of Marine Science 60, 818-826.

Table 1: Triennial trawl survey biomass estimates for widow rockfish from 1977-2004.

year	depth strata		US Vancouver	Columbia	Eureka	Monterey	Conception	U.S. total
1977	91-366 m	Biomass	844	362	8	195	154	1111
		CV	0.79	0.29	0.52	0.41	0.91	0.61
1980	55-366 m	Biomass	0	1175	228	249	*N/A*	1652
		CV	-	0.77	0.58	0.69	*N/A*	0.56
1983	55-366 m	Biomass	1879	909	267	392	*N/A*	3447
		CV	1.00	0.55	0.46	0.58	*N/A*	0.57
1986	55-366 m	Biomass	44	1413	1094	2346	*N/A*	4897
		CV	0.55	0.78	0.78	0.85	*N/A*	0.63
1989	55-366 m	Biomass	3533	614	2205	826	2129	9307
		CV	0.98	0.70	0.99	0.88	1.00	0.50
1992	55-366 m	Biomass	297	626	22	11526	708	13178
		CV	0.62	0.47	0.54	0.94	1.00	0.82
1995	55-366 m	Biomass	20	2315	90	584	11	3020
		CV	0.69	0.99	0.59	0.56	0.64	0.76
1998	55-366 m	Biomass	2241	293	97	1712	0	4343
		CV	0.49	0.28	0.34	0.50	1.00	0.32
2001	55-366 m	Biomass	53	102	41	20	10	224
		CV	0.70	0.48	0.47	0.84	0.70	0.30
2004	55-366 m	Biomass	27	57	281	488	16	868
		CV	0.82	0.49	0.65	0.72	0.85	0.46

Table 2: Year effects, standard errors, coefficients of variation, positive and binomial indices, and results that exclude 1977 for the base model and alternative model 1.

	Base model						Alternative model					
	index	jack.se	CV	pos	bin	no 1977	index	jack.se	CV	pos	bin	no 1977
1977	0.506	0.125	0.247	3.00	0.169		0.793	0.252	0.318	3.86	0.205	
1980	0.382	0.127	0.332	2.66	0.143	0.460	0.406	0.182	0.449	3.52	0.115	0.472
1983	0.565	0.163	0.289	3.32	0.170	0.683	0.609	0.191	0.313	3.28	0.185	0.686
1986	0.353	0.124	0.351	2.53	0.140	0.428	0.294	0.103	0.349	1.68	0.175	0.332
1989	0.390	0.186	0.477	3.73	0.105	0.463	0.577	0.360	0.623	6.58	0.088	0.673
1992	0.461	0.168	0.364	2.86	0.161	0.553	0.470	0.173	0.368	2.98	0.158	0.550
1995	0.305	0.097	0.317	2.57	0.119	0.355	0.265	0.123	0.464	2.73	0.097	0.291
1998	0.692	0.216	0.313	3.88	0.179	0.815	0.744	0.231	0.310	2.84	0.262	0.833
2001	0.112	0.039	0.350	1.39	0.081	0.129	0.169	0.067	0.394	1.67	0.101	0.182
2004	0.126	0.058	0.461	1.09	0.115	0.149	0.094	0.059	0.623	0.72	0.130	0.104

Table 3: Year effects, standard errors, coefficients of variation, and the positive and binomial indices for the two alternative models that account for ENSO effects.

	Alternative 2: No Niño years					Alt. Model 3: Scale Niño years by Niño factor					
	index	jack.se	CV	pos	bin	scalar	index	jack.se	CV	pos	bin
1977	0.581	0.172	0.295	3.36	0.173		0.506		*(all other values assumed*		
1980	0.411	0.149	0.363	2.76	0.149		*0.382*		*be the same, or scaled*		
1983						*0.534*	*0.302*		*similarly to year index,*		
1986	0.379	0.145	0.383	2.69	0.141		0.353		*as the base model)*		
1989	0.419	0.217	0.518	4.03	0.104		0.390				
1992						*0.534*	*0.246*				
1995	0.303	0.107	0.352	2.54	0.119		0.305				
1998						*0.534*	*0.369*				
2001	0.111	0.042	0.379	1.38	0.081		0.112				
2004	0.125	0.058	0.468	1.07	0.117		0.126				

Table 4: Latitude and depth effects for base model 1.

latitude effects		depth effects	
34	0.237	50	0.04
36	0.403	100	0.37
38	0.449	150	0.91
40	0.866	200	1.01
42	0.386	250	0.47
44	0.159	300	0.20
46	0.227		

Table 5a: Parameters, deviance, and AIC scores for base model.

Base model AIC scores							
	positive model				binomial model		
	df	deviance	AIC		df	deviance	AIC
no factors		1579	1967.9	no factors		2981.0	2983.0
year only	9	1520.6	1967.5	year only	9	2942.5	2962.5
lat only	6	1536.1	1966.4	lat only	6	2934.4	2948.4
depth only	5	1522.6	1960.1	depth only	5	2723.2	2735.2
all factors	20	1431.0	1959.7	all factors	20	2648.2	2690.0

Table 5b: Parameters, deviance, and AIC scores for alternative model 1.

Alternative Model AIC scores							
	positive model				binomial model		
	df	deviance	AIC		df	deviance	AIC
no factors		909.1	1193.8	no factors		1731.0	1733.2
year only	9	842.9	1189.0	year only	9	1695.4	1715.4
lat only	3	850.5	1179.7	lat only	3	1704.5	1712.5
depth only	4	909.1	1193.8	depth only	4	1635.6	1645.6
all factors	16	781.0	1172.0	all factors	16	1575.1	1609.1

Table 5c: Parameters, deviance, and AIC scores for alternative model 2.

Alternative Model 2 AIC scores							
	positive model				binomial model		
	df	deviance	AIC		df	deviance	AIC
no factors		1014.0	1248.1	no factors		1934.0	1935.8
year only	6	1013.9	1248.1	year only	6	1903.4	1917.4
lat only	6	974.9	1247.9	lat only	6	1901.1	1915.1
depth only	5	979.5	1247.4	depth only	5	1801.3	1813.3
all factors	17	926.4	1244.2	all factors	17	1750.6	1786.6

Table 6 Comparisons of key assessment results between base model and alternative models.

Parameter and estimate	Base model	Alternative model 1	Alternative model 2	Alternative model 3
Steepness (*h*)	0.2810	0.2793	0.749	0.2771
Unfished spawning output (B_0) (million of eggs)	49676	49513	48083	49722
Current spawning output (B_t) (million of eggs)	15444	15070	13111	15055
Depletion ($100*B_t/B_0$)	31.09	30.44	27.27	30.28

Figure 1: Triennial trawl survey swept-area biomass estimates of widow rockfish, 1977-2004, for the Monterey through U.S. Vancouver INPFC statistical areas.

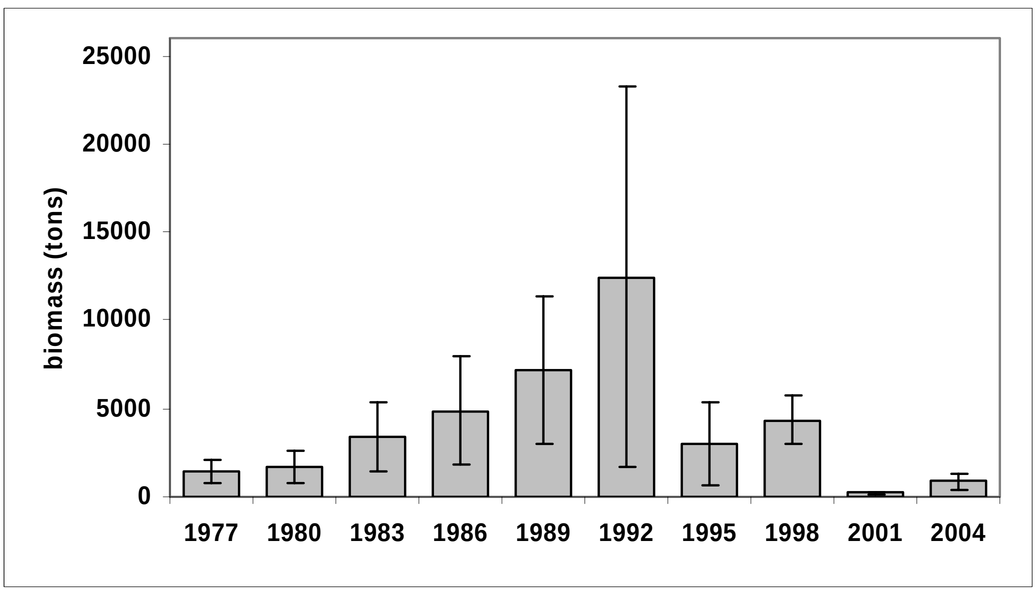


Figure 2: Percent length frequency compositions from triennial survey index.

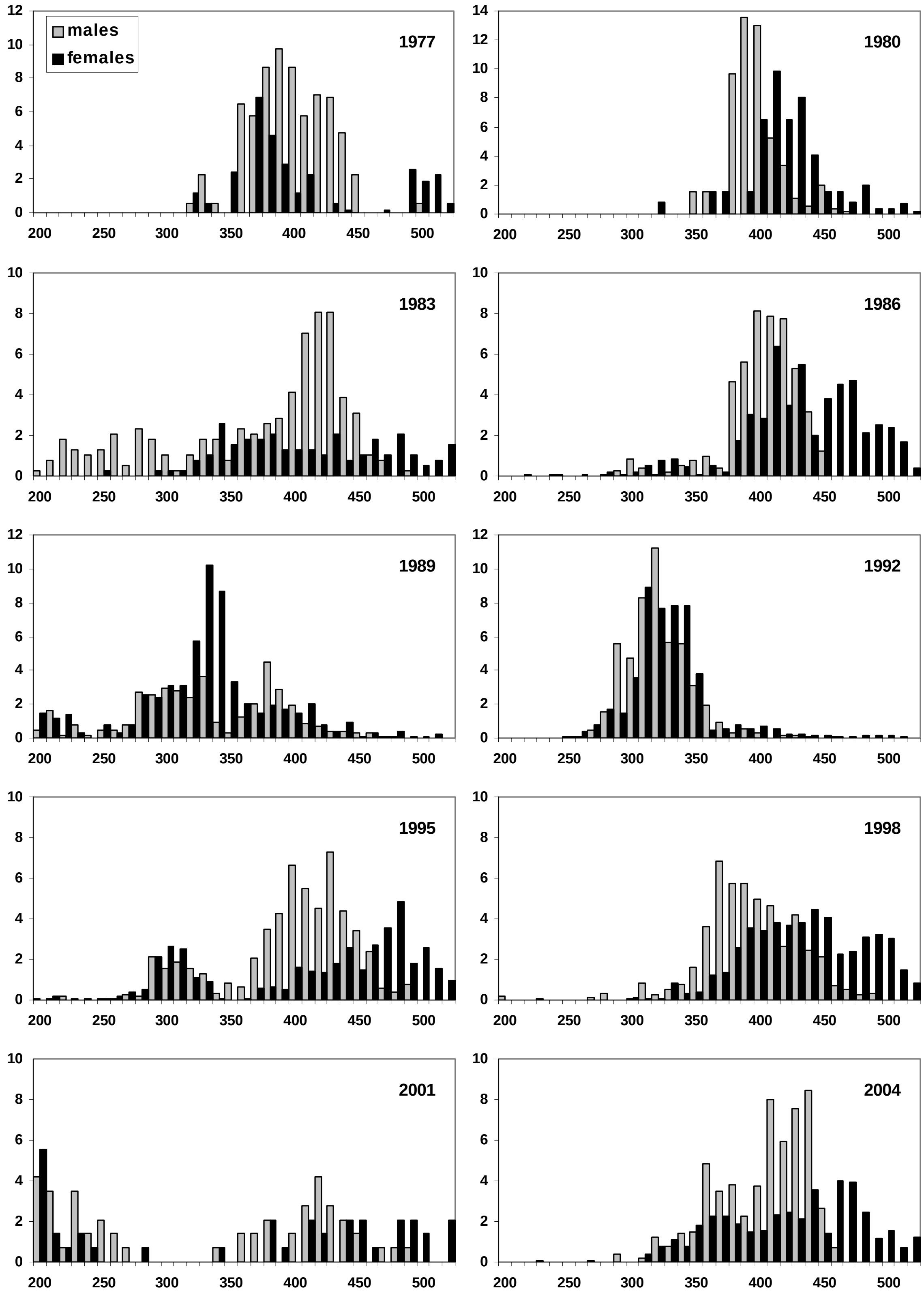


Figure 3: Binned frequency distribution, in log scale, of triennial survey CPUE values, and percentage of total relative catch represented by bin (note that 22 tows had CPUE values greater than 0 but less than 0.1)

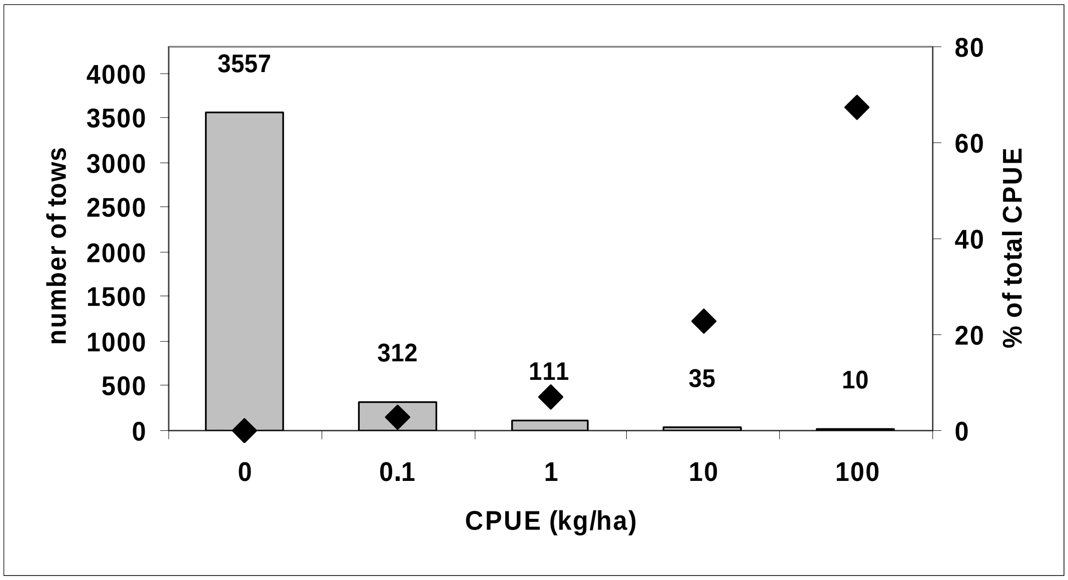


Figure 4: Locations of triennial trawl survey tows (1977-2004) and associated CPUE estimates of widow rockfish, for the Monterey through U.S. Vancouver INPFC statistical areas.

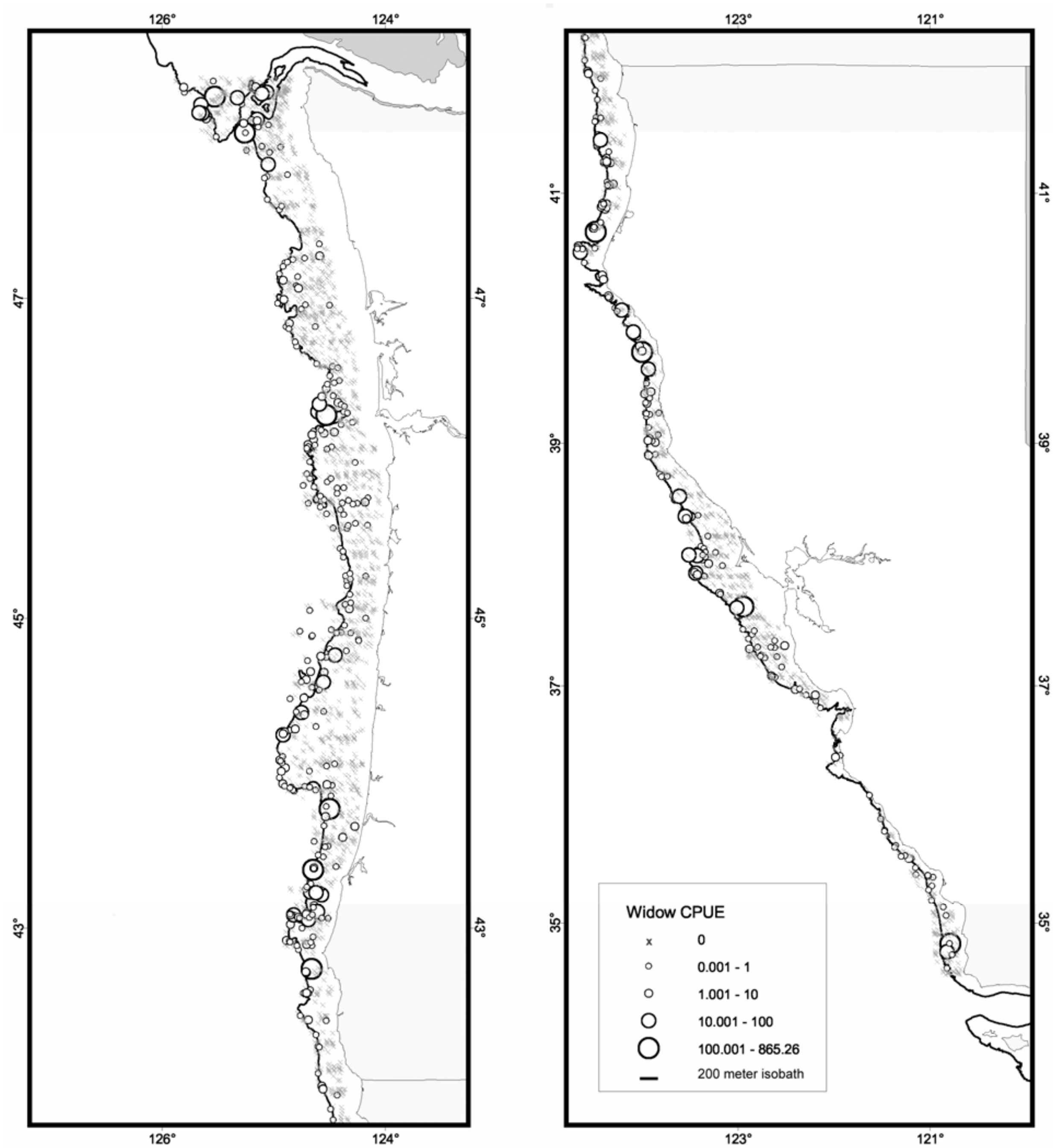


Figure 5: Cumulative frequency of widow rockfish CPUE by depth (upper panel), and cumulative frequency of widow rockfish CPUE by latitude (lower panel).

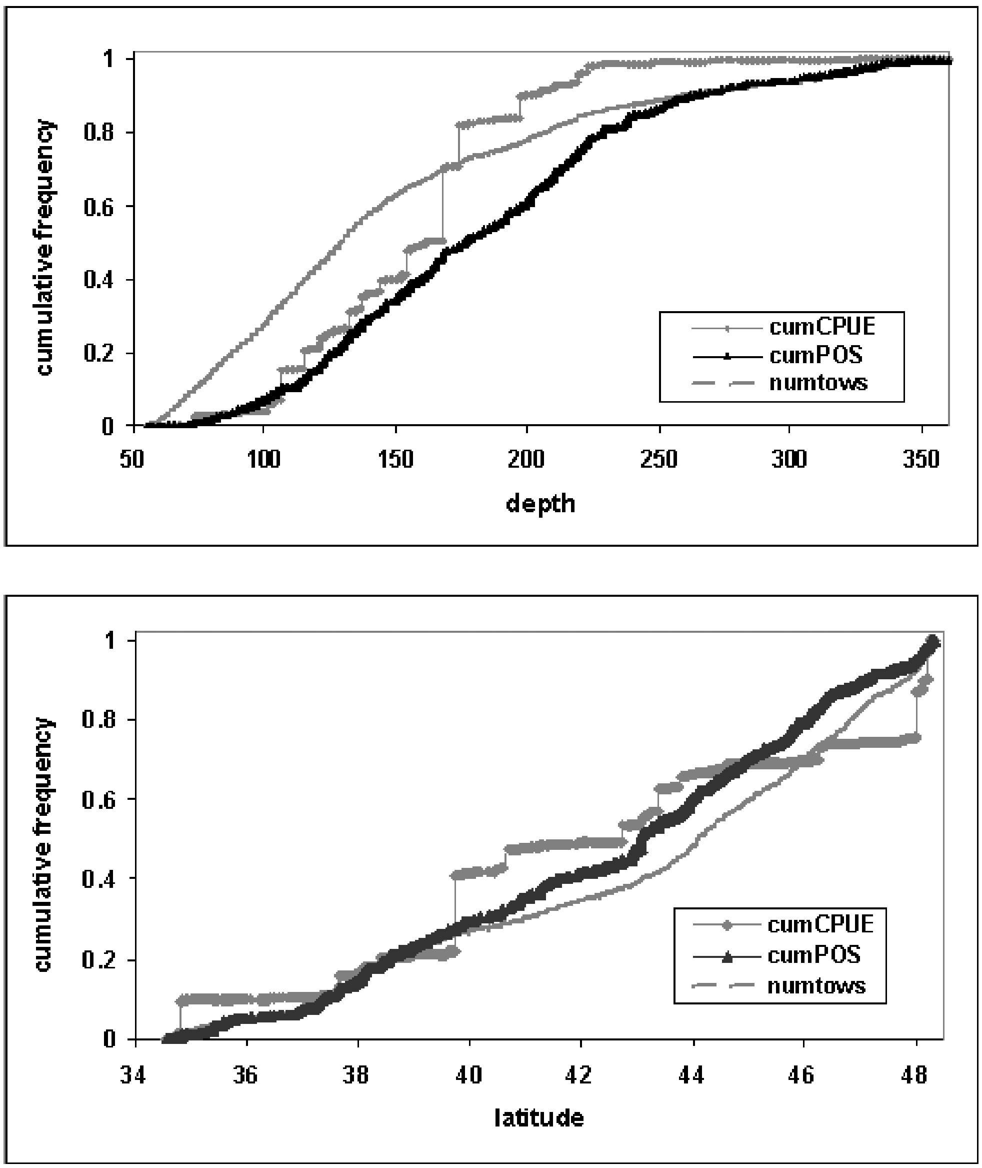


Figure 6: Model results from the baseline model and alternative model 1.

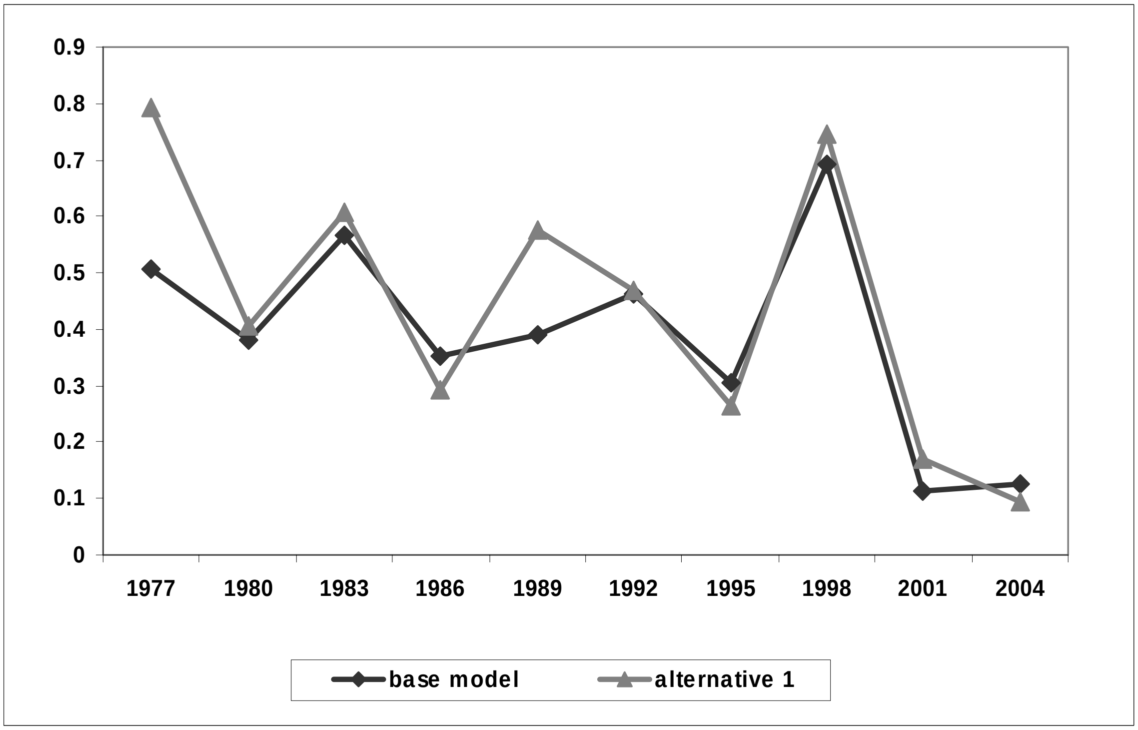


Figure 7: Widow rockfish base model index and 13 month running mean for the Multivariate ENSO Index (MEI).

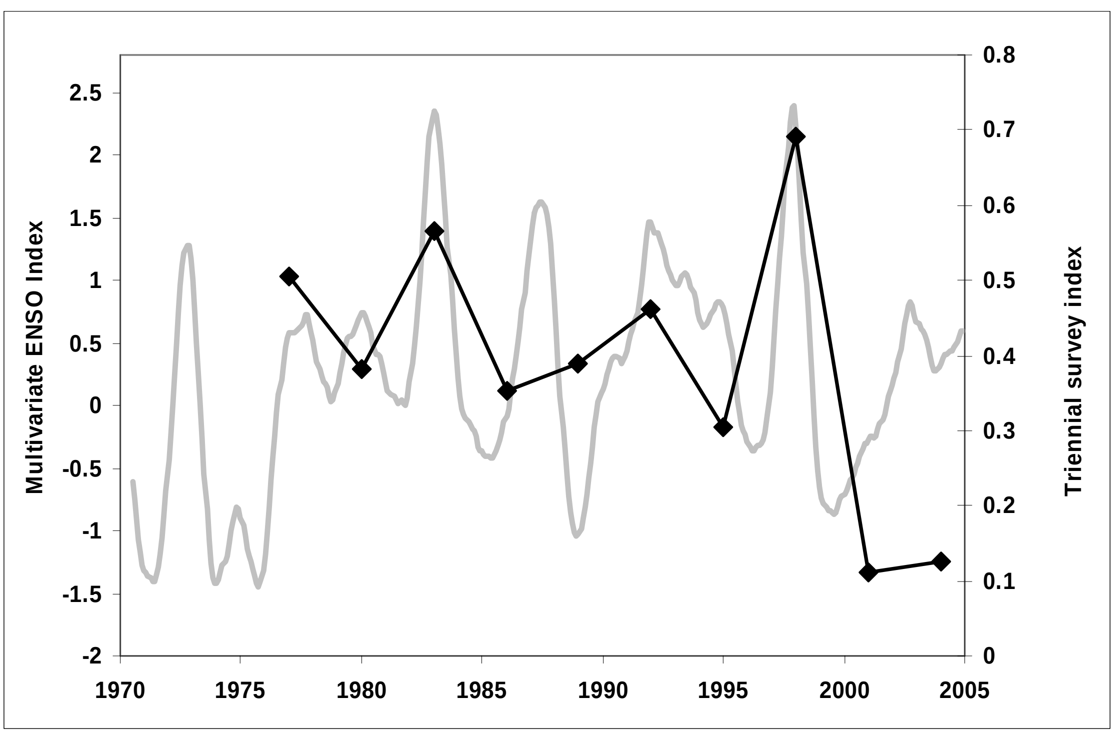


Figure 8: Results from Alternative models 2 and 3, with base model for comparative purposes.

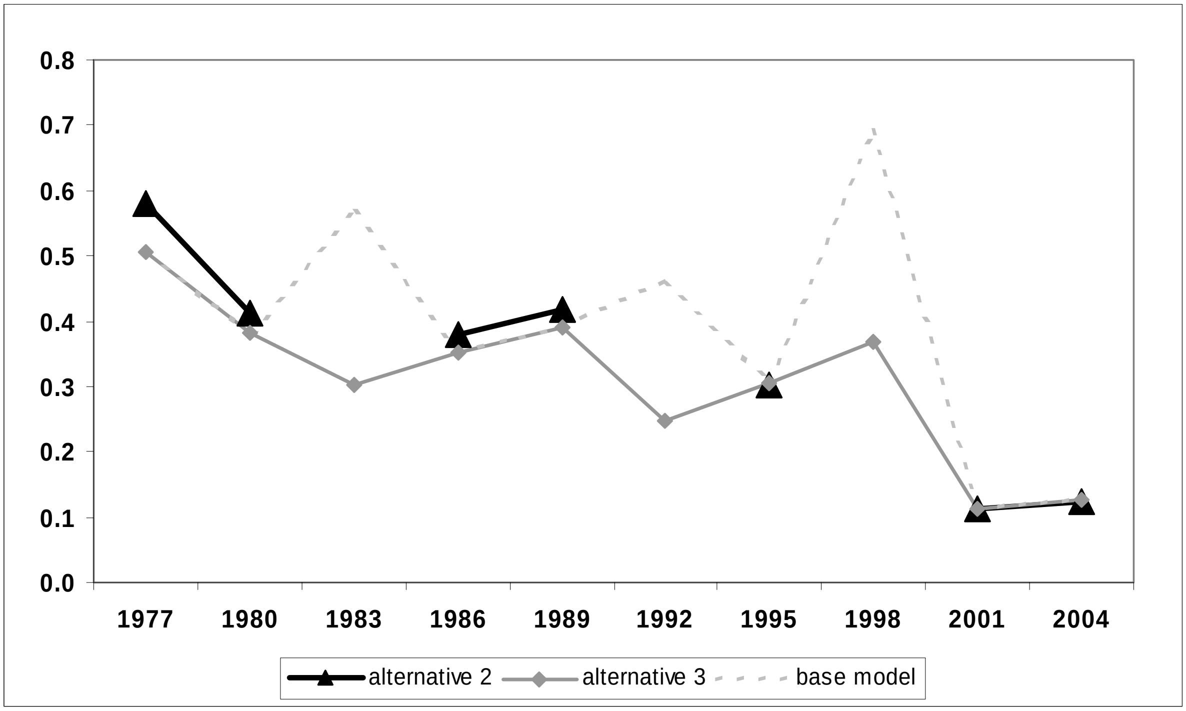


Figure 9a: Depth effects (in meters) from the depth and latitude binned base model

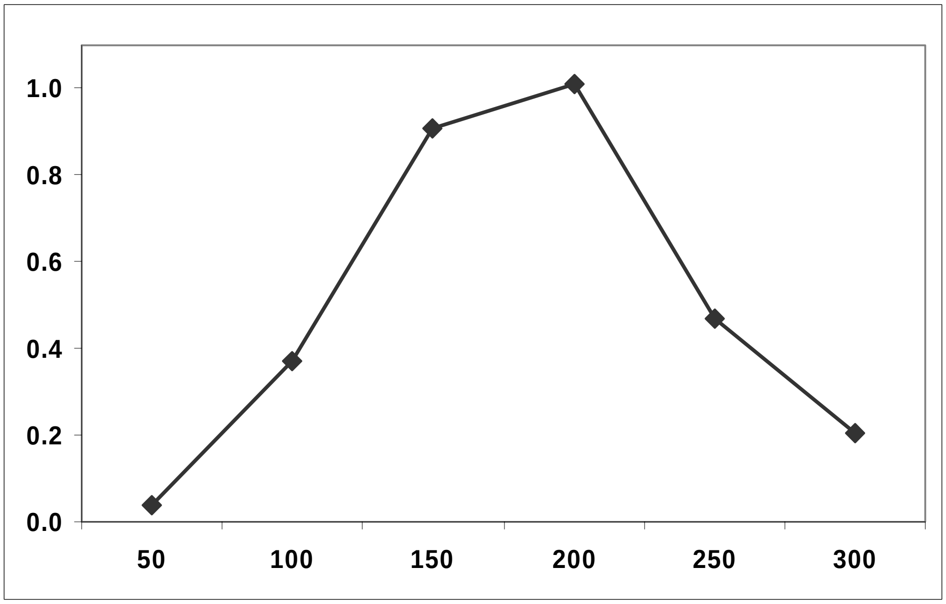


Figure 9b: Latitude effects from the depth and latitude binned base model (34 represents 34° to 36° latitude, etc)

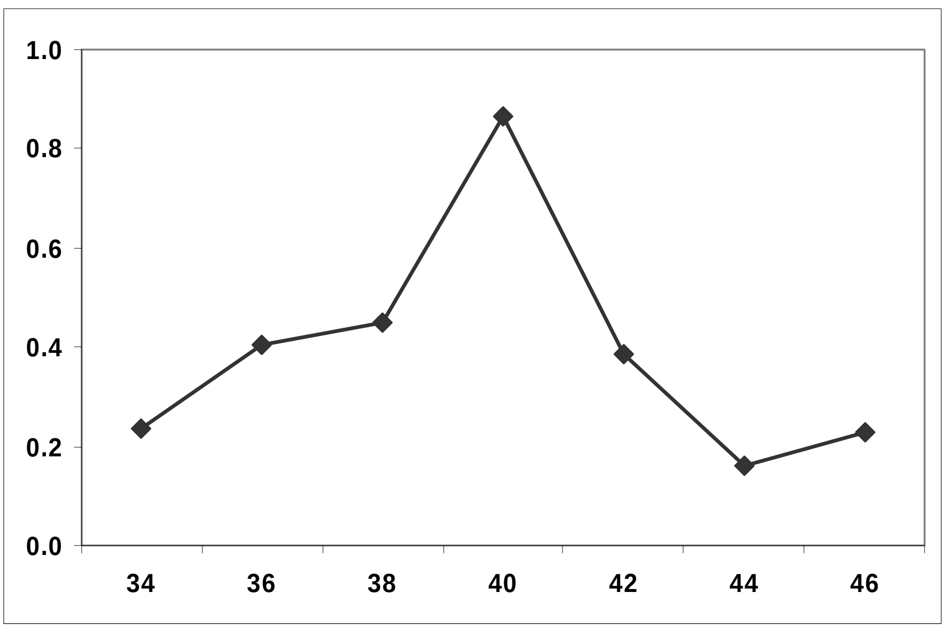
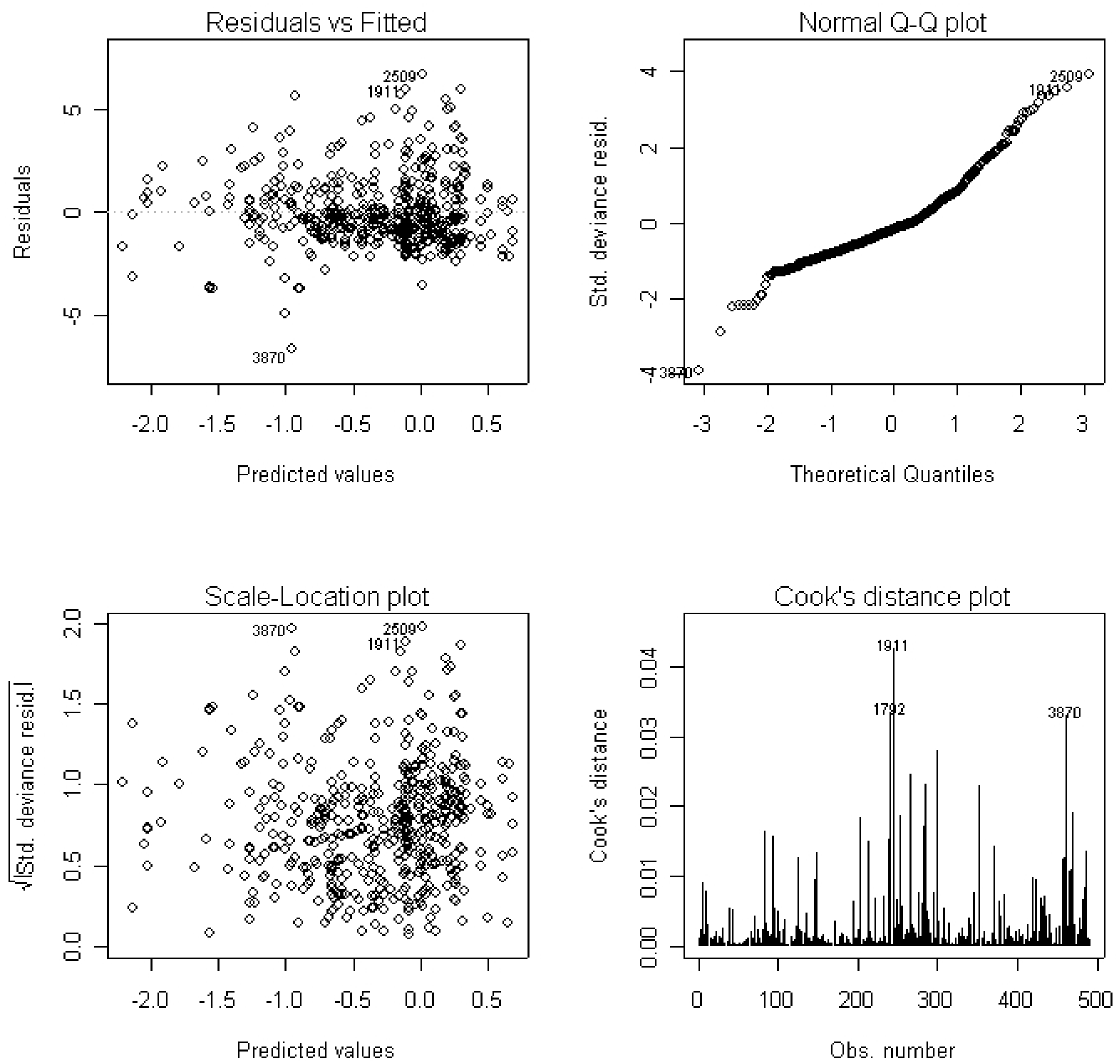


Figure 10. Diagnostics of the goodness of fit of the positive model for the base model.



Appendix C: Description of assessment model

The widow population is assumed to be subject to four fisheries in two regions. Region 1 consists of the Vancouver-Columbia trawl fishery, Oregon midwater trawl fishery, and Oregon bottom trawl fishery. Region 2 consists of the Eureka-Monterey-Conception trawl fishery.

Initial condition and cohort growth:

Initial conditions of the population are numbers of fish at sex x, at age a and at the first model year (y = 0) in 1958, which is given by:

$$N_{x,0,a} = \begin{cases} 0.5Re^{R_1^{\delta}} & \text{if } a = a_{\min} \\ N_{x,0,a-1}e^{-M_x} & \text{if } a_{\min} < a < a_{\max} \\ \dfrac{N_{x,0,a-1}e^{-M_x}}{1-e^{-M_x}} & \text{if } a = a_{\max} \end{cases} \qquad (10)$$

where R = mean recruitment

R_1^{δ} = recruitment residual at year 0

$a_{\min}$ = age of recruitment (minimum age in model)

$a_{\max}$ = maximum age, including age-plus groups

M_x = natural mortality for sex x, which is constant across year and age

Numbers of fish in subsequent years are given by:

$$N_{x,y,a} = \begin{cases} 0.5Re^{R_y^{\delta}} & \text{if } a = a_{\min} \\ N_{x,y-1,a-1}e^{-\left(M_x+\sum_f F_{x,y-1,a-1}^f\right)} & \text{if } a_{\min} < a < a_{\max} \\ N_{x,y-1,a-1}e^{-\left(M_x+\sum_f F_{x,y-1,a-1}^f\right)} + N_{x,y-1,a_{\max}}e^{-\left(M_x+\sum_f F_{x,y-1,a_{\max}}^f\right)} & \text{if } a = a_{\max} \end{cases} \qquad (11)$$

where R_y^{δ} = recruitment residual at year y, and $\sum_y R_y^{\delta} = 0$.

Fishing mortality is given by:

$$F_{x,y,a}^f = FF_f e^{FF_{f,y}^{\delta}} S_{x,y,a}^f \qquad (12)$$

where FF_f = full fishing mortality for fishery f

$FF_{f,y}^{\delta}$ = fishing mortality residual for fishery f and at year y with $\sum_y FF_{f,y}^{\delta} = 0$

$S_{x,y,a}^f$ = selectivity by fishery f, at sex x, year y, and age a.

Selectivity and catch:

Double logistic selectivity was used:

$$s_a^f = \left(\frac{1}{1+e^{-\eta_{2,f}\left(a-\eta_{1,f}\right)}}\right)\left(1-\frac{1}{1+e^{\eta_{4,f}\left(a-\eta_{3,f}\right)}}\right)\frac{1}{\max\left(s^f\right)} \qquad (13)$$

where $\eta_{1,f}$, $\eta_{2,f}$, $\eta_{3,f}$, and $\eta_{4,f}$ = parameters to be estimated

$\max(S^f)$ = maximum selectivity by fishery f.

Double logistic selectivity allows the selectivity pattern to be dome-shaped or asymptotic on either the left or the right size of the selectivity curve. Selectivity is set to be same for both sexes, so $S_{1,y,a}^f = S_{2,y,a}^f$. However, selectivity may vary from year to year. In this case, year-specific parameters $\eta_{2,f}$, which determine steepness of the left side of the selectivity, are estimated. If selectivity does nor vary from year to year, $S_{s,y,a}^f = S_{s,1,a}^f = S_{s,2,a}^f = \ldots$. Annual catch by fishery f at sex x, and age a is given by:

$$C_{x,y,a}^f = N_{x,y,a}\frac{F_{x,y,a}^f}{M_x+\sum_f F_{x,y,a}^f}\left(1-e^{-\left(M_x+\sum_f F_{x,y,a}^f\right)}\right) \qquad (14)$$

Landing by fishery f at year y, Ψ_y^f, is given by:

$$\Psi_y^f = \left(1-D_y\right)\sum_x\sum_a C_{x,y,a}^f W_{f,x,a} \qquad (15)$$

where $W_{f,x,a}$ = weight of fish in fishery f, at sex x an age a, which is region specific (see below)

D_y = annual mean discard rate.

A vector of observed proportions of catch-at-age compositions for fishery f, at sex x and year y, $\mathbf{\Theta}_{x,y}^f$, is adjusted by an ageing error matrix:

$$\mathbf{\Theta}_{x,y}^f = \mathbf{\Omega}\tilde{\mathbf{\Theta}}_{x,y}^f \qquad (16)$$

where $\tilde{\mathbf{\Theta}}_{x,y}^f$ = vector of proportions of catch-at-age compositions from catch-age expansion data

$\mathbf{\Omega}$ = ageing error matrix with dimension of $A*A$ (A is number of age class), and each column representing probabilities of true age.

Biomass and spawning output:

Annual biomass at sex x and age a is given by:

$$B_{x,y,a} = \sum_r \phi_r N_{x,y,a} W_{r,x,a} \qquad (17)$$

where ϕ_r = proportion of population in region r, and $\sum_r \phi_r = 1$

$W_{r,x,a}$ = weight of fish in region r at sex x and age a.

Annual spawning biomass is given by:

$$SSB_y = \sum_r \phi_r P_{r,a} N_{2,y,a} W_{r,2,a} \quad (18)$$

where $P_{r,a}$ = proportion of mature females ($x = 2$) in region r and at age a .

Annual spawning output is given by:

$$SO_y = \sum_r \phi_r P_{r,a} N_{2,y,a} G_{r,a} \quad (19)$$

where $G_{r,a}$ = fecundity in region r and at age a , and is derived from an empirical relationship (Boehlert et al. 1982):

$$G_{r,a} = 605.71 W_{r,2,a} - 261830.7 \quad (20)$$

Note that the spawning output of year 0 (SO_0), which is also termed as B_0 , is an important parameter often used for determining target population levels.

Growth, length-weight relationship:

$$L_{r,x,a} = L^{\infty}_{r,x}\left(1 - e^{-K_{r,x}\left(a - t^0_{r,x}\right)}\right) \quad (21)$$

$$W_{r,x,a} = \tau^1_r L_a^{\tau^2_r} \quad (22)$$

where $L_{r,x,a}$ = length in region r at sex x and age a

$L^{\infty}_{r,x}$, $K_{r,x}$, and $t^0_{r,x}$ = growth parameters in region r and at sex x

τ^1_r and τ^2_r = length-weight parameters in region r .

Stock-recruit relationship:

The Beverton-Holt relationship is used:

$$R_y = \frac{SO_{y-a_{\min}}}{\alpha + \beta SO_{y-a_{\min}}} e^{R^{\delta}_y} \quad (23)$$

where R_y = recruitment in billions of eggs at year y

$SO_{y-a_{\min}}$ = spawning output at year $y - a_{\min}$

α and β = recruitment parameters to be estimated.

The relationship can be reparameterized by using a steepness parameter (h):

$$\alpha = \frac{\frac{B_0}{R}(1-h)}{4h} \quad (24)$$

and

$$\beta = \frac{5h - 1}{4hR} \quad (25)$$

where B_0 and R_0 are defined previously ($B_0 = SO_0$).

The "steepness" is the expected fraction of R_0 at $0.2B_0$, and is set to range from 0.2 to 1.0. When $h = 0.2$, recruits are a linear function of spawning output ($\beta = 0$, and

$R_y = \frac{1}{\alpha} SO_{y-a_{\min}} e^{R_y^\delta}$). When $h = 1$, recruits are constant and independent of spawning output ($\alpha = 0$, and $R_y = \frac{1}{\beta} e^{R_y^\delta}$).

Abundance index:

The abundance index (I) for each fishery or survey (i) has the following relationship:

$$I_i = q_i N S_f \qquad (26)$$

where q_i = catchability coefficient for fishery or survey i

N = population abundance

S_f = selectivity of fishery or survey f that is associated with i .

A power transformation could also be used to transform index or abundance. If it is used to transform index:

$$I_i^P = q_i N S_f \qquad (27)$$

where P = power parameter for index i .

Likelihood components:

Total likelihood is the sum of all individual likelihood from catch-at-age compositions, fishery landings, and CPUE indexes from surveys and commercial catch data. Where there are missing observed values, the likelihood values are set to zeros. The total negative logarithm of the likelihood, which will be minimized during the parameter estimation, is given by:

$$-\log(L) = \sum_i \lambda_i L_i \qquad (28)$$

where L_i = likelihood value for component i

λ_i = weighting factor for component i .

Catch-at-age composition:

$$L_1 = -\sum_f \sum_y n_y^f \sum_x \sum_a \theta_{x,y,a}^f \log\left(\frac{\hat{\theta}_{x,y,a}^f}{\theta_{x,y,a}^f}\right) \qquad (29)$$

where θ and $\hat{\theta}$ = observed and estimated proportions of catch-at-age compositions by fishery f at sex x , year y , and age a

n_y^f = sampled trips in fishery f and year y .

Landings:

$$L_2 = \sum_f \left\{ \frac{\left[\log\left(\Psi_y^f\right) - \log\left(\hat{\Psi}_y^f\right)\right]^2}{2\left(\sigma_f^\Psi\right)^2} + \log\left(\sigma_f^\Psi\right) \right\} \qquad (30)$$

where Ψ_y^f and $\hat{\Psi}_y^f$ = observed and estimated landings by fishery f in year y

σ_f^{Ψ} = standard error for $\log\left(\Psi_y^f\right)$ which is set to be small (0.05) based on the assumption of small observation errors of catch data.

Recruitment:

Recruitment residuals are assumed to have no autocorrelations:

$$L_3 = 0.5\sum_y\left[\left(\frac{R_y^{\delta}}{\sigma_R}\right)^2 - \log(\sigma_R)\right] \tag{31}$$

Survey and CPUE indexes:

$$L_{4-9} = \sum_j\left\{\frac{\left[\log\left(I_{j,y}\right) - \log\left(\hat{I}_{j,y}\right)\right]^2}{2\left(\sigma_j^I\right)^2} + \log\left(\sigma_j^I\right)\right\} \tag{32}$$

where $I_{j,y}$ and $\hat{I}_{j,y}$ = observed and estimated index from series j and year y

σ_j^I = standard error for $\log\left(I_{j,y}\right)$.

Appendix D: Input data for widow rockfish stock assessment base model.

```
# ****************************************************************
#  Widow rockfish stock assessment data
#  Xi He
#  National Marine Fisheries Service
#  Southwest Fisheries Science Center
#  Santa Cruz Lab
#  xi.he@noaa.gov
#  July 2005
#  Filename: wdwmaster.dat
# ****************************************************************

# number of region
2
# number of fishery
4
# number of sex
2
# number of observed indexes
6
# Starting and ending year of the model
1958
2004
47
# Recruitment age and total number of age bins
3
18
# Vector of ages for age bins
3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

# number of likelihood components
9

# Natural mortality
0.125 0.125

# Discard rate (D value) by year (landing = catch * (1-D) )
0.06	0.06	0.06	0.06	0.06
0.06	0.06	0.06	0.06	0.06
0.06	0.06	0.06	0.06	0.06
0.06	0.06	0.06	0.06	0.06
0.06	0.06	0.06	0.06	0.06
0.16	0.16	0.16	0.16	0.16
0.16	0.16	0.16	0.16	0.16
0.16	0.16	0.16	0.16	0.16
0.16	0.16	0.16	0.16	0.16
0.16	0.16

# Smoothed fraction of total landings in the north\
# fractions from 1968-77 was used in years before 1968, same as in 2000 assessment
# foreign landings from Jean Rogers were not used to compute fractions before 1968

# new data
0.548	0.548	0.548	0.548	0.548
0.548	0.548	0.548	0.548	0.548
0.548	0.548	0.548	0.548	0.548
0.548	0.548	0.548	0.548	0.569
0.598	0.593	0.592	0.598	0.607
0.666	0.670	0.668	0.703	0.726
0.746	0.770	0.789	0.795	0.783
0.773	0.771	0.755	0.754	0.735
0.723	0.738	0.748	0.731	0.731
0.731	0.731

# Biological information
# Growth parameters (Linf,K,t0 for male north, female north, male south, female south)
# age 22 used for wgt of 20+
44.00	50.54	41.50	47.55
```

0.18 0.14 0.25 0.20
-2.81 -2.68 -0.28 -0.17

Length weight parameters (b and a for male and female)
0.01188 0.00545
3.06631 3.28781

proportions of maturity of females
north
0.01 0.02 0.10 0.32 0.68 0.90 0.98 0.99 1.00
1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
south
0.13 0.21 0.64 0.90 0.90 1.00 1.00 1.00 1.00
1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00

fecundity of females (millions of eggs)
north
0.0000 0.0000 0.0723 0.1526 0.2325 0.3102 0.3843 0.4540 0.5186
0.5780 0.6322 0.6812 0.7253 0.7648 0.8000 0.8313 0.8590 0.9241
south
0.0050 0.0100 0.0300 0.0861 0.1788 0.2664 0.3466 0.4184 0.4813
0.5358 0.5824 0.6219 0.6552 0.6831 0.7064 0.7258 0.7419 0.7751

index values 1968-1999 (-1 = no data)
NMFS Tiburon/Santa Cruz Lab midwater trawl index
data copied from Excel file "compare_time_series_with-without_stations.xls" sent by EJ 5-9-2004"
note that there were no estimates in 1992, 1996, and 1998 because of no positive catches
1/2 of historical low estimates (value in 1994) were uesed in those years.
CVs were set very high.
only last 2 years data added, proportioan to old data from data sent by EJ 4-28-2004
-1.000000 -1.000000 -1.000000 -1.000000 -1.000000
-1.000000 -1.000000 -1.000000 -1.000000 -1.000000
-1.000000 -1.000000 -1.000000 -1.000000 -1.000000
-1.000000 -1.000000 -1.000000 -1.000000 -1.000000
-1.000000 -1.000000 -1.000000 -1.000000 -1.000000
-1.000000 4.456287 14.319479 0.152868 4.809881
3.757728 0.206186 0.230129 1.452406 0.067504
0.878655 0.135008 0.230438 0.067504 0.283063
0.067504 0.296648 0.287885 1.311048 6.561266
1.742240 2.379322

Oregon bottom trawl index
-1.00000 -1.00000 -1.00000 -1.00000 -1.00000
-1.00000 -1.00000 -1.00000 -1.00000 -1.00000
-1.00000 -1.00000 -1.00000 -1.00000 -1.00000
-1.00000 -1.00000 -1.00000 -1.00000 -1.00000
-1.00000 -1.00000 -1.00000 -1.00000 -1.00000
-1.00000 331.47 100.88 227.08 169.08
93.97 164.10 78.49 73.59 83.16
53.58 100.34 109.96 94.81 97.23
56.56 84.46 -1.00000 -1.00000 -1.00000
-1 -1

Whiting bycatch index - foreign
2005 new index - same as in 2003 but with STAR recom. and rescaled to mean
-1.000000 -1.000000 -1.000000 -1.000000 -1.000000
-1.000000 -1.000000 -1.000000 -1.000000 -1.000000
-1.000000 -1.000000 -1.000000 -1.000000 -1.000000
-1.000000 -1.000000 -1.000000 -1.000000 0.770
1.205 0.703 1.993 0.728 0.243
-1.000000 2.937 0.407 1.111 0.390
0.513 -1.000000 -1.000000 -1.000000 -1.000000
-1.000000 -1.000000 -1.000000 -1.000000 -1.000000
-1.000000 -1.000000 -1.000000 -1.000000 -1.000000
-1.000000 -1.000000

Whiting bycatch index - joint venture (JV)
2005 new index - same as in 2003 but with STAR recom. and rescaled to mean
-1.000000 -1.000000 -1.000000 -1.000000 -1.000000

```
-1.000000	-1.000000	-1.000000	-1.000000	-1.000000
-1.000000	-1.000000	-1.000000	-1.000000	-1.000000
-1.000000	-1.000000	-1.000000	-1.000000	-1.000000
-1.000000	-1.000000	-1.000000	-1.000000	-1.000000
2.889	-1.000000	 0.776	 0.823	 0.320
0.659	 0.824	 0.710	-1.000000	-1.000000
-1.000000	-1.000000	-1.000000	-1.000000	-1.000000
-1.000000	-1.000000	-1.000000	-1.000000	-1.000000
-1		-1

# Whiting bycatch index - domestic
# 2005 new index - same as in 2003 but with STAR recom. and rescaled to mean
-1.000000	-1.000000	-1.000000	-1.000000	-1.000000
-1.000000	-1.000000	-1.000000	-1.000000	-1.000000
-1.000000	-1.000000	-1.000000	-1.000000	-1.000000
-1.000000	-1.000000	-1.000000	-1.000000	-1.000000
-1.000000	-1.000000	-1.000000	-1.000000	-1.000000
-1.000000	-1.000000	-1.000000	-1.000000	-1.000000
-1.000000	-1.000000	-1.000000	1.2642	0.7812
0.8009	1.4653	0.4546	1.0182	0.8855
1.3301	-1.000000	-1.000000	-1.000000	-1.000000
-1.000000	-1.000000

# Triennual Survey index
# July 7 2005 results from John, base model 1
-1	-1	-1	-1	-1
-1	-1	-1	-1	-1
-1	-1	-1	-1	-1
-1	-1	-1	-1	0.506
-1	-1	0.382	-1	-1
0.565	-1	-1	0.353	-1
-1	0.390	-1	-1	0.461
-1	-1	0.305	-1	-1
0.692	-1	-1	0.112	-1
-1	0.126


# cv for each index
# cv for NMFS Tiburon/Santa Cruz Lab midwater trawl index
-1.0000	-1.0000	-1.0000	-1.0000	-1.0000
-1.0000	-1.0000	-1.0000	-1.0000	-1.0000
-1.0000	-1.0000	-1.0000	-1.0000	-1.0000
-1.0000	-1.0000	-1.0000	-1.0000	-1.0000
-1.0000	-1.0000	-1.0000	-1.0000	-1.0000
-1.0000	0.4346	0.4897	0.5020	0.2485
0.2869	0.4164	0.4297	0.3197	2.0000
0.2849	0.4880	0.4941	2.0000	0.4214
2.0000	0.5001	0.3657	0.2721	0.3156
0.5		0.5

# cv for Oregon bottom trawl index
-1		-1		-1		-1		-1
-1		-1		-1		-1		-1
-1		-1		-1		-1		-1
-1		-1		-1		-1		-1
-1		-1		-1		-1		-1
-1.0	0.2121	0.1875	0.2928	0.2730
0.2897	0.1749	0.1348	0.1275	0.1179
0.1314	0.1128	0.1387	0.1357	0.1502
0.1718	0.1684	-1.0	-1.0	-1.0
-1		-1

# cv for Whiting bycatch index - foreign
# 2005 new index - same as in 2003 but with STAR recom. and rescaled to mean
-1		-1		-1		-1		-1
-1		-1		-1		-1		-1
-1		-1		-1		-1		-1
-1		-1		-1		-1	0.1153162
0.1118053	0.1186495	0.1311275	0.1257054	0.2466747
-1		0.1253805	0.1074312	0.1026710	0.0880962
```

```
0.1243402	-1	-1	-1	-1
-1	-1	-1	-1	-1
-1	-1	-1	-1	-1
-1	-1
-1	-1

# cv for Whiting bycatch index - joint venture (JV)
# 2005 new index - same as in 2003 but with STAR recom. and rescaled to mean
-1	-1	-1	-1	-1
-1	-1	-1	-1	-1
-1	-1	-1	-1	-1
-1	-1	-1	-1	-1
-1	-1	-1	-1	-1
0.12015916	-1	0.11650305	0.08088591	0.08748436
0.07741054	0.06352467	0.07400396	-1	-1
-1	-1	-1	-1	-1
-1	-1	-1	-1	-1
-1	-1

# cv for Whiting bycatch index - domestic
# 2005 new index - same as in 2003 but with STAR recom. and rescaled to mean
-1	-1	-1	-1	-1
-1	-1	-1	-1	-1
-1	-1	-1	-1	-1
-1	-1	-1	-1	-1
-1	-1	-1	-1	-1
-1	-1	-1	-1	-1
-1	-1	-1	0.1251	0.1251
0.1038	0.0685	0.1057	0.0824	0.0767
0.0786	-1	-1	-1	-1
-1	-1

# Triennual Survey CV
-1	-1	-1	-1	-1
-1	-1	-1	-1	-1
-1	-1	-1	-1	-1
-1	-1	-1	-1	0.1647139
-1	-1	0.17362109	-1	-1
0.20646497	-1	-1	0.13429315	-1
-1	0.20142058	-1	-1	0.17819659
-1	-1	0.1330084	-1	-1
0.24706085	-1	-1	0.04130032	-1
-1	0.3


# landings, data copied from "AllLanding for model.txt"
# VAL-COL Fishery landings
-1.0	-1.0	-1.0	-1.0	-1.0
-1.0	-1.0	-1.0	3670.0	3900.0
1693.0	356.0	554.0	701.0	410.0
617.0	293.0	454.0	948.0	1318.0
605.0	966.0	16190.0	21779.3	14802.4
3222.4	1450.4	1537.0	2559.1	3722.0
3078.1	3378.3	2240.7	1176.2	946.5
1746.9	1074.4	1087.3	965.1	1016.2
563.1	525.4	379.7	302.4	65.1
15.5	30.0
# OR midwater trwal fishery landings
-1.0	-1.0	-1.0	-1.0	-1.0
-1.0	-1.0	-1.0	-1.0	-1.0
-1.0	-1.0	-1.0	-1.0	-1.0
-1.0	-1.0	-1.0	-1.0	-1.0
-1.0	-1.0	-1.0	-1.0	-1.0
1452.0	3567.6	3185.0	2976.9	4984.8
4101.6	4870.9	3234.8	1845.5	1149.4
1754.8	1678.4	1394.2	1463.6	1523.5
758.3	1721.0	2276.1	966.0	154.6
7.6	12.4

# OR bottom trwal fishery landings
```

```
-1.0    -1.0    -1.0    -1.0    -1.0
-1.0    -1.0    -1.0    -1.0    -1.0
-1.0    -1.0    -1.0    -1.0    -1.0
-1.0    -1.0    -1.0    -1.0    -1.0
-1.0    -1.0    -1.0    -1.0    -1.0
1487.6   1334.2    870.8   1170.7   1169.3
1121.0   1970.9   2167.5   1940.1   2624.3
3386.2   2382.5   2277.7   2114.5   2244.7
1329.7    794.0     16.3     38.9      5.6
0.2      2.4

# EUR-CON fishery landings
-1.0    -1.0    -1.0    -1.0    -1.0
-1.0    -1.0    -1.0    96.0    249.0
336.0     21.0      1.0      1.0     13.0
207.0    280.0    358.0    412.0    883.0
502.0   2326.0   5666.0   5227.3  11244.8
4324.7   3506.0   3570.2   2800.2   3035.1
2183.0   2266.0   2579.2   1369.2   1330.6
1347.4   1248.4   1943.8   1529.0   1707.4
1303.8    902.3   1140.9    504.9     51.1
5.1     27.8

# Age compositions from four fisheries

# VAN-COL Fishery, data copied from "WAAge5.txt"
# number of years of age comps
25
# years of age comps
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
# number of sampled trips, data copied from "nSample_trip.txt"
# next line: real number of trips
# 18   31   40   25   22   16   27   36   20   30   41   35   31   34   28   33   25   29   22   29   21   10   12    5   19
# next line: fitted effective sample sizes
# 100  174  223  140  121  90  151  202  111  167  230  197  174  190  156  185  140  162  121  162  116  55  67  28  106
# Dont change formats of next 2 lines (read by effective sample size programs)
# VAN-COL Fishery new sample counts
100  174  223  140  121  90  151  202  111  167  230  197  174  190  156  185  140  162  121  162  116  55  67  28  106

# male age comps
0.000000  0.000000  0.009363  0.021512  0.020342  0.055539  0.095547  0.110577  0.046018  0.029204  0.011890  0.013060
0.005852  0.004096  0.002341  0.002341  0.001170  0.002926
0.000444  0.006609  0.024435  0.063737  0.045524  0.024041  0.047744  0.087771  0.067569  0.047083  0.025763  0.017104
0.011660  0.005331  0.004276  0.003388  0.002887  0.008502
0.000155  0.008491  0.030499  0.084375  0.030692  0.044964  0.020568  0.021494  0.032650  0.071686  0.044941  0.034309
0.034855  0.021097  0.014068  0.008806  0.005466  0.016884
0.000000  0.007569  0.153715  0.113485  0.028422  0.017474  0.014261  0.013099  0.013587  0.018363  0.020143  0.014780
0.015317  0.008811  0.006339  0.006692  0.005666  0.019890
0.000000  0.003350  0.053703  0.161029  0.083344  0.033419  0.013850  0.004392  0.005597  0.006802  0.007517  0.012931
0.012788  0.010684  0.006802  0.007681  0.007681  0.028558
0.000000  0.008297  0.074816  0.080420  0.124782  0.066450  0.021605  0.009465  0.003556  0.005909  0.005317  0.006053
0.005460  0.002658  0.005909  0.004724  0.002514  0.028344
0.000000  0.007004  0.060179  0.173641  0.075174  0.048950  0.014384  0.005971  0.005285  0.005216  0.003465  0.003122
0.004632  0.006073  0.003224  0.002297  0.001542  0.029481
0.000000  0.006265  0.024049  0.120012  0.194208  0.046191  0.012870  0.008530  0.002837  0.004189  0.005540  0.004207
0.003007  0.004055  0.003750  0.002112  0.001504  0.011251
0.000000  0.000000  0.014864  0.060143  0.136868  0.198862  0.034969  0.013274  0.004554  0.002449  0.000859  0.002620
0.003136  0.000859  0.000172  0.000515  0.000687  0.014043
0.000000  0.002563  0.017604  0.093364  0.094971  0.157016  0.087374  0.009204  0.003722  0.001158  0.000000  0.001282
0.000232  0.000927  0.000232  0.000463  0.001513  0.008464
0.000000  0.000463  0.025076  0.077338  0.152505  0.068068  0.097415  0.029967  0.011481  0.004530  0.000978  0.000463
0.000000  0.000463  0.000515  0.000978  0.001030  0.007465
0.000000  0.001239  0.010046  0.061669  0.114105  0.107253  0.073670  0.043532  0.049591  0.010278  0.003949  0.002903
0.001665  0.000619  0.004045  0.001142  0.001142  0.018292
0.000000  0.002617  0.019543  0.030901  0.071545  0.077261  0.081928  0.048736  0.051520  0.029444  0.019793  0.007934
0.004909  0.002700  0.001717  0.000000  0.000900  0.011618
0.000185  0.000185  0.016425  0.058431  0.050747  0.063019  0.056698  0.035194  0.029057  0.030791  0.022921  0.020327
0.012207  0.006507  0.005330  0.004338  0.001984  0.013384
```

0.000000 0.001331 0.010582 0.041369 0.086868 0.057047 0.045363 0.037112 0.028125 0.022800 0.025962 0.016475
0.012947 0.011150 0.004926 0.003595 0.002696 0.017475
0.000691 0.010249 0.030940 0.056238 0.096199 0.099808 0.063916 0.028599 0.030595 0.018657 0.014971 0.023609
0.010403 0.007409 0.006142 0.007217 0.002457 0.011977
0.000825 0.012122 0.059141 0.111858 0.104217 0.057559 0.032922 0.018325 0.013448 0.010364 0.007925 0.006347
0.007925 0.002367 0.003156 0.003192 0.002403 0.007925
0.000000 0.002832 0.036764 0.148943 0.129095 0.049633 0.015218 0.009554 0.006238 0.006811 0.006631 0.008137
0.001326 0.003316 0.002653 0.000663 0.000753 0.003979
0.000000 0.001088 0.014273 0.042774 0.145687 0.109655 0.039772 0.014534 0.007136 0.008529 0.007702 0.003307
0.002481 0.002481 0.006615 0.000827 0.000000 0.005788
0.000000 0.001831 0.011040 0.040933 0.080731 0.107025 0.081930 0.041423 0.022625 0.009912 0.009801 0.009154
0.004577 0.005224 0.003662 0.004577 0.001831 0.005224
0.000000 0.000000 0.004588 0.057879 0.112760 0.071044 0.073473 0.072574 0.038416 0.012596 0.012326 0.005248
0.002099 0.009117 0.006298 0.003149 0.002099 0.005248
0.000000 0.000000 0.004115 0.051421 0.125572 0.084227 0.061767 0.053575 0.037152 0.039345 0.033114 0.008307
0.016538 0.006231 0.006192 0.006231 0.002077 0.006231
0.000000 0.001570 0.020404 0.025113 0.056503 0.097311 0.062781 0.051795 0.023543 0.025113 0.010987 0.014126
0.001570 0.001570 0.004709 0.001570 0.001570 0.003139
0.000000 0.003354 0.060372 0.080496 0.083850 0.060372 0.016770 0.003354 0.000000 0.000000 0.000000 0.003354
0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.034579 0.102089 0.044458 0.039518 0.027992 0.009880 0.013173 0.004940 0.003293 0.004940
0.003293 0.001647 0.103171 0.003293 0.000000 0.106464

female age comps
0.000000 0.000000 0.009150 0.018485 0.013561 0.025721 0.087940 0.141807 0.084614 0.062747 0.034713 0.017742
0.021253 0.018513 0.005267 0.007023 0.006437 0.013246
0.000000 0.007494 0.017214 0.046582 0.043915 0.020375 0.020432 0.062351 0.078447 0.071291 0.037376 0.028320
0.018543 0.010161 0.005388 0.005778 0.005167 0.027296
0.000311 0.007559 0.018373 0.059590 0.028839 0.041575 0.018823 0.014979 0.014679 0.049251 0.039979 0.040337
0.032736 0.032280 0.016563 0.015107 0.005932 0.037088
0.000000 0.005567 0.153308 0.113974 0.040329 0.020551 0.009182 0.013519 0.013334 0.016294 0.029275 0.022800
0.021589 0.013149 0.010306 0.006877 0.004523 0.027811
0.001062 0.001941 0.044000 0.152020 0.075377 0.025555 0.018160 0.005270 0.006496 0.007007 0.011378 0.016832
0.025126 0.023716 0.020100 0.010888 0.013543 0.081403
0.000000 0.008297 0.070811 0.081461 0.117263 0.057561 0.027515 0.008568 0.006951 0.005317 0.007526 0.005460
0.012394 0.009592 0.010921 0.007221 0.007526 0.099337
0.000000 0.002024 0.053314 0.177620 0.091239 0.069749 0.020146 0.013248 0.003947 0.006967 0.007652 0.006142
0.008884 0.008402 0.007717 0.009157 0.003497 0.060653
0.000152 0.004475 0.013899 0.095086 0.224047 0.056797 0.036973 0.025570 0.009424 0.006740 0.003750 0.001960
0.007062 0.007536 0.004833 0.007518 0.004225 0.035374
0.000000 0.002449 0.007346 0.056149 0.150873 0.206253 0.035268 0.017268 0.012072 0.008205 0.002964 0.000343
0.002620 0.000515 0.000343 0.000859 0.000172 0.007428
0.000000 0.002563 0.007104 0.075898 0.092900 0.183621 0.104391 0.008972 0.009790 0.005822 0.000695 0.001050
0.001050 0.001513 0.000000 0.000927 0.003613 0.020000
0.000000 0.001442 0.027599 0.062045 0.115589 0.077798 0.119347 0.059061 0.012203 0.005509 0.002523 0.002935
0.000463 0.001030 0.002471 0.000978 0.000927 0.029344
0.000000 0.000000 0.003852 0.054294 0.084316 0.099026 0.065618 0.056733 0.053597 0.010801 0.009330 0.004665
0.004142 0.002478 0.000619 0.003000 0.002381 0.040009
0.000000 0.003025 0.023468 0.025342 0.055352 0.091347 0.081863 0.056670 0.069345 0.045878 0.029852 0.011692
0.007850 0.004417 0.000900 0.003600 0.002125 0.024210
0.000000 0.000992 0.008240 0.059488 0.037733 0.068088 0.069636 0.054083 0.049865 0.084602 0.047576 0.029668
0.015358 0.008851 0.002910 0.004523 0.001918 0.028742
0.003527 0.002662 0.013346 0.046762 0.073879 0.067858 0.043795 0.054384 0.041437 0.043268 0.052121 0.034747
0.024631 0.016042 0.012947 0.007589 0.004426 0.030753
0.000691 0.009366 0.032054 0.050326 0.077658 0.081612 0.055470 0.036814 0.023493 0.027217 0.017198 0.020537
0.009674 0.006871 0.010749 0.004760 0.001574 0.013858
0.000000 0.001578 0.068428 0.112111 0.107589 0.064339 0.053686 0.023920 0.014381 0.018253 0.013448 0.011117
0.017428 0.004770 0.003945 0.001578 0.002403 0.019006
0.000000 0.000663 0.028716 0.167241 0.141840 0.052825 0.033179 0.023569 0.016848 0.017995 0.017331 0.010037
0.007294 0.010610 0.005395 0.001989 0.002653 0.029268
0.000000 0.001088 0.012053 0.047736 0.165172 0.153429 0.046648 0.020322 0.022758 0.023063 0.019539 0.021454
0.014273 0.004395 0.011271 0.004656 0.002481 0.017014
0.000000 0.001239 0.012224 0.046000 0.066841 0.126525 0.104823 0.052952 0.032860 0.022838 0.015081 0.013195
0.014378 0.008562 0.005816 0.011309 0.005493 0.018364
0.000000 0.000000 0.001769 0.053442 0.088260 0.097226 0.076924 0.069246 0.046094 0.021383 0.009837 0.009447
0.006298 0.006298 0.006298 0.009447 0.002099 0.007018
0.000000 0.000000 0.002077 0.024653 0.053421 0.090227 0.057421 0.014346 0.031076 0.024884 0.047768 0.035268
0.016615 0.018692 0.004154 0.006192 0.008307 0.022807
0.000000 0.001570 0.023543 0.025113 0.026682 0.102020 0.097311 0.042377 0.043947 0.032960 0.028252 0.025113
0.021973 0.009417 0.001570 0.010987 0.004709 0.020404

0.003354 0.013416 0.100620 0.053664 0.046956 0.057018 0.040248 0.010062 0.026832 0.006708 0.006708 0.006708
0.003354 0.003354 0.000000 0.000000 0.003354 0.003354
0.000000 0.001647 0.031285 0.123495 0.054338 0.060924 0.067510 0.037872 0.031285 0.016466 0.019759 0.011526
0.006586 0.001647 0.001647 0.001647 0.013173 0.016466

OR Midwater Trawl Fishery
note that there are no age samples in 2003, so agecomp=(-1) for 2003, number of trip for 2003 is set to (-1)
number of years of age comps
21
years of age comps
1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004
next line: real number of trips
32 53 56 68 39 65 61 59 43 50 22 30 32 47 41 62 55 39 17 -1 4
next line: fitted effective sample sizes
108 179 189 228 131 219 206 199 145 169 74 102 108 158 140 209 185 131 56 -1 13
Dont change formats of next 2 lines (read by effective sample size programs)
OR Midwater Trawl Fishery new sample counts
108 179 189 228 131 219 206 199 145 169 74 102 108 158 140 209 185 131 56 -1 13

male age comps
0.000000 0.001319 0.017593 0.173774 0.112637 0.008768 0.019432 0.006853 0.008680 0.007585 0.015521 0.022620
0.001850 0.007780 0.003536 0.001885 0.000799 0.011921
0.000000 0.002119 0.066729 0.069127 0.223896 0.065433 0.007443 0.005645 0.002895 0.000000 0.001651 0.004627
0.012730 0.002508 0.002202 0.000000 0.000000 0.009610
0.000000 0.000000 0.005477 0.104213 0.073568 0.195207 0.059686 0.004991 0.005093 0.003767 0.000000 0.000447
0.001135 0.012793 0.003980 0.002753 0.001404 0.007583
0.000000 0.000000 0.014196 0.125268 0.217513 0.074011 0.041905 0.022240 0.002491 0.003416 0.002991 0.000421
0.000236 0.001845 0.003615 0.000000 0.001370 0.003318
0.000463 0.001134 0.013597 0.076953 0.244116 0.129001 0.033834 0.020208 0.007744 0.000000 0.001440 0.000441
0.000851 0.000000 0.002627 0.002040 0.000000 0.003489
0.000000 0.005576 0.018629 0.054351 0.121196 0.199054 0.068330 0.016187 0.009606 0.002806 0.000780 0.000588
0.000503 0.000680 0.002170 0.002169 0.003530 0.005834
0.000000 0.003259 0.027658 0.029435 0.056774 0.099210 0.133459 0.067073 0.032413 0.015428 0.007388 0.003535
0.000000 0.000956 0.000000 0.001783 0.000000 0.004200
0.000000 0.000000 0.007865 0.064272 0.099804 0.106824 0.065076 0.089038 0.038706 0.009747 0.011371 0.003156
0.002466 0.001678 0.001335 0.000000 0.000553 0.009008
0.000000 0.000000 0.035945 0.039720 0.087052 0.083027 0.080416 0.041211 0.085709 0.030049 0.021923 0.013500
0.002018 0.004160 0.000000 0.000000 0.001193 0.013024
0.000000 0.000000 0.016302 0.070921 0.055203 0.081487 0.049299 0.038564 0.034325 0.059574 0.026062 0.017941
0.014803 0.006404 0.000000 0.003025 0.001142 0.010385
0.000060 0.001656 0.008803 0.075885 0.155556 0.079729 0.046850 0.041458 0.011685 0.019825 0.031305 0.000000
0.001604 0.005385 0.000000 0.000000 0.000000 0.009487
0.000031 0.004062 0.016837 0.024621 0.130919 0.094844 0.048282 0.043438 0.032006 0.022568 0.029549 0.006968
0.001389 0.000584 0.000199 0.005330 0.000099 0.001390
0.000000 0.008243 0.073067 0.092792 0.070761 0.065215 0.049392 0.033786 0.013582 0.008126 0.023971 0.009317
0.017184 0.008103 0.003180 0.000000 0.004503 0.005028
0.000000 0.002472 0.031114 0.240239 0.116098 0.042764 0.026053 0.026697 0.016128 0.013262 0.008786 0.003029
0.013826 0.012758 0.000238 0.000317 0.000627 0.002079
0.000000 0.000000 0.011590 0.081244 0.194209 0.111829 0.054206 0.014576 0.025467 0.014974 0.003056 0.007315
0.000585 0.000827 0.008645 0.002236 0.000510 0.004328
0.000000 0.001307 0.025490 0.038238 0.109048 0.181498 0.087210 0.021738 0.004939 0.005506 0.000349 0.000900
0.001168 0.000127 0.000704 0.000518 0.000027 0.002181
0.000000 0.000000 0.005109 0.032082 0.072429 0.085135 0.107367 0.083443 0.044698 0.030223 0.004426 0.006738
0.008699 0.002806 0.000456 0.000033 0.000014 0.000058
0.000000 0.000000 0.001242 0.018150 0.098439 0.099310 0.120418 0.061821 0.049969 0.041947 0.016620 0.005991
0.001932 0.003066 0.001511 0.001557 0.004046 0.003968
0.000000 0.008723 0.008813 0.043887 0.089952 0.148003 0.117899 0.033222 0.013022 0.008925 0.009604 0.006716
0.000000 0.008839 0.004705 0.000000 0.007456 0.001564
-1.000000 -1.000000 -1.000000 -1.000000 -1.000000 -1.000000 -1.000000 -1.000000 -1.000000 -1.000000 -1.000000 -1.000000 -
1.000000 -1.000000 -1.000000 -1.000000 -1.000000 -1.000000
0.000000 0.080014 0.140150 0.202790 0.080660 0.026095 0.014545 0.001682 0.002243 0.001682 0.001121 0.001682
0.001121 0.000000 0.000000 0.000561 0.001121 0.000561

female age comps
0.000000 0.001510 0.019934 0.162448 0.181347 0.014814 0.030019 0.006296 0.006676 0.003755 0.028175 0.060927
0.016433 0.008933 0.006848 0.005805 0.005883 0.017642
0.000000 0.000000 0.053076 0.066565 0.251723 0.085721 0.011142 0.010688 0.008649 0.000000 0.000528 0.007035
0.017174 0.001930 0.000732 0.001306 0.001919 0.005197

0.000000 0.000000 0.009632 0.136515 0.082265 0.167834 0.067183 0.004427 0.010719 0.004415 0.000000 0.000378
0.003940 0.016357 0.001389 0.002327 0.001567 0.008954
0.000000 0.001290 0.016675 0.112688 0.198001 0.080151 0.038100 0.020477 0.001549 0.004767 0.001785 0.000132
0.000917 0.001633 0.002851 0.001500 0.000435 0.002213
0.000984 0.004680 0.014524 0.076746 0.192350 0.099018 0.025664 0.016977 0.008845 0.004252 0.004467 0.000000
0.001045 0.000000 0.001373 0.004050 0.002694 0.004392
0.000000 0.004348 0.026249 0.036418 0.079465 0.197050 0.086376 0.023765 0.011445 0.005620 0.004468 0.001832
0.000000 0.000745 0.000509 0.001577 0.001323 0.006822
0.000000 0.000000 0.018125 0.033563 0.054101 0.079333 0.150790 0.103895 0.037364 0.021728 0.009049 0.002238
0.001919 0.000577 0.000840 0.000000 0.000000 0.003908
0.000000 0.000000 0.010207 0.061722 0.096026 0.060650 0.068546 0.098079 0.042946 0.013639 0.009989 0.004482
0.003192 0.000781 0.000484 0.000484 0.002413 0.015458
0.000000 0.000000 0.023080 0.029597 0.070216 0.075317 0.042247 0.063636 0.088798 0.031001 0.015295 0.006497
0.001193 0.001984 0.002030 0.002224 0.000000 0.007939
0.000000 0.000619 0.010235 0.067949 0.036055 0.079940 0.065430 0.035775 0.045776 0.067009 0.033835 0.023914
0.020267 0.010147 0.004298 0.005024 0.001773 0.006514
0.000000 0.000060 0.008346 0.048716 0.157869 0.064175 0.055961 0.041445 0.034903 0.024695 0.028568 0.014965
0.020718 0.004541 0.000000 0.000000 0.002325 0.003423
0.000000 0.004768 0.005481 0.030657 0.058610 0.087557 0.088895 0.056843 0.042520 0.038741 0.032444 0.046168
0.012590 0.007441 0.014045 0.001228 0.000153 0.008744
0.000000 0.007131 0.067434 0.059398 0.076746 0.079752 0.049421 0.023895 0.038792 0.016466 0.018451 0.023365
0.018283 0.005841 0.000700 0.000878 0.000572 0.026625
0.000000 0.002580 0.012439 0.169835 0.081572 0.038429 0.037679 0.017000 0.014256 0.011551 0.013032 0.013201
0.006873 0.016518 0.001471 0.002426 0.000000 0.004652
0.000000 0.000037 0.004497 0.036935 0.158466 0.091903 0.047566 0.030986 0.031988 0.014652 0.014922 0.012049
0.003880 0.001903 0.006640 0.000777 0.002699 0.004503
0.000000 0.000166 0.022686 0.036414 0.081014 0.185689 0.092911 0.040511 0.019957 0.008138 0.011300 0.006752
0.000919 0.007343 0.003825 0.000516 0.000007 0.000904
0.000000 0.000000 0.008677 0.031407 0.070586 0.097748 0.079331 0.090545 0.060205 0.026866 0.016246 0.007038
0.008829 0.003891 0.003141 0.001463 0.005690 0.004620
0.000000 0.000000 0.000000 0.012758 0.067117 0.066960 0.071267 0.068666 0.049195 0.060219 0.016257 0.009531
0.008203 0.008080 0.013686 0.008207 0.005712 0.004153
0.000000 0.002825 0.009167 0.017950 0.065404 0.114271 0.090580 0.082117 0.036436 0.033172 0.014684 0.004683
0.009396 0.000044 0.004637 0.000044 0.001564 0.001696
-1.000000 -1.000000 -1.000000 -1.000000 -1.000000 -1.000000 -1.000000 -1.000000 -1.000000 -1.000000 -1.000000 -1.000000 -
1.000000 -1.000000 -1.000000 -1.000000 -1.000000 -1.000000
0.005417 0.110513 0.075197 0.151982 0.070732 0.022576 0.005871 0.000561 0.000561 0.000561 0.000000 0.000000
0.000000 0.000000 0.000000 0.000000 0.000000 0.000000

OR Bottom Trawl Fishery
number of years of age comps
16
years of age comps
1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999
next line: real number of trips
27 23 22 34 33 45 49 78 82 61 63 43 27 40 30 26
next line: fitted effective sample sizes
94 81 78 118 114 157 172 273 287 214 220 150 94 139 105 91
Dont change formats of next 2 lines (read by effective sample size programs)
OR Bottom Trawl Fishery new sample counts
94 81 78 118 114 157 172 273 287 214 220 150 94 139 105 91

male age comps
0.000000 0.002000 0.030445 0.189548 0.117081 0.016035 0.015324 0.003114 0.003439 0.001948 0.018194 0.013253
0.009686 0.007799 0.006124 0.002928 0.001011 0.009201
0.000000 0.002502 0.036013 0.074608 0.200140 0.051173 0.001874 0.004660 0.004952 0.000000 0.001042 0.008356
0.028493 0.000000 0.005334 0.003539 0.000143 0.007644
0.000000 0.002454 0.013907 0.200127 0.081379 0.084660 0.058424 0.002879 0.018185 0.005389 0.002106 0.000000
0.001445 0.017611 0.002031 0.001018 0.002843 0.015694
0.000000 0.000000 0.011118 0.109017 0.203522 0.070081 0.039469 0.015803 0.002859 0.002428 0.006852 0.000000
0.000000 0.005938 0.005288 0.001991 0.000000 0.007686
0.001871 0.011031 0.016633 0.079520 0.207515 0.102423 0.021828 0.011340 0.007407 0.003053 0.000490 0.000111
0.001142 0.000177 0.002442 0.003514 0.001270 0.006522
0.000000 0.008833 0.024646 0.049996 0.092063 0.174036 0.067810 0.031354 0.014894 0.008040 0.000000 0.006094
0.000196 0.000020 0.001275 0.000668 0.006091 0.006210
0.000000 0.003583 0.046610 0.044816 0.055997 0.068434 0.115960 0.057955 0.020822 0.019537 0.009585 0.004483
0.001307 0.002656 0.000000 0.000000 0.000000 0.011648
0.000000 0.000147 0.004189 0.070284 0.100833 0.070524 0.042126 0.076314 0.037653 0.009481 0.011792 0.003212
0.001068 0.003579 0.000182 0.000000 0.001193 0.011880

```
0.000000 0.000210 0.017104 0.021507 0.083738 0.072799 0.059036 0.034356 0.048167 0.017539 0.028795 0.015892
0.004209 0.004150 0.005980 0.001566 0.002672 0.017018
0.000000 0.000000 0.005855 0.035253 0.034549 0.088243 0.091091 0.046518 0.033369 0.054327 0.034564 0.022812
0.013524 0.004287 0.002129 0.003937 0.000464 0.016873
0.000000 0.003066 0.014275 0.056658 0.107092 0.068690 0.042280 0.016704 0.020763 0.028991 0.023737 0.008231
0.006195 0.004521 0.008745 0.002407 0.000000 0.010728
0.000000 0.002979 0.033648 0.108932 0.073740 0.135371 0.039055 0.044337 0.020910 0.017927 0.007067 0.012256
0.004705 0.005004 0.005162 0.000343 0.000000 0.002308
0.000000 0.001546 0.078624 0.082232 0.058865 0.058378 0.022296 0.017354 0.016860 0.020354 0.015502 0.002110
0.016646 0.004691 0.001983 0.010887 0.000918 0.007283
0.000000 0.006259 0.044095 0.229768 0.118118 0.047116 0.031456 0.020552 0.009284 0.017502 0.007340 0.006334
0.000686 0.005679 0.001947 0.000212 0.000000 0.003644
0.000000 0.000000 0.008048 0.051295 0.182533 0.115763 0.034581 0.021837 0.017118 0.020333 0.006225 0.009028
0.000040 0.001808 0.007220 0.000000 0.003032 0.007934
0.000000 0.004410 0.028185 0.065780 0.117624 0.177422 0.072072 0.027160 0.008664 0.000260 0.000000 0.007039
0.001389 0.000369 0.000145 0.000260 0.006664 0.002549

# female age comps
0.000000 0.000000 0.029195 0.150224 0.185481 0.027626 0.015787 0.011391 0.007173 0.004612 0.012420 0.029933
0.015032 0.008095 0.004631 0.005248 0.002645 0.043377
0.000442 0.000000 0.019813 0.048296 0.197706 0.126662 0.014812 0.017391 0.011417 0.000077 0.007641 0.022032
0.036411 0.010210 0.013434 0.002712 0.003324 0.037146
0.000000 0.001065 0.024770 0.106380 0.062244 0.095632 0.067643 0.006899 0.017635 0.013058 0.000257 0.000000
0.003719 0.043899 0.009910 0.006981 0.004659 0.025100
0.000000 0.001576 0.010234 0.117399 0.171871 0.063467 0.050337 0.029975 0.003580 0.003687 0.001518 0.003055
0.000272 0.004721 0.016566 0.013579 0.003342 0.022768
0.009606 0.014331 0.009403 0.077325 0.171310 0.103797 0.040625 0.026669 0.015156 0.010274 0.004624 0.005987
0.000830 0.002484 0.006360 0.010148 0.002759 0.010020
0.000000 0.001242 0.025824 0.027018 0.064659 0.144556 0.088917 0.041537 0.039946 0.014916 0.006732 0.006454
0.005084 0.003964 0.005380 0.003800 0.009658 0.018086
0.000000 0.000346 0.045983 0.035820 0.037131 0.067841 0.137383 0.107247 0.036003 0.017221 0.008657 0.004878
0.006605 0.002256 0.002494 0.001175 0.001334 0.024232
0.000000 0.000276 0.008559 0.057365 0.061216 0.065968 0.073102 0.107811 0.057796 0.032714 0.032940 0.007005
0.004608 0.004366 0.002101 0.000526 0.003298 0.035890
0.000000 0.000000 0.009753 0.008144 0.081541 0.088796 0.068771 0.057565 0.089954 0.047986 0.031772 0.019963
0.014438 0.004916 0.006446 0.001441 0.002506 0.031269
0.000000 0.000000 0.000299 0.025279 0.025262 0.075644 0.073311 0.044332 0.040169 0.066328 0.042838 0.028744
0.017316 0.020636 0.005716 0.008841 0.005620 0.031867
0.000000 0.002217 0.008820 0.042980 0.100462 0.063347 0.056897 0.063275 0.046037 0.026311 0.064738 0.028538
0.019849 0.012475 0.012450 0.006566 0.006008 0.015944
0.000000 0.004849 0.012570 0.037066 0.109137 0.084212 0.050834 0.038905 0.045410 0.025559 0.017455 0.024881
0.003947 0.002003 0.013073 0.001605 0.000000 0.014750
0.000097 0.007272 0.076010 0.101629 0.082023 0.086098 0.050735 0.028263 0.040649 0.032268 0.008394 0.004318
0.039893 0.000000 0.001771 0.010131 0.002891 0.011030
0.000000 0.008041 0.030840 0.103883 0.094444 0.030399 0.046719 0.030626 0.019097 0.014813 0.008142 0.013020
0.009741 0.016087 0.004702 0.000592 0.005036 0.013827
0.000000 0.000000 0.011607 0.047322 0.140566 0.110448 0.053762 0.024241 0.030259 0.017303 0.025682 0.013208
0.015729 0.002847 0.008011 0.001866 0.001373 0.008983
0.000000 0.000000 0.023360 0.057678 0.067752 0.146783 0.062621 0.042079 0.039373 0.008637 0.011882 0.006203
0.007617 0.002111 0.000000 0.001389 0.001141 0.001385

# EUR-CON Fishery
# number of years of age comps
27
# years of age comps
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
# number of trips sampled
# next line: real number of trips
# 7 11 26 44    149    189    169    175    154    135    127    170 155   95    55    22
        28    11    35    61    37    31 17    7    14    3    7
# next line: fitted effective sample sizes
# 5  7  16  27  93  117  104  109  96  83  78  105  97  59  35  14  18  7  22  38  23  19  11  5  9  2  5
# Dont change formats of next 2 lines (read by effective sample size programs)
# EUR-CON Fishery new sample counts
5  7  16  27  93  117  104  109  96  83  78  105  97  59  35  14  18  7  22  38  23  19  11  5  9  2  5

# male age comps
0.000000 0.000000 0.000000 0.000167 0.038794 0.061910 0.113807 0.038798 0.047047 0.016198 0.015682 0.000104
0.015850 0.038590 0.000104 0.022908 0.000376 0.055254
```

0.000000 0.000000 0.000000 0.000000 0.011438 0.011620 0.048578 0.016812 0.020248 0.015707 0.009403 0.017248
0.001826 0.019215 0.010845 0.019730 0.000012 0.047583
0.000000 0.000000 0.001824 0.014065 0.002924 0.006643 0.039520 0.032312 0.050845 0.031275 0.025393 0.028792
0.009843 0.052786 0.003750 0.016236 0.004651 0.060013
0.000799 0.008361 0.010002 0.027066 0.025037 0.027711 0.025569 0.030219 0.042947 0.046706 0.023835 0.032838
0.015918 0.028874 0.012306 0.004370 0.013545 0.025365
0.000000 0.000106 0.043649 0.007338 0.036963 0.033485 0.030316 0.013544 0.043159 0.076267 0.035984 0.029549
0.019650 0.013771 0.016956 0.010418 0.008094 0.031557
0.000000 0.000086 0.022886 0.140348 0.031918 0.033224 0.012798 0.005381 0.007744 0.009472 0.019691 0.020034
0.012469 0.012446 0.004708 0.023251 0.002119 0.027271
0.000000 0.000000 0.022177 0.136865 0.144882 0.027534 0.035797 0.014452 0.013815 0.001723 0.010158 0.030363
0.014161 0.004130 0.005053 0.003807 0.004250 0.029903
0.000000 0.000227 0.008622 0.062244 0.162794 0.144850 0.012740 0.025432 0.011326 0.002269 0.002575 0.010161
0.021668 0.002268 0.004800 0.003061 0.003256 0.026758
0.000000 0.002672 0.041614 0.045810 0.082096 0.123917 0.129130 0.013757 0.021789 0.017389 0.001018 0.000893
0.008456 0.029102 0.005577 0.008659 0.003709 0.037843
0.001179 0.000152 0.054998 0.114196 0.043553 0.059667 0.090873 0.112021 0.019943 0.029954 0.021102 0.002845
0.000000 0.018666 0.014648 0.002809 0.011094 0.025925
0.000044 0.035380 0.000332 0.065560 0.060575 0.090206 0.060701 0.051129 0.034404 0.014184 0.008844 0.007881
0.003430 0.003586 0.006491 0.016135 0.001500 0.016273
0.000000 0.004922 0.108813 0.072992 0.077959 0.119011 0.046296 0.050071 0.019741 0.011676 0.020419 0.015728
0.008211 0.000000 0.000338 0.007197 0.005816 0.008951
0.000198 0.000005 0.045231 0.116161 0.029490 0.046574 0.037731 0.056019 0.029941 0.024640 0.016278 0.022979
0.019002 0.014258 0.003722 0.002474 0.008377 0.005882
0.000000 0.002436 0.015488 0.119032 0.119577 0.049449 0.037842 0.065086 0.022067 0.016393 0.020120 0.012377
0.001613 0.003541 0.003664 0.002594 0.002776 0.017436
0.000000 0.001110 0.011299 0.018839 0.138318 0.094889 0.037718 0.016739 0.044004 0.027766 0.021343 0.019358
0.011102 0.005458 0.016019 0.001048 0.001845 0.023196
0.000000 0.000000 0.084585 0.163306 0.095533 0.077734 0.009972 0.001732 0.009303 0.006881 0.010719 0.000920
0.020993 0.004707 0.001861 0.004059 0.000628 0.032682
0.001882 0.003574 0.007108 0.070279 0.148029 0.109588 0.064736 0.021235 0.023515 0.006816 0.007885 0.004744
0.006368 0.008510 0.000880 0.004805 0.000299 0.005238
0.000000 0.033490 0.039138 0.033789 0.056445 0.196870 0.044622 0.066035 0.057784 0.003157 0.028233 0.006769
0.020519 0.001013 0.004425 0.008088 0.000051 0.003038
0.003544 0.005653 0.046056 0.045052 0.066636 0.114331 0.117781 0.033128 0.026658 0.018426 0.015394 0.003008
0.024927 0.006853 0.002391 0.002031 0.008824 0.013330
0.000000 0.001634 0.008364 0.108288 0.040725 0.051077 0.052119 0.048417 0.049544 0.035874 0.026884 0.022934
0.012512 0.005025 0.004030 0.012426 0.006304 0.012199
0.000000 0.007713 0.081754 0.060620 0.092682 0.068982 0.053847 0.020544 0.045442 0.025031 0.018261 0.017733
0.005455 0.007462 0.009450 0.000313 0.000000 0.012849
0.000792 0.001303 0.018542 0.072137 0.059251 0.100602 0.069004 0.051386 0.026777 0.022079 0.029557 0.016272
0.006032 0.005804 0.005619 0.012011 0.004983 0.031026
0.000000 0.000000 0.003526 0.043905 0.060881 0.116213 0.055216 0.044377 0.027284 0.028240 0.009386 0.000345
0.002868 0.003058 0.008237 0.002356 0.002153 0.001940
0.000000 0.000172 0.000000 0.010409 0.072637 0.012072 0.064488 0.092402 0.034594 0.039625 0.032375 0.030079
0.041966 0.021130 0.004095 0.003259 0.000000 0.006689
0.000000 0.010264 0.001604 0.001684 0.015276 0.034963 0.043864 0.104166 0.028628 0.020809 0.097590 0.031715
0.060703 0.001604 0.030191 0.000000 0.032557 0.035925
0.000000 0.278761 0.013274 0.008850 0.008850 0.035398 0.039823 0.039823 0.000000 0.017699 0.000000 0.004425
0.013274 0.013274 0.000000 0.000000 0.000000 0.004425
0.000000 0.000000 0.023237 0.000000 0.014953 0.030713 0.053950 0.069711 0.038998 0.014953 0.047282 0.023237
0.007476 0.031522 0.038998 0.000000 0.007476 0.007476

female age comps
0.000000 0.000000 0.000104 0.000000 0.123507 0.205950 0.041377 0.041169 0.018469 0.000000 0.061665 0.000208
0.000104 0.000000 0.000000 0.000208 0.000104 0.041545
0.000000 0.000000 0.000000 0.000000 0.028922 0.067305 0.158389 0.061886 0.061392 0.039940 0.075410 0.011394
0.019222 0.036234 0.011029 0.022589 0.029519 0.126505
0.000000 0.000000 0.000955 0.005649 0.003696 0.024150 0.063373 0.097604 0.097413 0.039497 0.051375 0.061888
0.017530 0.013496 0.029120 0.040354 0.006779 0.066250
0.000000 0.003318 0.004867 0.013777 0.035738 0.019389 0.024915 0.054715 0.072763 0.090769 0.026772 0.055740
0.045834 0.039020 0.025392 0.039669 0.010802 0.035053
0.000000 0.000304 0.032146 0.009081 0.035448 0.031095 0.024213 0.007839 0.036008 0.101644 0.051171 0.036445
0.034257 0.032311 0.023285 0.024933 0.016688 0.052326
0.000000 0.009591 0.075351 0.167412 0.047273 0.048111 0.015052 0.008820 0.002312 0.008036 0.037318 0.021821
0.012045 0.028244 0.019692 0.016134 0.025748 0.071191
0.000000 0.000000 0.025400 0.124378 0.113089 0.026752 0.029462 0.011598 0.007136 0.003342 0.019946 0.045211
0.009560 0.010595 0.006944 0.007132 0.010240 0.050144
0.000000 0.000151 0.001560 0.038649 0.152562 0.144097 0.019940 0.038756 0.006481 0.001962 0.002983 0.010131
0.022748 0.001717 0.006368 0.006675 0.009452 0.030716

```
0.000000 0.001094 0.032346 0.027042 0.073440 0.081848 0.100382 0.007086 0.021131 0.009354 0.004758 0.001774
0.001549 0.027713 0.003342 0.003768 0.003633 0.026310
0.001179 0.000098 0.047208 0.095361 0.021292 0.050757 0.050894 0.055412 0.011451 0.010172 0.004021 0.002340
0.000793 0.004487 0.002818 0.005991 0.000865 0.011236
0.000140 0.085843 0.037469 0.075957 0.071866 0.055259 0.032502 0.037143 0.021209 0.003896 0.014219 0.019743
0.004235 0.006851 0.003575 0.006002 0.008808 0.038628
0.000000 0.003411 0.081763 0.042605 0.042417 0.081496 0.053703 0.037811 0.021243 0.009702 0.007578 0.003805
0.006337 0.005543 0.000000 0.000650 0.001295 0.022498
0.000005 0.003187 0.050819 0.108911 0.056288 0.036766 0.088722 0.070834 0.037058 0.024351 0.009827 0.008493
0.006215 0.001197 0.003355 0.001205 0.002170 0.011633
0.000226 0.007123 0.008134 0.112901 0.128173 0.060714 0.030229 0.033110 0.023240 0.016982 0.013082 0.010959
0.008170 0.008172 0.006845 0.000731 0.001688 0.018028
0.000000 0.000232 0.015337 0.031121 0.108172 0.086481 0.039057 0.030308 0.037403 0.026187 0.025779 0.043862
0.015023 0.000488 0.001450 0.001391 0.005892 0.041767
0.000000 0.004208 0.033435 0.135163 0.123584 0.096949 0.036693 0.004437 0.001141 0.009519 0.007614 0.001330
0.000782 0.000971 0.001365 0.005160 0.005189 0.006846
0.001882 0.001724 0.022476 0.067422 0.161344 0.066366 0.050772 0.019637 0.025889 0.016917 0.015069 0.006851
0.009371 0.007548 0.006287 0.000228 0.001724 0.023001
0.000000 0.008129 0.009087 0.015496 0.050148 0.136555 0.049764 0.068335 0.023258 0.004577 0.007731 0.002032
0.005057 0.007653 0.000000 0.007704 0.000000 0.001013
0.005316 0.007498 0.039650 0.042831 0.041834 0.081434 0.058032 0.049604 0.037617 0.029501 0.010778 0.009947
0.012242 0.002580 0.001429 0.007214 0.004894 0.003579
0.000076 0.001013 0.007263 0.082973 0.037783 0.055790 0.052979 0.041542 0.064828 0.047760 0.030352 0.020260
0.004756 0.021095 0.006388 0.006955 0.005416 0.014417
0.000000 0.001686 0.053952 0.029427 0.075695 0.029682 0.045987 0.045308 0.052631 0.060361 0.028177 0.007907
0.009615 0.006146 0.006612 0.001982 0.003342 0.013353
0.000193 0.001612 0.010229 0.073635 0.045978 0.093642 0.041606 0.047047 0.038160 0.022148 0.021134 0.015287
0.014316 0.014162 0.003980 0.008607 0.001844 0.013246
0.000000 0.000000 0.006821 0.032812 0.098604 0.073335 0.075038 0.056790 0.039492 0.027416 0.059198 0.032557
0.032994 0.021127 0.002356 0.000562 0.023627 0.007284
0.000000 0.000000 0.000000 0.008190 0.060086 0.098599 0.036981 0.065238 0.063643 0.032407 0.037632 0.022603
0.020863 0.000945 0.012646 0.022527 0.033776 0.017871
0.000000 0.010264 0.001604 0.001403 0.031113 0.014715 0.038210 0.111904 0.048715 0.073654 0.004090 0.033960
0.030753 0.033399 0.003769 0.003368 0.000000 0.007538
0.013274 0.411504 0.039823 0.000000 0.000000 0.013274 0.004425 0.022124 0.004425 0.000000 0.000000 0.013274
0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.000000 0.014953 0.015761 0.014953 0.015761 0.038190 0.038190 0.068499 0.059810 0.066882 0.075571
0.014548 0.052738 0.046474 0.030713 0.007476 0.029501

# Ageing Error Matrix
# row is true age, column is observed age (column sums to 1)
0.7620	0.1217	0.0006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000
0.2315	0.7560	0.1244	0.0006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000
0.0065	0.1217	0.7500	0.1274	0.0007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0005	0.1244	0.7440	0.1303	0.0008	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0006	0.1274	0.7380	0.1332	0.0009	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0006	0.1303	0.7320	0.1361	0.0010	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0007	0.1332	0.7260	0.1390	0.0011	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0008	0.1361	0.7200	0.1419	0.0012	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0009	0.1390	0.7140	0.1448	0.0014	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0010	0.1419	0.7080	0.1476	0.0015	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0011	0.1448	0.7020	0.1505	0.0017
	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0012	0.1476	0.6960	0.1533
	0.0019	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0014	0.1505	0.6900
	0.1561	0.0020	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0015	0.1533
	0.6840	0.1590	0.0023	0.0000	0.0000
```

```
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0017
	0.1561	0.6780	0.1617	0.0026	0.0007
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0019	0.1590	0.6720	0.1657	0.0313
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0020	0.1617	0.6660	0.3080
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0023	0.1657	0.6600

# UseXHhPrior (0=no, 1=yes)
1
# To replace cv for indices with estimated RMSE (0=no, 1=yes)
1
# RMSE for index data
0.437869  0.459065  0.742357  0.811474  0.338432  0.506723
# Power coefficient Readin value for SC Lab index (PowCoefficientSCLabIndexReadin)
1.0
# Power coefficient to be estimated? (-1=no, 2=yes) (PowCoefficientSCLabIndexEstimated) => this set estimation phase
2
# Include triennial survey index (IncludeTriSurvey)
1

# Rebuilding options: Parameter for rebuilding data output
# end year for B0 calculation
1982
# start year for recruitment resampling
1986
# number of recent years for weighting fecundity, weight, and selectivity
7
# recruitment overidding for rebuilding analysis (1 = yes, 0 = no)
0
# First year of the projection
2005
# Year declared overfished
2001
# Generate future recruitments using historical recruitments (1), historical recruits/spawner (2), or a stock-recruitment (3)
3
# Year for Tmin Age-structure
2001
# Number of simulations
2000
```