Status of the Sablefish Resource off the Continental U.S. Pacific Coast in 2007

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EXECUTIVE SUMMARY

Status: This assessment finds the overall status of the West Coast sablefish stock to be improved relative to the previous assessment. Estimates of biomass are made from the U.S./Canada border, continuing south to the U.S./Mexico border. As indicated by the base model, both the depletion (≈ 38%) and the ending year biomass (≈ 93k mt) are greater than those reported in the previous 2005 assessment. This increase can be attributed in part to the continued progression of the strong 1999 and 2000 year-classes into the population, as well as into the spawning stock biomass. However, based on somewhat erratic levels of estimated recruitment from 2001-2006, the previously mentioned increasing trend should be viewed with caution. Furthermore, because of a series of poor recruitments in the mid- to late-1990's, if fished at the full OY level, the stock is projected to become more depleted for the next five years. Evidence continues to suggest that larval survival is modulated in part by climate change as expressed by annual fluctuations in the California Current System. Forecasts of the possible future status of the stock beyond the year 2006 do not take into account any possible future trends in either climate change or conditions of the California Current System.

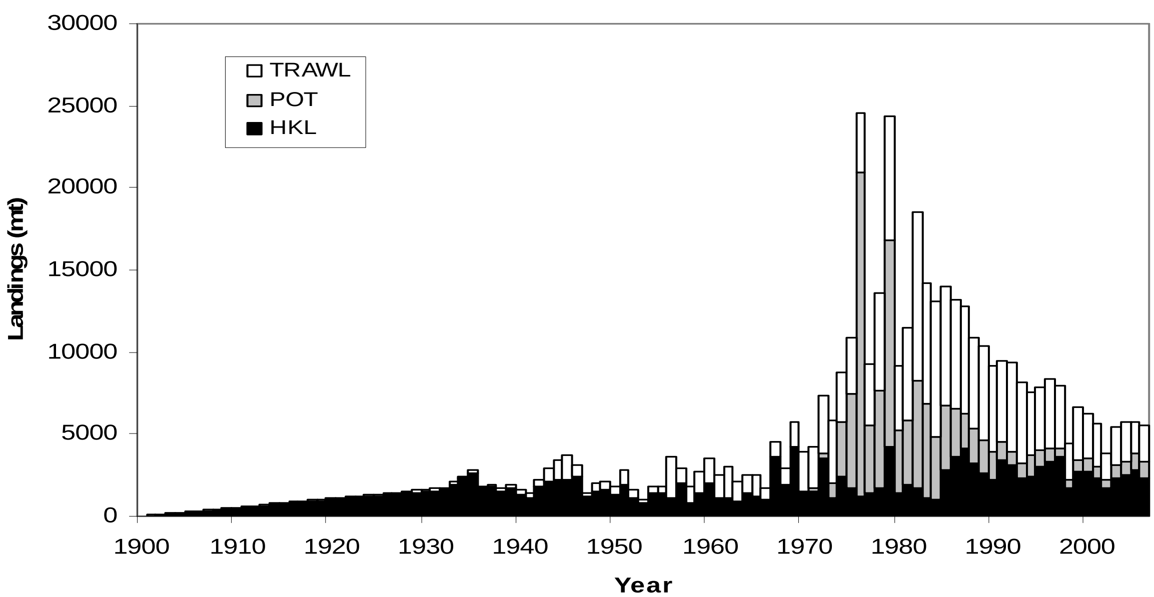


Figure ES- 1. *Total landings of sablefish off the US West Coast by gear, 1900-2006*

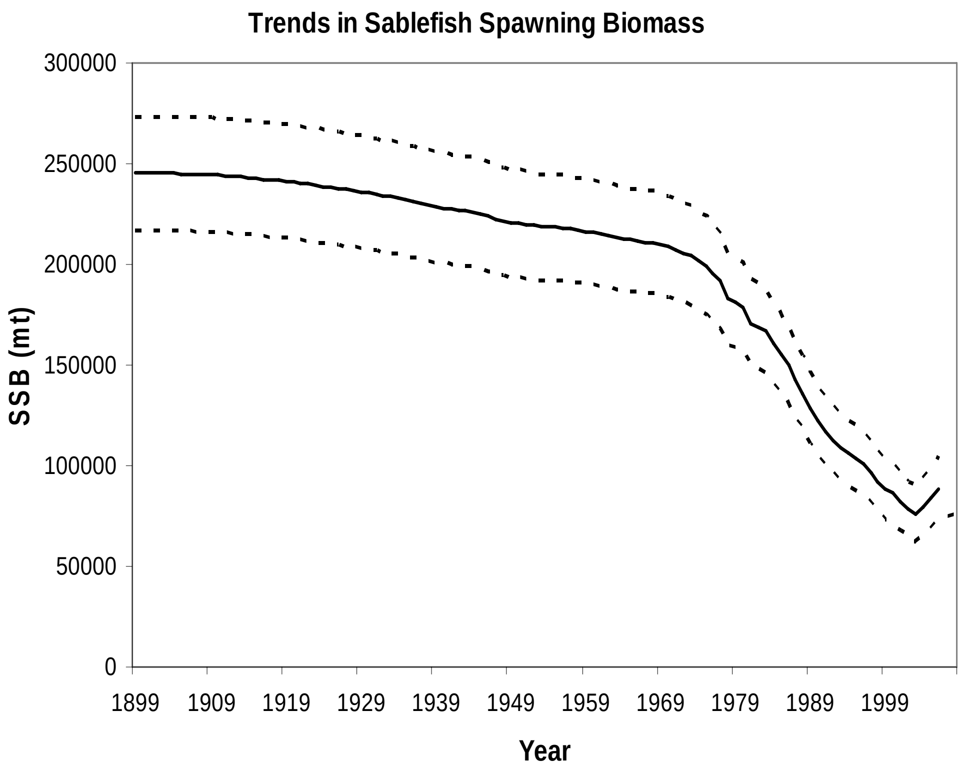
Stock: Sablefish, or blackcod, (*Anoplopoma fimbria*) are distributed in the Northeastern Pacific Ocean from the southern tip of Baja California, northward to the north-central Bering Sea and in the Northwestern Pacific Ocean from Kamchatka, southward to the northeastern coast of Japan. In this assessment, the West Coast sablefish population was modeled as single stock extending from the southern border of the Conception INPFC area through the northern border of the U.S. Vancouver INPFC area.

Landings: Landings of sablefish from waters off Oregon, Washington, and California are classified into three gear types: hook and line, pot, and trawl. Catch estimates by gear type were available starting in 1915. Catches in the assessment model began at zero in the year 1900 and were increased linearly through the year 1915. Data were generally available for the years from 1916 through 1932, though landings were estimated through interpolation for years without data. Landings in 1933 were reported to be approximately 2,000 metric tons and stayed at this level until approximately 1967 when they began increasing to more recent levels.

ES-1. *Recent sablefish catches (mt) by INPFC area and gear type*

	Vancouver-Columbia			Eureka-Monterey			Conception			Combined			
Year	HKL	POT	TWL	HKL	POT	TWL	HKL	POT	TWL	HKL	POT	TWL	TOTAL
1992	1997	363	2649	989	249	2504	93	187	301	3079	798	5457	9366
1993	1743	613	2729	499	180	1965	85	55	266	2328	847	4959	8147
1994	1498	1048	2075	761	309	1582	115	13	161	2375	1370	3822	7579
1995	1982	749	1872	882	315	1761	115	2	213	2978	1065	3848	7905
1996	1920	522	2121	1309	227	1876	125	1	214	3354	750	4211	8318
1997	2105	356	1872	1372	227	1743	107	1	154	3585	584	3771	7943
1998	1190	384	1097	468	63	978	99	0	115	1757	448	2191	4401
1999	1909	628	1726	712	125	1365	96	2	83	2717	755	3175	6649
2000	1944	661	1449	683	190	1148	83	1	37	2711	852	2727	6291
2001	1634	508	1639	612	163	945	111	1	29	2357	672	2624	5655
2002	1173	307	830	444	154	715	128	11	50	1745	472	1597	3817
2003	1568	569	1226	609	219	1001	127	12	79	2304	799	2331	5435
2004	1933	527	1415	504	269	789	87	16	80	2524	811	2447	5785
2005	1995	649	1081	730	336	815	78	12	55	2803	996	1955	6212
2006	1657	678	1293	611	272	834	66	87	9	2334	1037	2137	5861

Data and Assessment. Landings and age- and length-composition data for this assessment were obtained from the Sablefish Port (SPORT) database, maintained by the Northwest Fisheries Science Center (NWFSC). Historic landings were derived from Pacific Marine Fisheries Commission, Bulletin Number 3. This year's assessment (2007) utilized several indices of abundance: the 1980-2004 Alaska Fisheries Science Center (AFSC) and NWFSC Triennial shelf survey; the 1997-2001 AFSC slope survey; the 1998-2006 NWFSC "slope survey" (i.e. deep tows from the NWFSC bottom trawl survey); the 2003-2006 NWFSC "shelf survey" (i.e. shallow tows from the NWFSC survey years with expanded depth coverage); sea surface height (SSH) data, 1925-2006; and zooplankton abundance data, 1979-2001. Sea-surface height and zooplankton data were used to index recruitment deviations from the estimated stock-recruitment function. These multiple data sources were combined in a maximum likelihood statistical framework using the Stock Synthesis Model 2 (SS2, version 2.00b, March 22, 2007).



Reference Points. For sablefish, the proxy for BMSY is calculated as 40% of the unfished spawning stock biomass (SSB). The stock is declared overfished if the current SSB is estimated to be below 25% of the unfished SSB. The MSY-proxy harvest rate for sablefish is SPR = F45%. The current assessment estimates that sablefish can support a maximum sustainable yield (MSY) of approximately 6,328 mt using the SB40% proxy, 4,871 mt when using the SPR proxy, and 6,303 mt when using the actual estimated values instead of proxies.

Recent estimated trend in spawning stock biomass and depletion

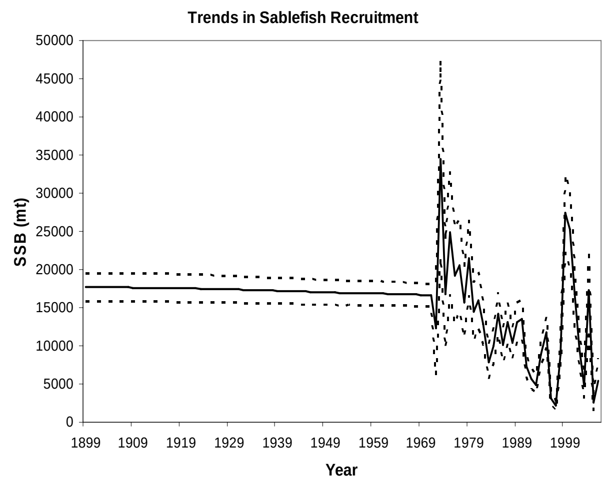
Year	SSB	95% CI	Depletion	95% CI
1997	92,013	76,991 - 107,035	37.5%	NA
1998	88,345	73,554 - 103,136	36.0%	NA
1999	86,227	71,640 - 100,814	35.2%	NA
2000	82,288	67,986 - 96,590	33.6%	NA
2001	78,176	64,188 - 92,164	31.9%	NA
2002	76,171	62,302 - 90,040	31.1%	NA
2003	79,264	64,934 - 93,594	32.3%	NA
2004	83,826	68,636 - 99,014	34.2%	NA
2005	88,632	72,398 - 104,866	36.1%	NA
2006	91,686	74,559 - 108,813	37.4%	32.1% - 44.5%
2007	93,895	75,968 - 111,822	38.3%	32.4% - 45.4%

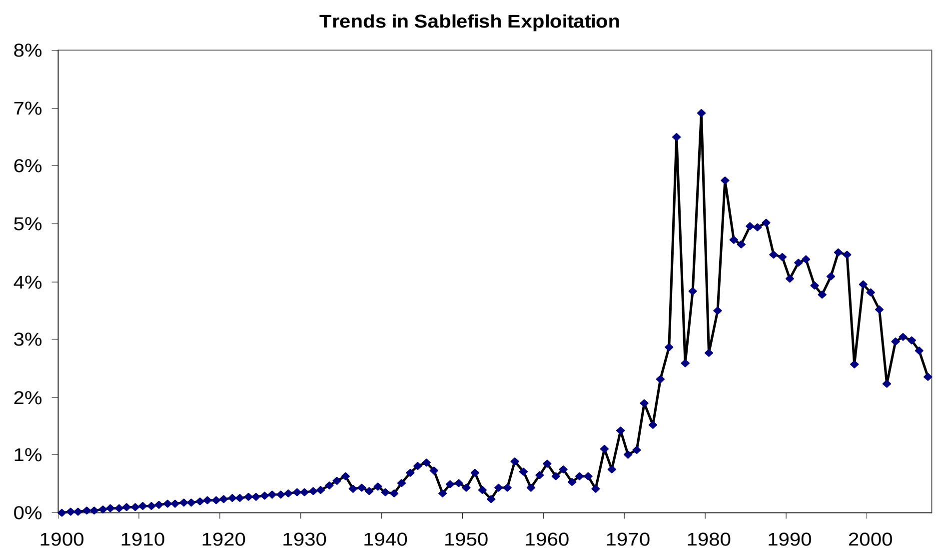
Stock Biomass. As modeled here, sablefish SSB steadily declined during the period 1900-2002. Increases in SSB since 2002 are primarily the result of two recent strong year classes (1999 and 2000) recruiting into the population.

Recruitment. Two strong year classes, one in 1999 and another in 2000 have punctuated the past twenty years of sablefish recruitment. A significant relation was observed between second quarter (April, May, and June) sea surface height in the northern coast (44-48 degrees latitude) and age-0 sablefish survivorship. A weaker, yet still significant, relationship was found between recruitment deviations and zooplankton species composition. While SSH is thought to affect sablefish recruitment at the physical oceanographic level, zooplankton species composition is thought to affect survival at a more basic biological level. The SSH and zooplankton index were significantly related, suggesting they are acting in concert on overall survivorship.

Recent estimated trend in sablefish recruitment

Year	Recruitment (1000s)	95% CI
1997	2,104	1,511 - 2,696
1998	8,833	6,807 - 10,860
1999	27,388	22,323 - 32,453
2000	25,358	20,331 - 30,383
2001	16,790	12,964 - 20,616
2002	9,735	7,175 - 12,296
2003	4,752	3,184 - 6,320
2004	17,506	12,308 - 22,704
2005	2,627	1,467 - 3,787
2006	5,278	2,310 - 8,245

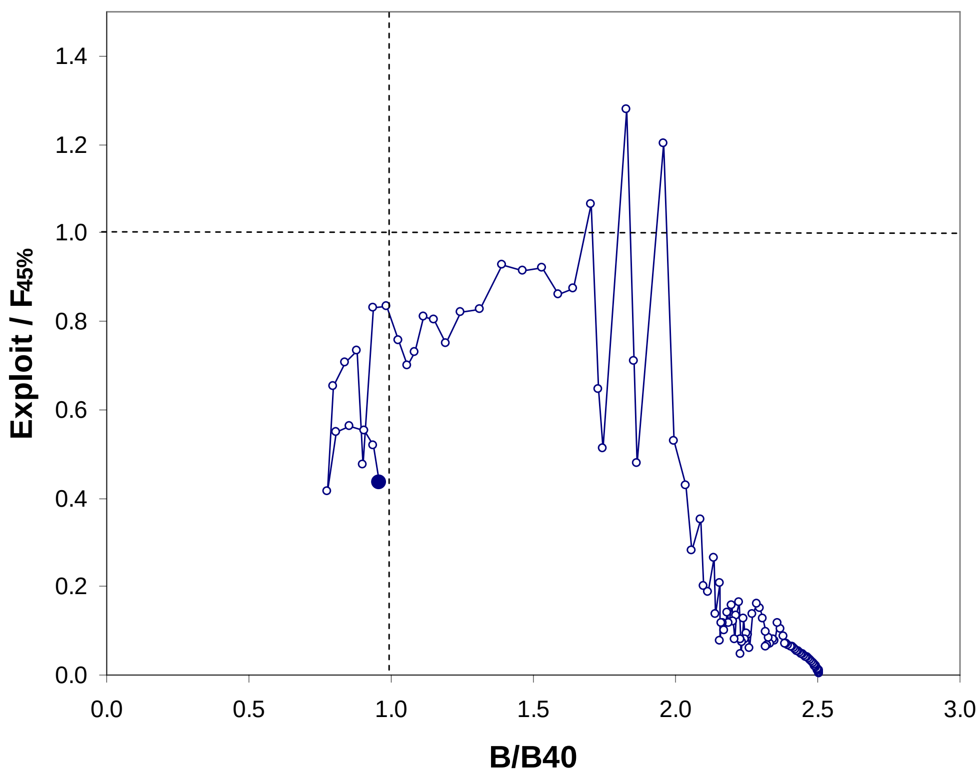




Exploitation Status: The base model for sablefish produces an estimated unfished SSB of 244,688 mt (~95% confidence interval: 216,898 - 273,542) with a mean expected recruitment of 17,656 thousand age-0 fish. The current SSB is estimated to be 93,895 mt (~95% CI: 75,968 - 111,822). Therefore, with this model configuration, the current depletion level for the year 2007 is estimated to be 38.3% (~95% CI: 32.4 - 45.4). Historical exploitation rates peaked in the late-1970s at over 6%. The current total exploitation rate in 2007 is estimated to be 2.35%.

Recent trends in Sablefish exploitation

1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
4.47%	2.57%	3.95%	3.81%	3.52%	2.24%	2.97%	3.03%	2.98%	2.80%	2.35%



Management Performance. Sablefish catch (landings plus estimated/assumed discards) has been below the ABC for the past ten years.

Forecasts. Forecasts of the possible future status of the sablefish stock were generated for the base case model, with future selectivity equal to the average of 2005-2007, catch being allocated between the three gear types in approximately the same manner as prescribed by the Pacific Fishery Management Council, and recruitments taken directly from the estimated stock-recruitment function. Based on the current estimates of recruitment strength in recent years, the depletion level is projected to fall from 38.3% to 32.1% by 2019, assuming full harvest of future OYs under the "40/10" harvest policy.

Projected potential sablefish catch, landings, spawning stock biomass and depletion for base model						
Year	ABC Catch	OY Catch	SSB	95% CI	Depletion	95% CI
2008	6,058	5,933	95,389	76,791 - 113,987	38.9%	32.4% - 45.4%
2009	9,914	9,795	94,686	75,646 - 113,726	38.6%	31.8% - 45.4%
2010	9,217	8,988	91,285	73,113 - 109,457	37.2%	30.7% - 43.7%
2011	8,808	8,484	88,354	70,802 - 105,906	36.0%	29.7% - 42.4%
2012	8,623	8,225	86,164	68,786 - 103,542	35.1%	28.7% - 41.6%
2013	8,567	8,110	84,561	66,988 - 102,134	34.5%	27.8% - 41.1%
2014	8,564	8,058	83,316	65,377 - 101,255	34.0%	27.1% - 40.9%
2015	8,569	8,019	82,264	63,936 - 100,592	33.5%	26.3% - 40.7%
2016	8,562	7,973	81,317	62,640 - 99,994	33.2%	25.7% - 40.6%
2017	8,538	7,914	80,434	61,465 - 99,403	32.8%	25.2% - 40.4%
2018	8,501	7,843	79,600	60,390 - 98,810	32.5%	24.6% - 40.3%
2019	8,454	7,765	78,810	59,398 - 98,222	32.1%	24.2% - 40.1%

Research and Data Needs. Despite a long history of scientific investigations, there remain many questions with regard to sablefish biology, the fishery (past and present) and the possible current and future status of the stock:

(1) While the significant relation between the SSH index and sablefish age-0 survival demonstrates that this should be a reliable (at least near term) index, the zooplankton index may support the underlying biological mechanism as to exactly WHY this relationship is being observed. Investigations into the food habits of age-0 fish, especially during the spring months, could help with this understanding. The date of the Spring Transition also shows promise as an early indicator of recruitment strength and should be investigated further. Also, further research should be conducted to evaluate alternative methods for incorporating ecosystem metrics into the assessment. For example, should the two current indices be combined into one index by way of a principal component analysis or should the current (or similar) multivariate method be used. The simulation work conducted for the recent Groundfish Harvest Policy Evaluation Workshop should be continued and should address issues of this nature.

(2) Consistency in the manner in which the three states (Washington. Oregon, and California) collect port samples of length-and age-composition data should be a goal. Given the problems associated with grading, samples should not sub-sampled by these categories. Furthermore, at-sea observer collection of otolilths from fixed-gear vessels that land their fish headed should be continued.

(3) While well under way, continued observer coverage of both trawl and fixed gears is critical to estimating the quantity and length composition of the discarded catch. Field-oriented work to investigate discard mortality rates should be conducted to compliment the existing lab work.

Rebuilding Projections. The stock of sablefish of the Continental United States was not found to be currently overfished, and therefore does not require rebuilding projections.

Regional Management Concerns. While sablefish growth has been shown to differ from Washington to California, it is doubtful that the existing amount of fishing effort in the south warrants managing the sablefish as two separate stocks. More interesting is the possibility of developing a transboundary stock assessment covering U.S. West Coast and the waters off southern Vancouver Island in Canada. Many of the recent recruitment trends observed in each area show a great deal of similarity.

Unresolved Problems and Major Uncertainties. The major sources of uncertainty in this stock assessment are (1) survey catchability (Q), and (2) discard quantity and length composition, and, in a very inter-related manner, discard mortality. When freely estimated, the value was $Q = 0.36$). However, based on the framework suggested by the STAR Panel during the meeting, survey catchability was fixed at a value of 0.56 for the base-run. Values that went into the estimation framework were arrived at via consensus of those in attendance. Given the steep descending limb of the NWFSC "slope" survey selectivity curve, a Q of 0.56 most correctly can be said to apply only to those fish of a total length of 53 cm., the peak of the integrated length/age selectivity curve. The shape of this curve still allows for the ability of fish larger than 53 cm. to out-swim the trawl gear (as has been presumed) and for the smaller fish to escape capture based on size and age. Although discard quantity and length-composition data were available from the NWFSC West Coast Groundfish Observer Program, these data only cover a short, recent time period. Still unknown are the discard rates for the three gear types for the vast majority of the time period covered by the assessment. Depending on the discard mortality rate of discarded sablefish (which presumably differs by depth, time of year, time on deck, etc.), assumed historic discard rates may or may not be have a significant influence on the estimated current status of the stock. Finally, there is a great deal of uncertainty surrounding the estimate of virgin spawning stock biomass (*B0*). This assessment assumes that there is a significant relation between climatic conditions of the California Current System (CCS) and survival of age-0 sablefish. Sea surface height data going back to 1925 suggests that there may have been a fundamental shift in the mean SSH around the year 1961. If this is the case, it is difficult to estimate how or even if, this shift may have affected the productivity of the stock. Furthermore, the variability of productivity of the CCS prior to 1925 are unknown. Consequently, the concept of a static "virgin" biomass is challenged by one in which an unfished sablefish population would exhibit substantial variability in response to long-term oscillation in environmental conditions. Without a longer time series of environmental data, it is not possible to determine if environmental conditions near 1925 represent a reasonable long-term average state, relative to the productivity for the sablefish stock.

Overall Perspectives. A unification of sablefish recruitment, climate change, and the factors that affect the California Current System is suggested: as goes climate change, so goes sablefish recruitment. If future climate change results in a more erratic California Current System, as predicted by some models, the results may be more erratic sablefish recruitment. Should this happen, the fishery may end up being supported by fewer, less frequent, strong year classes rather than by a greater number of "average" strength year classes.

At present, the strong 1999 and 2000 years classes are fully within the fishery. Whether these two year classes are due to past management actions or merely favorable oceanographic conditions is not clear. Caution should be exercised when using the apparent high abundance of these two year classes as an index of overall stock health. Although the two year classes are estimated to be the strongest in recent history, adjacent year classes do not appear to be as strong.

STAT Response to Issues Raised in the STAR Panel Report

The STAT found many of the concerns raised in the report to be either totally unfounded or too general to be of any help to the process. The STAT made written mention of these generalities and inaccuracies during the report writing process, but the final report failed to address many of the STAT concerns and maintained many of its original criticisms and extremely ambiguous tone. As a result, the STAT feels compelled to address several Panel comments in this document.

As catch estimates are made further into the future, the use of environmental indicators to help forecast recruitment strength will become more important. The environmental indices used are and exactly the same as those used in the previous assessment and extremely similar to those published in Schirripa and Colbert (2004). Despite statements made in the STAR Panel report, this publication does indeed do a type of validation that was fully accepted by the peer reviewers of the documents. Given the low p-values of the regression (p = 0.00004191) and the biology supporting the index, it is highly unlikely that the relationship is spurious. There was an obvious difference of philosophy between the STAR Panel and the STAT as to the importance of including these data. While the report terms the use of such indices as “fashionable”, the STAT challenges this characterization by pointing out that no other assessment on the west coast is currently using environmental data to help determine and/or forecast recruitment.

The STAR Panel’s conclusion that the complexity of the model was not justified given the likely information content of the data was not supported by any specific details or examples of consequence. In fact, the STAT made large strides to decrease the complexity of previous model configurations by reducing the number of fisheries to both one and two gear types, partitioning the commercial and survey data into fewer units, eliminating the use of the “super year” approach to the biomass estimates, and utilizing a “swept-area” estimation procedure for biomass estimates to make survey catchability easier to interpret.

The STAR Panel’s conclusion that “many of the data sets had not been scrutinized or analyzed enough” was not accompanied by any specific examples of data sets to which they were referring. The Panel’s conclusion is especially puzzling to the STAT for two reasons, (1) following careful examination of the data, the STAT’s base model had fully dismissed 6 of the 12 previously used data sets (including lengths and ages) and partially dismissed one other. Furthermore, the STAT spent a great deal of time and effort reviewing the commercial landings data with a designated industry representative until a mutually agreed upon resolution was reached. This left only the survey data, which is known to be highly scrutinized on an ongoing basis.

The STAR Panel report is inaccurate in its use of the terms “ad hoc methods” and “smoothing” to get the model working. As was explained during the STAR panel, some lengths at L-infinity were mistakenly left in the data file, however there was no predetermined intention of leaving the data in this condition, as “smoothing” would suggest. The report fails to mention that the values were all at L-infinity and as such had very little, if any, influence on model outcomes.

Finally, the reference to model runs made by the STAR Panel itself was somewhat troubling and does not seem to adhere to procedures outlines in the Terms of Reference. While the STAT sees no problem with, in fact encourages, examination of the assessment input files, it seems irregular to have the STAR do it’s own model runs and then bring those results to the meeting, even if not for consideration as a final run.

Summary tables for Sablefish

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Landings (mt)	4396	6647	6290	5653	3814	5434	5782	5754	5508	5933
Estimated Discards (mt)	8.42	4.64	4.93	231.24	112.52	16.6	16.02	3.91	16.37	
Estimated Total Catch (mt)	4404	6652	6295	5884	3927	5451	5798	5758	5524	5933
ABC (mt)	5200	9700	9700	7900	5000	8500	8500	8400	8200	6200
OY * (if different from ABC) (mt)	5200	7900	7900	7000	4600	6800	7800	7800	7600	5933
SPR	61.4%	47.6%	48.6%	49.9%	64.3%	58.8%	61.0%	63.7%	66.0%	70.5%
Exploitation Rate (total catch/summary biomass)	2.6%	3.9%	3.8%	3.5%	2.2%	3.0%	3.0%	3.0%	2.8%	2.3%
Summary Age "2+" Biomass (B) (mt)	170,075	163,427	156,921	160,923	170,558	180,956	187,899	189,613	195,783	194,425
Spawning Stock Biomass (*SB*) (mt)	88,345	86,227	82,288	78,176	76,171	79,264	83,826	88,632	91,686	93,895
Uncertainty in Spawning Stock Biomass estimate (SD)	7,395	7,293	7,151	6,994	6,935	7,165	7,594	8,117	8,564	8,963
Recruitment at age "0"	8,828	27,369	25,330	16,747	9,698	4,726	17,357	2,609	5,343	9,564
Uncertainty in Recruitment estimate (SD)	1,013	2,531	2,510	1,909	1,276	780	2,578	576	1,506	5,805
Depletion (SB/SB0)	36.0%	35.2%	33.6%	31.9%	31.1%	32.3%	34.2%	36.1%	37.4%	38.3%
Uncertainty in Depletion estimate (SD)	-	-	-	-	-	-	-	-	3.1%	3.3%

	Point Estimate	Uncertainty in estimates (If Available)		
Unfished Spawning Stock Biomass (SB_0) (mt)	244,797	216,898	-	273,542
Unfished Summary Age 2+ Biomass (B_0) (mt)	464,394	NA		NA
Unfished Recruitment (R_0) at age 0	17,635	15,802	-	19,510
Reference points based on $SB_{40\%}$				
MSY Proxy Spawning Stock Biomass ($SB_{40\%}$)	97,919	86,604	-	109,234
SPR resulting in $SB_{40\%}$ ($SPR_{SB40\%}$)	60.2%	51.8%	-	68.5%
Exploitation rate resulting in $SB_{40\%}$	3.13%	NA		NA
Yield with $SPR_{SB40\%}$ at $SB_{40\%}$ (mt)	6,328	4,607	-	8,048
Reference points based on SPR proxy for MSY				
Spawning Stock Biomass at SPR (SB_{SPR})(mt)	41,544	2,096	-	80,992
$SPR_{MSY\text{-}proxy}$	45.00%			
Exploitation rate corresponding to SPR	5.40%	NA		NA
Yield with $SPR_{MSY\text{-}proxy}$ at SB_{SPR} (mt)	4,871	245	-	9,496
Reference points based on estimated MSY values				
Spawning Stock Biomass at MSY (SB_{MSY}) (mt)	91,559	71,670	-	111,448
SPR_{MSY}	58.56%	46.86%	-	70.26%
Exploitation Rate corresponding to SPR_{MSY}	3.33%	NA		NA
MSY (mt)	6,303	4,529	-	8,077

Decision Table 1 based on model that includes sea surface height index and three states of nature which assume varying degrees of stock size by varying the NWFSC Combined survey catchability (Q) and various catch levels. Catch is in metric tons of killed fish.

						Low Stock Size Q = 0.712 Less Likely (p=0.25)		Base Case Q = 0.56 More likely (p=0.50)		High Stock Size Q = 0.445 Less Likely (p=0.25)	
Management Decision	**Year**	**H&L Catch**	**Pot Catch**	**Trawl Catch**	**TOTAL**	**SSB**	**Depletion**	**SSB**	**Depletion**	**SSB**	**Depletion**
	2009	1,243	1,341	4,685	7,269	73,394	32.2%	94,693	38.6%	120,581	45.5%
	2010	1,128	1,249	4,342	6,719	71,142	31.2%	92,541	37.7%	118,545	44.7%
	2011	1,025	1,185	4,177	6,387	69,270	30.4%	90,744	37.0%	116,816	44.0%
Low Catch	2012	958	1,147	4,131	6,236	67,988	29.8%	89,587	36.5%	115,772	43.7%
	2013	924	1,127	4,142	6,194	67,164	29.4%	88,951	36.3%	115,313	43.5%
40:10	2014	913	1,117	4,169	6,199	66,606	29.2%	88,636	36.1%	115,234	43.5%
Low Stock Size	2015	912	1,112	4,189	6,213	66,179	29.0%	88,494	36.1%	115,372	43.5%
	2016	916	1,108	4,195	6,219	65,809	28.8%	88,440	36.1%	115,628	43.6%
	2017	921	1,104	4,187	6,211	65,464	28.7%	88,433	36.1%	115,952	43.7%
	2018	924	1,099	4,170	6,192	65,136	28.5%	88,455	36.1%	116,317	43.9%
	2009	1,672	1,986	6,139	9,797	73,394	32.2%	94,693	38.6%	120,581	45.5%
	2010	1,502	1,845	5,641	8,989	69,884	30.6%	91,292	37.2%	117,270	44.2%
	2011	1,351	1,747	5,387	8,485	66,868	29.3%	88,361	36.0%	114,378	43.1%
Base Case Catch	2012	1,248	1,686	5,293	8,226	64,547	28.3%	86,170	35.1%	112,271	42.3%
	2013	1,189	1,646	5,275	8,111	62,751	27.5%	84,567	34.5%	110,819	41.8%
40:10	2014	1,162	1,620	5,277	8,058	61,253	26.8%	83,321	34.0%	109,788	41.4%
Base Case	2015	1,151	1,600	5,270	8,020	59,901	26.2%	82,269	33.5%	109,001	41.1%
	2016	1,147	1,582	5,245	7,974	58,615	25.7%	81,322	33.2%	108,359	40.9%
	2017	1,145	1,565	5,204	7,914	57,363	25.1%	80,439	32.8%	107,808	40.7%
	2018	1,143	1,549	5,152	7,843	56,137	24.6%	79,604	32.5%	107,328	40.5%
	2009	2,147	2,512	7,718	12,377	73,394	32.2%	94,693	38.6%	120,581	45.5%
	2010	1,942	2,351	7,143	11,437	68,635	30.1%	90,019	36.7%	116,005	43.7%
	2011	1,755	2,239	6,866	10,860	64,433	28.2%	85,869	35.0%	111,902	42.2%
High Catch	2012	1,622	2,167	6,780	10,569	60,986	26.7%	82,515	33.6%	108,639	41.0%
	2013	1,543	2,120	6,780	10,443	58,096	25.5%	79,779	32.5%	106,063	40.0%
40:10	2014	1,493	2,073	6,750	10,316	55,507	24.3%	77,404	31.6%	103,918	39.2%
High Stock Size	2015	1,468	2,036	6,711	10,214	53,081	23.3%	75,248	30.7%	102,049	38.5%
	2016	1,454	2,003	6,650	10,107	50,731	22.2%	73,214	29.9%	100,351	37.8%
	2017	1,444	1,973	6,570	9,988	48,425	21.2%	71,262	29.1%	98,772	37.2%
	2018	1,434	1,945	6,478	9,857	46,152	20.2%	69,377	28.3%	97,292	36.7%
	2009	1,061	1,124	3,901	6,086	73,394	32.2%	94,693	38.7%	120,581	45.5%
	2010	985	1,069	3,688	5,742	71,709	31.4%	93,152	38.1%	119,120	44.9%
	2011	913	1,031	3,607	5,551	70,308	30.8%	91,856	37.5%	117,870	44.4%
Catch to	2012	866	1,013	3,617	5,496	69,422	30.4%	91,125	37.2%	117,229	44.2%
Stablize at B40%	2013	845	1,008	3,674	5,527	68,944	30.2%	90,868	37.1%	117,122	44.2%
40:10	2014	842	1,012	3,743	5,597	68,697	30.1%	90,899	37.1%	117,356	44.3%
Base Case	2015	851	1,018	3,805	5,675	68,555	30.0%	91,075	37.2%	117,774	44.4%
	2016	864	1,027	3,853	5,744	68,446	30.0%	91,313	37.3%	118,280	44.6%
	2017	878	1,035	3,888	5,800	68,335	29.9%	91,569	37.4%	118,819	44.8%
	2018	890	1,042	3,911	5,843	68,212	29.9%	91,824	37.5%	119,367	45.0%

Decision Table 2 based on model that does not includes sea surface height index and three states of nature which assume varying degrees of stock size by varying the NWFSC Combined survey catchability (Q) and various catch levels. Catch is in metric tons of killed fish.

						Low Stock Size Q = 0.712 Less Likely (p=0.25)		Base Case Q = 0.56 More likely (p=0.50)		High Stock Size Q = 0.445 Less Likely (p=0.25)	
Management Decision	**Year**	**H&L Catch**	**Pot Catch**	**Trawl Catch**	**TOTAL**	**SSB**	**Depletion**	**SSB**	**Depletion**	**SSB**	**Depletion**
	2009	1,185	1,461	4,381	7026	73,561	30.8%	95,386	36.9%	122,045	43.2%
	2010	1,072	1,370	4,048	6489	71,298	29.8%	93,241	36.0%	120,013	42.5%
	2011	972	1,306	3,879	6156	69,381	29.0%	91,387	35.3%	118,201	41.8%
Low Catch	2012	903	1,265	3,820	5988	67,997	28.4%	90,102	34.8%	116,981	41.4%
	2013	866	1,238	3,814	5918	67,031	28.0%	89,290	34.5%	116,283	41.1%
40:10	2014	849	1,220	3,820	5889	66,315	27.7%	88,777	34.3%	115,932	41.0%
Low Stock Size	2015	843	1,206	3,821	5870	65,727	27.5%	88,431	34.2%	115,784	41.0%
	2016	842	1,193	3,808	5843	65,201	27.3%	88,176	34.1%	115,754	40.9%
	2017	842	1,182	3,784	5808	64,709	27.1%	87,974	34.0%	115,796	41.0%
	2018	841	1,171	3,752	5764	64,240	26.9%	87,810	33.9%	115,886	41.0%
	2009	1,699	1,843	6,151	9693	73,561	30.8%	95,386	36.9%	122,045	43.2%
	2010	1,522	1,704	5,626	8852	69,982	29.3%	91,912	35.6%	118,688	42.0%
	2011	1,363	1,598	5,345	8306	66,872	28.0%	88,846	34.4%	115,685	40.9%
Base Case Catch	2012	1,251	1,526	5,227	8003	64,428	27.0%	86,481	33.5%	113,392	40.1%
	2013	1,184	1,477	5,185	7846	62,490	26.2%	84,681	32.8%	111,703	39.5%
40:10	2014	1,148	1,442	5,164	7754	60,846	25.5%	83,230	32.2%	110,406	39.1%
Base Case	2015	1,130	1,414	5,134	7678	59,350	24.8%	81,973	31.7%	109,340	38.7%
	2016	1,120	1,390	5,086	7596	57,927	24.3%	80,826	31.3%	108,413	38.3%
	2017	1,112	1,368	5,023	7504	56,546	23.7%	79,748	30.9%	107,578	38.1%
	2018	1,104	1,348	4,951	7402	55,201	23.1%	78,728	30.5%	106,818	37.8%
	2009	2,163	2,611	7,692	12466	73,561	30.8%	95,386	36.9%	122,045	43.2%
	2010	1,953	2,450	7,094	11497	68,617	28.7%	90,554	35.0%	117,306	41.5%
	2011	1,758	2,330	6,783	10872	64,203	26.9%	86,202	33.3%	112,972	40.0%
High Catch	2012	1,599	2,221	6,589	10410	60,525	25.3%	82,599	31.9%	109,410	38.7%
	2013	1,499	2,140	6,496	10135	57,450	24.1%	79,642	30.8%	106,549	37.7%
40:10	2014	1,440	2,076	6,431	9947	54,724	22.9%	77,083	29.8%	104,144	36.8%
High Stock Size	2015	1,405	2,022	6,359	9786	52,177	21.8%	74,749	28.9%	102,013	36.1%
	2016	1,383	1,974	6,268	9624	49,723	20.8%	72,549	28.0%	100,056	35.4%
	2017	1,365	1,930	6,160	9455	47,328	19.8%	70,440	27.2%	98,223	34.7%
	2018	1,348	1,890	6,043	9280	44,981	18.8%	68,409	26.4%	96,495	34.1%

INTRODUCTION

Distribution. Sablefish, or blackcod, (*Anoplopoma fimbria*) are distributed in the Northeastern Pacific Ocean from the southern tip of Baja California, northward to the north-central Bering Sea and in the Northwestern Pacific Ocean from Kamchatka, southward to the northeastern coast of Japan. Although few studies have critically evaluated issues regarding the stock structure of this species, it appears there may exist at least three different stocks of sablefish along the west coast of North America: (1) a stock that exhibits relatively slow growth and small maximum size that is found south of Monterey Bay (Phillips and Imamura 1954; Cailliet et al. 1988); (2) a stock that is characterized by moderately fast growth and large maximum size that occurs from northern California to Washington (Fujiwara and Hankin 1988a; Methot 1994, 1995); and (3) a stock that grows very quickly and contains individuals that reach the largest maximum size of all sablefish in the Northeastern Pacific Ocean, distributed off British Columbia, Canada and in the Gulf of Alaska (Mason et al. 1983; McFarlane and Beamish 1990; Methot 1995). For the purposes of this assessment we consider the two potential stocks of the continental U.S. west coast as one unit stock, ranging from the U.S.-Canadian border south to the U.S.-Mexican border.

Henceforth, we use the terms stock and population interchangeably and defined in the broad context of fish stock assessment following Gulland (1983), A group of organisms can be treated as a stock if possible differences within the group and interchanges with other groups can be ignored without making the conclusions reached depart from reality to an unacceptable extent. That is, although most literature supports the hypothesis that sablefish do not exhibit large latitudinal movement (Phillips et al. 1954; Kennedy and Smith 1972; Low et al. 1976; Shaw 1984; McFarlane and Beamish 1990), long migrations have been documented (Fujioka et al. 1988) and thus, in the absence of further research, it would be necessarily difficult to evaluate the degree of mixing between hypothesized stocks. Additionally, only limited information exists concerning the juvenile biology (McFarlane and Beamish 1983a) and post-larval stage (Mason et al. 1983) of this species, which further complicates assessing the extent to which stocks may exchange genetic material (see Stock Structure below).

Life History. Sablefish off the U.S. Pacific coast exhibit a protracted spawning period from October through April, with peak spawning occurring in January and February. Sablefish spawn along the continental slope in deep waters, generally greater than 500 m (roughly 274 fm). Eggs (2.1 mm in diameter) are buoyant and rise to the surface. After hatching, post-larval sablefish are believed to inhabit surface waters offshore. Within a few months they begin to migrate inshore, where they may remain until reaching maturity several years later. When mature, fish begin to migrate offshore. The seasonal (within year) migration patterns of sablefish are poorly understood, but it appears substantial numbers of fish remain in relatively deep water (>500 m) following maturation. Length at 50% maturity for males and females is between 55-67 cm, most likely by age 5-7. However, studies have found considerable variation in maturity schedules for this species (Mason et al. 1983; Parks and Shaw 1987; McDevitt 1987; Fujiwara and Hankin 1988a; Hunter et al. 1989). It is important to note that Methot (1994, 1995) has shown that the ontogenetic movement of sablefish into deep water to spawn is more strongly correlated with age than with size.

Female sablefish generally reach larger sizes and older ages than males. The largest female sablefish analyzed in this assessment was a 102 cm fish and the oldest female was estimated to be between 80 and 92 years old. However, sample data analyzed in this assessment included few females greater than 85 cm in length or greater than 75 years old. The largest male sablefish was 91 cm and the oldest male was 68 years old. As with females, however, few males were greater than 70 cm in length or greater than 60 years old. Adult sablefish are top carnivores that feed primarily on fishes, cephalopods, and crustaceans (Low et al. 1976; Shaw 1984).

Commercial Fishery and Management. Sablefish have been commercially harvested from U.S. Pacific coast (West Coast) waters for over 100 years. Three periods of growth characterize the history of the West Coast groundfish fishery, including the sablefish resource. From the late 1800s to the early 1900s, little or no management was imposed on a relatively small commercial fishery. From the early 1900s to the early 1980s, management on a rapidly expanding fishery was the responsibility of the individual coastal states (California, Oregon, and Washington). Since the adoption of the Groundfish Fishery Management Plan by the Pacific Fishery Management Council (PFMC) in 1982, responsibility for managing the diverse, mature groundfish fishery has rested with the federal government and the PFMC.

The first period of growth for West Coast groundfish fisheries occurred during the late 1930s, when the United States became involved in World War II and wartime shortages of red meat created an increased demand for other sources of protein (Browning 1980). The West Coast sablefish fishery increased rapidly during the 1970s (Figure 1, Table 2). Foreign fishery regulations in the Gulf of Alaska most likely contributed to these increases, which were observed in both the domestic and foreign fleets, particularly that of the Republic of Korea (McDevitt 1987). From 1977 to the mid-1980s, commercial fishers from the United States took advantage of their newly protected fishing grounds (i.e., "Fishery Conservation and Management Act" was enacted in 1976, recently renamed to "Magnuson Stevens Fishery Conservation and Management Act") to record high catches of sablefish to meet the demands of flourishing export (primarily Asian countries) and domestic markets. Total West Coast sablefish landings surpassed 5,000 mt in 1972 and reached historic high values in 1976 (24,518 mt), 1979 (24,373 mt), and 1982 (18,548). From these highs, landings have steadily declined with annual totals of roughly 8,000 mt from 1993 to 1997 and amounts generally in the 5,500-6,600 mt range since 1999.

Prior to 1969, most sablefish were harvested with longline gear. Landings of trawl-caught sablefish began to increase during the early 1970s and today roughly 60% of the catch is harvested by trawls and 40% by fixed gears (primarily longlines and pots). The ex-vessel value of this fishery was nearly $26 million in 1996 (Jacobson 1998).

The first coast-wide-established regulations on the sablefish fishery off the U.S. Pacific coast were implemented as trip limits in October 1982 (Table 1 in PFMC 1998) in response to attainment of the Allowable Biological Catch (ABC). Beginning in 1983, trip limits were imposed on landings of sablefish less than 22 inches in length. Sablefish were first allocated between trawl and non-trawl fleets in 1987. Since 1982, the sablefish fishery has been managed intensively, with limited-entry, open-access, and fishing derby programs used in various manners to limit catches. Annual coast-wide catch limits for sablefish, along with landed amounts, are presented in Table 1.

Fishery in the 1990s. The harvest guideline for sablefish has ranged from 5,200 to 8,900 mt since 1991, when the first guideline was implemented (Table 1). In 1997, the 7,800 mt harvest guideline was allocated as follows: (1) 780 mt (10% of overall guideline) apportioned to Indian tribes; and of the remaining 7,020 mt (2) 463 mt allocated to vessels without permits (roughly 7%); and (3) 6,557 mt (93%) allotted to the limited entry (permit) program, with 3,803 mt (58%) apportioned for trawl gears and 2,754 mt (42%) for fixed gears.

In contrast, the non-trawl fishery was managed primarily as a derby, or Olympic-style, fishery, characterized by dramatic reductions in season lengths beginning in the late-1980s. In 1990 the unconstrained, fixed-gear season was closed in late June. In 1991, the fully open season lasted seven weeks, from April 1 through May 23. In 1992, about 1,300 mt were landed under early season trip limits of up to 1,500 lb/day, and the fully open season lasted from May 12 through May 26. In 1993, there was only a 250 lb/day trip limit prior to the open season on May 12; the open season extended through June 1. In 1994, the fully open season lasted from May 15 through June 3. In 1995, the open season lasted one week, from August 3 to August 13. The open season spanned only six days in 1996, from September 1 to September 6. In 1997, 9 days (August 25 to September 3) were set aside for the open season, with a mop-up period from October 1-15. In 1994, a license limitation program was implemented for West Coast Groundfish. Around that time, the PFMC began consideration of an Individual Quota program for the licensed non-trawl fishery. Beginning in 2001, the limited-entry non-trawl fishery has been managed primarily through the use of tiered cumulative limits (allocated on the basis of historical landings) which can be landed throughout a 7-month season. The remaining open-access fishery and some limited-entry non-trawl vessels are allowed to make smaller landings that are subject to daily/weekly limits and 2-month cumulative caps.

Sablefish are harvested by the trawl fishery in association with a variety of other species which are distributed to domestic and foreign markets. In order to extend harvest throughout the year, and provide stable supplies for fish for processing and distribution, the trawl fishery has been managed primarily through the use of trip limits. These evolved from simple per-trip limits in the 1980s to cumulative periodic (monthly or bi-monthly) limits by the mid-1990s. In addition to sablefish-specific limits, there have been various limits on the overall landings of deep-water complex species. For example, in 1996, limits of 70,000 lb per two-month period north of Cape Mendocino (40E30' N latitude) and 100,000 lb per two-month period south of Cape Mendocino (12,000 lb of sablefish per two-month period are allowed within the deep-water complex limit). In 1993, a minimum mesh size of 4.5 in was required in all non-pelagic groundfish fisheries.

Formal stock assessments of sablefish began in 1984 and have been conducted frequently since then (Francis 1984, 1985; McDevitt 1987; Methot and Hightower 1988, 1989, 1990; Methot 1992, 1994; Crone, et al. 1997; Methot, et al. 1998; Schirripa and Methot 2001; Schirripa 2002; Schirripa and Colbert 2005).

ASSESSMENT

Data Sources

Overview. The following sources of information were considered for use in this assessment: (1) commercial landings (1933-2006); (2) fishery-related biological data (1986-2006); (3) commercial fisher logbook data (1978-88); (4) pot survey data (1979-91); (5) shelf trawl survey data (1980-2004); (6) slope trawl survey data (1988-2006); (7) sea-surface height (1925-2006); (8) independent research studies that addressed sablefish growth, maturity, mortality, and fishery-related discard. These data sources are presented under broad categories, Fishery-related Data (1-3 above), Survey-related Data (4-6 above), environmental data (7 above), and Biological Factors (8- above).

Commercial Fishery Data

Commercial Fishery Landings. Catch information used in this analysis consisted of landing data (mt) from 1956 through 1980 that are archived in the Historical Annotated Landings (HAL) database (Lynde 1986), along with landing data from 1981 through 2006 that are maintained in the Pacific Fisheries Information Network (PacFIN) database (Daspit et al. 1997; Daspit 1996). The landing amounts by INPFC area and major gear (longline, pot, and trawl) presented in Table 2 may differ slightly from previous assessments, as a result of revisions submitted to PacFIN by State agencies (Daspit et al. 1997). Gears other than longline, pot, and trawl are combined into a single miscellaneous category. Gear codes were not available for landings by foreign vessels prior to 1981. Based on reported historical gear use, the following assignments were made: landings made by Japanese vessels were categorized as longline; Soviet Union (USSR) and Poland landings were classified as trawl; landings made by Korean boats were identified as pot; and all other foreign landings as miscellaneous. For assessment purposes, landings associated with unknown gear information were allocated to one of the major gears in proportion to known-gear totals by year and area (this procedure was also conducted on landings by gear and state described below). This reclassification was primarily necessary for a small amount of the landings from the Eureka, Monterey, and Conception INPFC areas (i.e., California), given gear information has been available for nearly all of the sablefish catch from the Vancouver and Columbia INPFC areas (i.e., Washington and Oregon).

Market Categories. Commercially-caught groundfish are landed primarily at processing facilities (fish dealers) in ports in California, Oregon, and Washington. In general, catches are sorted into individual species or groups of species, commonly referred to as market categories, either by the fishing boat while at sea or at the delivery site. Landing information from fishing trips is documented in fish tickets. Any fish dealer who purchases groundfish from a commercial fisher is required by law to complete a fish ticket indicating the weight and value of the market categories landed. The fish tickets provide important information about catch sizes, species composition, and economic value of the fishery. Biological samples are collected by port biologists at the processing facilities as part of a federally-coordinated sampling program (Bence 1997; Pearson 1997).

For the most part, sablefish are landed in their own market categories. Because the market value for this species is generally dependent on the size (which is recorded as "grade" on fish tickets) and condition ('round' or 'dressed') of the fish, landings of sablefish are often further sorted into sub-market categories. Since 1981, landing information for sablefish has been maintained at the sub-market category level (i.e., grade).

The myriad of strata and inconsistencies in the processing operations for landings of sablefish have seriously hindered collection and subsequent analysis of biological sample data. That is, the design used to collect data from the commercial fishery is based on a multistage approach that treats the market categories as the domains of study (Sen 1986; Crone 1995). Estimates (e.g., landings, length and age distributions, etc.) are derived within market categories (in this case, grades) and then summed over the categories to determine means, totals, and their sampling errors. In this sampling design, boat trips are the primary sampling units, baskets of fish represent the secondary sampling units, and the market categories are treated as post-stratification units. Grades are generally defined as 'ocean-run' (not sorted by size), extra-small, small, medium, and large. Sizes for dressed fish reflect lengths that have been converted from dorsal length to fork length using a conversion factor of 1.4085.

However, the processing operations for landings of sablefish are not similar across the three states, within a state, or even a port (i.e. a fish categorized as 'small' by one fish house may be categorized 'medium' at another. The problem is compounded in situations when a landing is further processed after it has been sampled. This results in sample information that cannot be easily matched to a corresponding fish ticket, because characteristics of the landing when sampled are not necessarily similar to those recorded on the fish ticket; landing data on fish tickets are commonly used as weighting variables in sample estimators. Ultimately, considerable preliminary analysis and subjective judgment are required to develop accurate length and age distributions from fishery-related data. The problems associated with the biological data collected from the port sampling program were first identified in the 1992 assessment (Methot 1992). For a complete list of issues surrounding the sablefish sampling see previous assessment (Schirripa and Colbert 2005).

For this assessment it was decided to reduce the complexity of the catch partitions so as to increase the sample size for any one individual partition. Furthermore, examination of the data showed that not all port sampling was being done in a stratified manner. Consequently, rather than partitioning in the same manner as the previous assessment (year, gear, state, condition, and grade), this assessment dropped the last two partitions and used on the first three (i.e.. year, gear, and state). This made for much larger sample sizes for catch, length, and age compositions and resulted in essentially identical compositions and results. This is demonstrated by the close agreement between the results of the 2005 assessment and those of the "bridge" model (configuration 0_Bridge described below).

Size Distributions. Biological data (primarily length, sex, and otoliths) from the commercial fishery have been collected every year since 1986, except in 1992, when only limited sampling was conducted in Washington. The numbers of samples (number of boat trips and total number of specimens) collected for each fishery are presented in Table 4.

In the most recent past assessment (2005), size distributions (fork length in cm) for each year (1986-91 and 1993-2006), gear (hook-and-line, pot, and trawl), and sex were based on the following strata: year, gear, state (California, Oregon, and Washington), condition (round and dressed), and grade (large, medium, small, and ocean-run). Extra-small fish in Oregon were combined with small fish. Total landing amounts were summarized from fish ticket records maintained in the PacFIN central database. Close inspection of the data shows that each of the three states adopted different sampling protocols at different times. For California, samples have been taken from graded fish from 1986-2006; for Oregon samples have been taken from graded fish from 1986-1995 and unsorted fish from 1995-present; for Washington samples have never been taken from sorted fish. Consequently, I used these dates to modify the strata definitions. As a result, California strata remained the same as past assessments (i.e. year, gear, state, condition, and grade). In Oregon the same strata were maintain for 1986-1995, but in 1996 and beyond only the 'ocean run' strata was used. In Washington, no 'grade' strata were considered and only the 'ocean run' strata were used. Fish were still partitioned by condition of either 'whole' or 'dressed'.

The most significant signal from the fishery length distributions is a clear trend of increasingly larger sablefish being landed by the trawl fishery over time (males and particularly, females) (Figure 4). However, beginning in 1996, a shift to increasingly smaller fish was observed. The pattern observed from 1986 to 1995 is a result of both the demographics of the sablefish population and the fleet itself, as well as economic factors related to high-grading. That is, as the trawl fleet fished deeper water (Brodziak 1997), it exerted increased pressure on a size- and age-segregated, by depth, sablefish population (Methot 1994, 1995). It appears that the fishery's movement to deeper water may not be to target solely on sablefish, but rather to harvest thornyheads (commonly caught with sablefish and Dover sole as part of a deep-water complex), which have gained considerable market value in recent years (B. Fisher, personal communication, retired captain, Newport, Oregon; R. Brown, personal communication, member of the Pacific Fishery Management Council, Portland, Oregon, 1996). The shift to smaller fish in the catches of trawlers is likely due to: (1) the increasing regulations on the fishery and their ability to realize trip-related quotas of sablefish without having to target on them (i.e., fishers catch their limits of sablefish while fishing for species such as thornyhead); and to some degree to (2) reduced amounts of high-grading of this species. The amount of small sablefish (<50 cm) in the 1997 length composition does correspond with the fishery member's communications with NMFS researchers regarding the increased amount of small fish in their hauls during the summer and fall of 1997 (T. Leach and G. Gunnari, personal communication, members of the Coos Bay Trawlers Association, Inc., Coos Bay, Oregon, 1997).

Age distributions. Otoliths were obtained from sablefish specimens that were collected from fishery landings by the State biological sampling programs. The numbers of samples (number of boat trips and total number of specimens) collected for each fishery are presented in Table 4. The "break-and-burn" method for preparing and analyzing otoliths (sagittae) has been used to determine the age of the fish (Beamish and Chilton 1982; McFarlane and Beamish 1983b; Fujiwara and Hankin 1988b). Data from 1987 to 2006 were used to develop age distributions by year, gear, and sex. Age data from otoliths were collected in 1992 (i.e., biological sampling program was discontinued in this year). Age data collected from 1987 through 1990 were analyzed by personnel at the Tiburon Laboratory, and otoliths collected from 1991 through 2006 were analyzed by staff of the Cooperative Ageing Program in Newport (see Age-determination Error above). Data from all grades were combined, given inspection of the data did not indicate any obvious difference in the distribution of age-at-size between the different grades. Also, data from all areas (states) were combined, primarily to utilize effectively the limited age data. However, Methot (1994) did caution that collapsing data across states could introduce additional variability into the final distributions, given the differences in the fishing practices between the three states. For example, in Washington, the trawl fishery has remained in relatively shallow water, where young sablefish predominate, while in Oregon and northern California, there has been a tendency for the fleet to fish deep water, where older animals are found. It is generally recognized that there is a need to develop state-stratified distributions, but the sample data were unavailable to accomplish this task.

Discard Amount. Observer data were used to estimate the total number of sablefish discarded by the three different gear types from 2001-2006. Estimation of the magnitude of total, mortal discard associated with the sablefish fishery before this time is problematic because few studies have addressed this issue. Annual assumed discard mortality rate and estimates of dead discards since 1970 are presented in Table 5. Several assumptions from previous sablefish assessment were maintained:

A. In years prior to trip limits (before 1982), the assumed annual percent discards associated with the total amount of trawl-caught sablefish was 20%. There is no information available to support the estimate for this time period. However, the estimate does not seem unrealistic, given that market conditions for sablefish most likely resulted in some level of high grading, i.e., since at least the early 1950s, fishers have received more money for large sablefish than for small fish.

B. In 1982, a 3,000-lb trip limit was imposed; however, we maintained the 20% discard estimate for this year as well, given no information was available at that time to justify the use of a different rate.

C. No trip limits were imposed from 1983 to 1984. For these two years, we assumed the annual percent discard associated with the total amount of trawl-caught sablefish was 20 percent.

D. Total coast-wide discard in 1985-1987 was based on Pikitch et al. (1988). The mean percent discard during these years was estimated to be 23.5% of the total trawl catch and 30.7% of the landed (retained) catch.

E. The assumed level of discard in 1988-1996 was 20% of the total trawl catch (20% of the landed catch), which was the rate measured by Pikitch et al. (1988) when the 6,000-12,000-lb trip limits were imposed.

F. From 1996 to 2000 data from the Enhanced Data Collection Program (EDCP) was used to estimate trawl fishery discards.

Size Related Discards. The size-specific component of discard by trawlers was examined in the 1988 and 1990 assessments (Methot and Hightower 1988, 1990). Data from the Eureka INPFC area in 1984 indicated 50% retention at 42.8 cm (Fujiwara and Hankin 1984), Estimated fraction of catch retained was estimated as,

$R = 1/ (1 + \exp(alpha(L - beta)))$

where R is fraction retained, L is length, and *alpha* and *beta* are estimated regression coefficients used as constants in the formula. For 1971-1984, *alpha* is -1.092 and *beta* is 42.8 and for 1985-1996, *alpha* is -0.526 and *beta* is 40.1. Separate retention curves are used in the model for the two time periods 1971-1984 and 1985-1996. The size distributions of the discarded sablefish (from the two studies above) are used in the model to estimate selectivity curves that are consistent with the size distribution of the retained and discarded catch, given the estimated retention function.

Discard Mortality. Work conducted on sablefish in the lab showed that while hooking and net towing accounted for some portion of the total mortality, temperature was much more important (Davis, et al. 2001). We used observations developed from laboratory experiments to estimate release mortality. For consistency, release mortality percentages were adopted from the values used by the Pacific Fishery Management Council's Groundfish Management Team. These values are 50 percent for the trawl fishery and 10 percent for the hook-and-line and pot fisheries (Table 5).

Alaska Fisheries Science Center Shelf Survey (Survey #5)

Overview. The shelf trawl surveys conducted by AFSC in 1980, 1983, 1986, 1989, 1992, 1995, 1998, 2001, and 2004 (2004 conducted by the NWFSC) provide valuable information regarding abundance of young sablefish. Survey methods are described in Weinberg et al. (1994) and NOAA (1995b). Sample data collected within the 30- to 200-fm depth stratum from the north Monterey INPFC area (36E48' N. latitude) to the U.S./Canada border were analyzed in this assessment. These depths and areas were similar across the surveys, which allowed trends in biomass to be effectively evaluated.

Biological data. Length distributions (fork length in cm) were calculated following the estimation methods described in Weinberg et al. (1994). Length distributions are presented for both sexes (Figure 9). Size-distribution data from the shelf trawl surveys generally provide useful information regarding the magnitude of recruitment to the sablefish population. In general, young sablefish (ages 1 to 3) predominate in shelf trawl survey data (Figure 9). For example, the major modes reflected in each size distribution from 1980 to 1995 consist of young fish, primarily age-1 animals (and some age 2-3 fish) between 32 and 41 cm. The model uses information in the size distributions to estimate the degree to which aspects of selectivity of this survey declined with increasing age.

Unusual in 2004 was the large number of sablefish caught in 55-183 fathom that were between 60 and 70 cm. Based on the progression of modes in the length compositions, these fish appear to be from the 1999-2000 year classes. Why these 'older', larger sablefish remained in the shallow depth, especially in the U.S. Vancouver and Columbia INPFC areas, is not clear.

Survey index - shelf trawl survey. We developed an index of stock abundance based on estimates of biomass from the shelf trawl surveys. This index was based on a swept-area estimate of relative biomass from samples in the 30-200 fm depth ranges. In the assessment model, estimates (biomass in mt) were treated as relative indices and not considered as absolute values. Biomass estimates were determined following Gunderson and Sample (1980). The trend in estimated biomass declined from 1980 through 1986, then climbed to a high value in 2001. For analysis of 'water-haul' data from this survey, see Zimmerman et al. (2001) for details.

Alaska Fisheries Science Center Slope Trawl Survey (Survey #6)

Since 1984, the AFSC has periodically conducted trawl surveys on the continental slope and outer continental shelf (100-700 fm) off the U.S. Pacific coast. Since 1998 NMFS has also participated in the Industry Co-operative Survey. Survey methods are described in Raymore and Weinberg (1990), Parks et al. (1993), and NOAA (1995a). These surveys provide an important source of information, given they are conducted in habitats preferred by this species. However, the available time series for these surveys were significantly reduced in this assessment, given recommendations from an independent review of groundfish stock assessments, particularly those regarding slope-related species (Parma et al. 1995). Possible biases, those arising from non-random sample-selection techniques and incomplete coverage of the target population, associated with these surveys led to the critical review. The primary criticism raised regarded the surveys susceptibility to mud loading and decreased net opening, which could affect (bias) catch rates.

In 1994, an experiment was conducted on a soft mud bottom at depths of 460-490 m off the central Oregon coast to evaluate important gear-related factors, such as door-bridle rigging, ground-gear weight, and scope length that may influence objective interpretation of slope trawl survey catches (Lauth et al. 1998). In general, the following conclusions were drawn from this experiment: (1) trawl performance was variable for the historically used standard trawl configuration, with improvements observed with the addition of either a 2-bridle door or lighter ground gear; (2) the interaction of door bridle and ground-gear weight had the most effect on trawl performance; and most importantly, (3) although the standard trawl performed erratically, catch rates of all four deep-water complex species were, in general, not significantly different (p >0.05) across the treatments tested. Given that this experiment indicated catch rates from standard trawl operations (gear associated with surveys prior to 1995) were not significantly different (p >0.05) than those from improved trawl operations (gear associated with surveys after 1995), we used these data to develop a relative measure of sablefish population abundance and incorporated this index into modeling procedures in 1998.

The major drawback associated with these surveys was that they have not been conducted over the entire assessment area (Monterey - U.S. Vancouver INPFC areas) in a given year, with the exception of the 1997 survey, which did cover the entire area. Conceptually, the lack of synoptic coverage associated with the surveys is a severe problem. However, in the assessment model we have a single area defined from the Monterey to the U.S. Vancouver INPFC area, which in effect, is based on the assumption that a single, homogeneous population inhabits this area. Given that the latitudinal dynamics exhibited by the population are generally constant from year to year, use of the surveys to construct relative abundance indices can at least be examined on a cautionary basis. We recognize that there is some information indicating that multiple stocks may exist along the West Coast. However, the limited amounts of data and modeling complexities preclude an assessment at this time that is based on this hypothesis. Given the lack of synoptic coverage associated with these surveys in individual years from 1988 to 1996, we felt the most prudent use of these data was to omit those years that did not have full coverage and use only the years that covered the entire survey area (1997-2001). Given the assumptions necessary to use the previous ‘super year’ approach, we felt this was the best use of the data.

Biological data. Size distributions (fork length in cm) were calculated following the weighted (CPUE) estimation methods described below for survey indices. Age distributions (year) were derived in a similar fashion as was done for the fishery-related biological data (see Fishery-related Data, Age distributions above).

Only size distributions associated with the ‘single years’ index were used in the analysis, given developing size distributions that correspond with the ‘super years’ index was expected to result in length compositions that compromise the model’s ability to follow size (year) classes across the entire time series. Again, we felt this was the best way to develop the size-distribution time series, given the problems associated with a non-synoptic survey design.

Northwest Fisheries Science Center Slope Trawl Survey (survey #7)

The NWFSC shelf-slope survey was conducted annually from 2003 to 2006. Survey methods are described in Keller et al. (2007). This survey ranged from 32°34' to 48°22' N.Lat. and covered all five INPFC areas included in the scope of this assessment (US Vancouver, Columbia, Eureka, Monterey, Conception). In depth, the survey covered depths between 55 and 1280 m (30-700 fathoms).

The numbers of samples collected from the slope trawl surveys are presented in Tables 6 and 7. In the previous assessment the decision was made to treat the AFSC Slope Trawl Survey and the NWFSC Slope Trawl Surveys. This decision was based largely on the fact that the two surveys had different selectivities, at least for sablefish. We overlaid the length compositions from the AFSC survey on those from the NWFSC survey and found what we considered enough difference to justify using the surveys separately. Differences in catchability was also described in Helser et al. (2004), who found that the fishery research vessel, *FRV Miller Freeman*, used in the AFSC Slope Trawl Survey was more efficient at catching sablefish than the West Coast fishing vessels used in the NWFSC Slope Trawl Survey. This could be due to the larger horsepower of the Miller Freeman, the longer tows made (30 minutes versus 15 minutes), or some other unknown factors.

A slight, increasing trend was observed in the percentage of large fish in the size-distribution data (males and females) collected from AFSC slope trawl surveys (1997-2001, Figure 10); however, this trend was variable across the time series and was not considered a strong signal. The strong 1999 year-class observed in several other data sources is apparent as age-1 fish in 2000. Furthermore, a bimodal distribution that year is further evidence of the "missing" year classes of the 1990's.

Length compositions from the NWFSC survey appeared to be a bit more truncated than those from the AFSC survey (Figure 11). Even so, evidence of a strong 1999 year-class was apparent in the mode of first seen in 2000 and again in 2001. These same fish were seen as age 2 in 2001, age-3 in 2002, and age-4 in 2003. Age compositions in 2004 suggest that in fact two strong year classes may be present, the 1999 as well as a 2000. Further evidence of this was present in the 2001 shelf survey, which is discussed below.

Survey Indices. Biomass estimates of sablefish from the two trawl surveys were made separately. Biomass from each survey was estimated using a simple "area swept" and "arithmetic mean" method.

Northwest Fisheries Science Center Shelf Trawl Survey (Survey #8)

While technically not designed or designated as a "shelf survey", tows made from the NWFSC Combined Shelf-Slope Survey between 30 and 100 fathoms were separated out and, for clarity and brevity, will here after be referred to as the NWFSC shelf survey. This survey is similar in concept then to the Alaska Fishery Science Center shelf survey (survey #5) in that it tends to index the younger sablefish. Fish caught tend to range from age 1 to approximately age 6, so age selectivity was modeled with a peak at age 1 and a descending limb there after. Length selectivity however was modeled such that any size fish was fully selected. Evidence of the strong 1999 and 2000 year-classes are evident in the age compositions (Figure 12). Also evident is a relatively strong 2004 year-class that should be entering the fishery in the next few years.

Environmental Data

Sea-Surface Height (survey #4). From 1925 to 1992 data on monthly average coastal sea surface height (SSH) was obtained from the NOAA Center for Operational Oceanographic Products and Services http://tidesandcurrents.noaa.gov/). We used data from Neah Bay and Toke Point, Washington and Astoria and Newport, Oregon and averaged the monthly SSH over April, May, and June to arrive at a coastal SSH between 44° N to 50° N Latitude (Figure 13). From 1993-2006, data from the satellites JASON and TOPEX were used in lieu of the tide-stage data. A polygon was drawn over the area from 44° N to 50° N Latitude to a depth of 1650 meters (Figure 14). Anomalies were calculated using a standard z-score from 1924 to 2006. Hereafter, this vector of SSH anomalies for the second calendar quarter of the year will be referred to as the SSH Index.

Zooplankton Anomalies (Survey #9). Data on annual zooplankton (copepod) anomalies were those reported in Mackus et al. (2006). Total dry weights of northern and southern species of copepods from South Vancouver Island were used as an index to deviations from the stock-recruitment curve (Figure 15). These anomalies are used to characterize the zooplankton species composition of the larval/juvenile sablefish habitat. Although this data was presented to the STAR, it was not used in the final base case.

Indices Not Used

There are two other indices that have been used in previous sablefish assessments with varying degree of acceptance from the respective Stock Assessment Review (STAR) Panels: commercial fisher logbook catch-per-effort and the Alaska Fisheries Science Center pot survey.

Commercial Fisher Logbook Data. Trawl logbook data have been collected by the states of California (CDFG), Oregon (ODFW), and Washington (WDFW) since the 1970s. These records provide a tow-by-tow account of reported retained catches of several groundfish species including sablefish. The 1997 sablefish assessment (Crone et al. 1997) considered the use of a time series of standardized catch per unit effort (CPUE) as a tuning index for the stock synthesis assessment model. This standardized CPUE series was based on general linear model (GLM) analyses described in Brodziak (1997). Crone et al. (1997) discussed some of the advantages and disadvantages of using standardized commercial CPUE as a measure of relative abundance for the sablefish stock. In comparison to the shelf, triennial, and fish pot surveys, the main advantages of the logbook index are larger sample sizes and more synoptic spatial and temporal coverage. In contrast, primary disadvantages include potential biases due to: (1) inaccurate catch or effort reporting; (2) changes in fisher behavior due to changes in market conditions and management regulations; (3) changes in fishing power of trawlers during 1978-97; and (4) existence of a nonlinear relationship between reported CPUE and relative abundance of sablefish. The relative importance of the trade-off between higher precision and potential bias of the commercial trawl logbook index is unknown.

The Commercial trawl logbook index has been presented and used in several of the past sablefish assessments. This index is based on the positive deep-water catch approach to selecting tows for inclusion in GLM analyses (Brodziak 1997; Crone et al. 1997). Using this approach, tows that captured any of the deep-water complex species (Dover sole, thornyheads, and sablefish) are assumed to represent effective fishing effort directed at sablefish in the context of a multi-species fishery (Tyler et al. 1984). Estimated year-effect coefficients from the GLM analyses were used to compute two separate time series of standardized CPUE for the trawl fishery. During 1978-1988, standardized CPUE varied considerably and had a moderate increasing trend. After deep-water complex trip limits were imposed in 1989, standardized CPUE declined during 1989-1991 and then increased from 1992-1994. There was another decline in 1995 followed by a moderate increase in standardized CPUE in 1996. The substantial increase in standardized CPUE in 1997 should be interpreted very cautiously because data from ODFW and CDFG logbook programs were not available in 1997 and because the year coefficient for 1997 has a much larger standard deviation than any other year due to low sample size. While standardized CPUE during 1978-1988 was used to model the time trend in relative sablefish biomass, the time series from 1989-1997 was not used because reported sablefish catch rates were likely biased due to trip limits and discarding practices. Further details concerning this index are available from previous sablefish assessments.

Pot Surveys. Pot surveys were conducted by NMFS in 1979-1981, 1983, 1985, 1987, and 1989 in northern INPFC areas (U.S. Vancouver and Columbia) and in 1984, 1986, 1988, and 1991 in southern INPFC areas (Eureka, Monterey, and Conception). No pot survey data are available after 1991. Catch information (number of fish/pot) and biological data were collected according to grade-specific categories: large fish (>68 cm); medium (62-67 cm); small (52-61 cm); and extra-small (<51 cm). Specific details concerning survey methods are described in Parks and Hughes (1981), Parks and Shaw (1983, 1985, 1987, 1989, 1990), and Kimura and Balsiger (1985).

Because of the lack of strong abundance indices at the time of the earlier assessments, all efforts were made to fully utilize any and all possible sources of abundance information. While these two sources of data where deemed appropriate and necessary to include when they were first derived, the ever increasing abundance of higher quality coast-wide trawl survey data has made it prudent to re-evaluate the usefulness of these two indices. On the positive side, these indices cover a time period for which no other abundance data is available. On the negative side, (1) the two indices give contradictory signals with regard to abundance trends, making for a flat likelihood surface in the assessment model; (2) neither of the indices do a satisfactory job of covering the entire assessment area with respect to either latitude or depth; (3) STAR Panels have been inconsistent with regard to which is included and which is excluded from the assessment. Several hours have been spent debating the same arguments with no clear conclusion. Consequently, because of the increased amount of more recent coast-wide trawl data, and in an effort to remove "noisy" data sets to attempt to clarify population dynamics signals, it was decided to discontinue the use of these two data sets.

History of Modeling Approaches

Francis (1984) utilized straightforward trend analysis to evaluate the status of the sablefish resource in 1984. This consisted of qualitative examinations of catch-per-unit-effort (CPUE) data generated from the pot survey conducted by NMFS from 1979 to 1983. The 1985 assessment utilized more formal quantitative analyses than those used in the 1984 assessment (Francis 1985). The 1985 assessment was based on a general, age-structured simulation model first introduced by Swartzman et al. (1985). Model parameters that were estimated included natural mortality, average weight-at-age, recruitment, and relative age-specific catchability. Relative age-specific catchability coefficients for trawl and fixed gear were estimated for different market categories (see Market Categories below), small fish (<5 lb), medium fish (5-7 lb), and large fish (>7 lb). Ultimately, simulation runs, based on various fixed/trawl gear scenarios, were conducted to examine critically the maximum long-term average surplus production (maximum sustainable yield, or MSY) associated with the stock. Input data incorporated into the model consisted primarily of research survey data, including slope and trawl surveys and pot surveys, and parameter estimates generated from independent research studies.

The 1987 sablefish assessment utilized additional sample information collected from shelf and slope trawl surveys conducted by NMFS, as well as data from the pot surveys (McDevitt 1987). The primary analysis was based on a modified yield-per-recruit procedure (Funk and Bracken 1984) that examined trends in yield and reproductive potential in accordance with a minimum size limit (22 in) that had been in place since 1983.

The sablefish assessment conducted in 1988 (Methot and Hightower 1988) was the first evaluation to incorporate separable catch-at-age analysis (see Model Description (1998) below) and in particular, the first to use the Stock Synthesis Model (Methot 1989, 1990). All subsequent stock assessments have used the Stock

Synthesis Model to evaluate the status of the sablefish population off the U.S. Pacific coast; the model has undergone considerable development since the first program was presented in 1988. The theoretical foundation and parameter estimation techniques utilized in the model are discussed below; see Model Description (1998). The modeling program used in 1988 was based on two types of fisheries (trawl gear and fixed gear) and two years of fishery-related biological data. Auxiliary information included trawl (shelf) and pot survey data, which were used to determine recruitment levels and develop a time series of relative abundance of middle-age sablefish, respectively. Estimates of exploitation rate were based on tag recapture information generated from a tagging study that began in 1971. Age-specific availability (selectivity) to the survey and fishery data was problematic, due largely to the scarcity and high variability of the available age composition information.

In general, the 1989 sablefish stock assessment followed similar modeling protocols as the 1988 assessment (Methot and Hightower 1989). Revisions in the age determination criteria for sablefish caused an increase in the observed proportion of old fish and a decrease in the estimate of natural mortality from 0.15 to 0.09. The modifications made in the 1989 assessment resulted in an increase in the estimate of current biomass, a decrease in the estimates of historical recruitment, and a decrease in the estimate of long-term potential yield.

Two significant changes were made in the 1990 sablefish assessment (Methot and Hightower 1990). First, stock structure assumptions were changed from a previously presumed single-unit stock to a two-stock supposition, a northern population (U.S. Vancouver and Columbia INPFC areas) and a southern population (Eureka, Monterey, and Conception INPFC areas). Information regarding low rates of mixing and differences in growth of sablefish between the two assessment areas supported this assessment revision. Second, greater emphasis was placed on the shelf trawl survey biomass estimates from southern Oregon (northern assessment area), primarily because slope trawl survey information from this general area (1984, 1988, and 1989) allowed a reliable trend to be evaluated and indirectly compared to model results.

In the 1992 sablefish assessment (Methot 1992), a single assessment area (i.e., single population hypothesis) was reinstituted in the modeling process, given that new evidence indicated size-at-age of sablefish was generally similar between the U.S. Vancouver/Columbia area and northern California (Eureka and Monterey INPFC areas). However, the Conception INPFC area was not incorporated in the primary assessment area, primarily due to noticeably smaller size-at-age and delayed maturity of sablefish from those waters. The 1992 assessment was the first evaluation of the sablefish population that utilized slope trawl survey data in an explicit fashion within the model. In previous assessments, slope survey data were used outside of the model itself, primarily to corroborate or refute findings generated from the modeling process. The biomass densities estimated by the slope trawl surveys were extrapolated to the entire assessment area (Monterey through U.S. Vancouver INPFC areas) to provide information that could be compared to model results. Model runs were configured to explore trade-offs in fitting the slope trawl survey biomass and the trend in numbers of medium and large sablefish in the pot survey. Because of the difficulties involved in summarizing biological data collected from the sablefish fishery (see Market Categories below), the assessment model was revised to utilize fishery-related data within market categories. Analysis of depth stratified age- and length-composition data used in the 1992 assessment indicated that the movement of sablefish into deep water was more closely related to their age than size.

The sablefish assessment conducted in 1994 used a similar modeling approach as the previous assessment done in 1992. That is, the model was configured to explore trade-offs in fitting the biomass levels measured in the slope trawl surveys, the trend in numbers of sablefish in the pot surveys, and the trend in recruitments from the shelf trawl surveys (Methot 1994). In this assessment, the pot survey data from the northern survey (U.S. Vancouver and Columbia INPFC areas) and the southern survey (Eureka and Monterey INPFC areas) were combined as pairs of observations so that each estimate of catch-per-unit-effort (number of fish/pot) used in the model reflected annual (two years collapsed into one year) values that were based on coastwide data. Biological data from the pot surveys were not combined because of possible differences of individual year classes. In all previous assessments, the northern and southern pot surveys were treated independently and as different measures of the stock trend, each with its own selectivity characteristics relative to the entire stock. As was the case in the previous assessment (1992), slope trawl survey data were used in the model as absolute measures of biomass; extrapolation techniques were used to derive coastwide estimates. A preliminary model, exploratory migration model, was proposed in this assessment to try to account for the patterns observed in the different survey trends. The hypothesis was that an annual emigration rate of roughly 3% of the total amount of sablefish, beginning at age 4, from the '<500-fm' depth stratum to the '>500-fm' stratum could explain the dramatic decline observed in the pot survey, while also estimating a realistic *Q* (catchability coefficient) for the slope trawl survey. In previous assessments, *Q* values for the slope trawl survey near 2.0 were necessary to fit the trend in the pot survey. Methot (1994) recommended that further critical evaluation be conducted with this exploratory model before adopting management measures based on its results.

The assessment in 1997 (Crone et al. 1997) was conducted in a similar fashion as was done in 1994. Sample data utilized in the model included both fishery (longline, pot, and trawl) and research survey (trawl and pot) information. Estimates of total biomass and catch-per-unit-effort (CPUE) generated from research survey and commercial fisher logbook data were used to develop relative indices of sablefish abundance; this auxiliary information was used for tuning purposes in the model. Trends derived from the majority of the different sources of survey data generally indicated a declining population from the mid-1980s to the present, although most trends did not follow strictly linear declines and no source of information could be supported definitively on a statistical basis. Modeling focused on exploring trade-offs in fitting the survey trends presented above in accordance with biological information from commercial fisheries and research surveys. As expected, no single model configuration was found that fit all indices well, i.e., model runs were based on the simultaneous examination of all the data, which necessarily required accommodating various discrepancies between the survey indices. Various combinations of the survey indices (configurations) resulted in two broad, opposing interpretations of the state of the stock. The two model scenarios were: (1) a baseline configuration that equally emphasized sample information from each survey; and (2) a configuration that de-emphasized trend indices generated from pot surveys and slope trawl surveys. Collectively, these model scenarios provided a qualitative measure of the uncertainty in the overall assessment and in particular, the magnitude of the variability (bias and sampling error) in the survey data. In general, model runs that included population trends derived from pot and slope trawl survey information (model scenario 1) indicated the stock had not responded favorably to exploitation practices, while runs that de-emphasized these survey data (model scenario 2) suggested the stock had experienced relatively slow rates of decline.

The assessment in 1998 (NMFS/STAT 1998) was conducted in a similar fashion as was done in 1997. Once again, much of the focus of the analysis was centered on the inclusion and exclusion of the pot survey index and the commercial logbook CPUE as an index. The size-based version of the Stock Synthesis model was configured to explore trade-offs in fitting the survey trends in accordance with biological information from commercial fisheries and research surveys. As expected from previous assessments, no single model configuration was found that fit all indices well, and various combinations of the survey indices were found to result in differing interpretations of the state of the stock. However, all attempts to include some indices while excluding others were found to be quite subjective. Consequently, a base-run model configuration was adopted in which all available indices of abundance were used simultaneously. As expected, there were considerable uncertainty associated with the stock size (and other) estimates derived from the base-run model.

The 2001 assessment (Schirripa and Methot 2001) focused on evaluating the sensitivity of the model and the outcomes to changes in the survey data. These changes include the combining of the AFSC slope survey data and the NWFSC Industry Co-operative Survey data using a GLM procedure. This analysis made it possible to extend the southern boundary of the assessment south to Point Conception. Also considered was occurrence of ‘water hauls’ in the AFSC shelf survey data. As with previous assessments, the inclusion and exclusion of pot survey and logbook indices of abundance were evaluated. This assessment was the first to introduce the possibility that sablefish recruitment may be linked to environmental factors. A seemingly meaningful relationship was demonstrated between changes in northern and southern copepod abundances and sablefish recruitment. This observation led to conditions and projections that considered two competing “states of nature” to calculate the mean virgin recruitment: a “density-dependent” state that used the average of 1975-1991 recruitments, and a “regime shift” state that used the 1975-2000 recruitments.

The 2002 assessment (Schirripa 2002) served as an update to the last full assessment conducted for sablefish in 2001. This update, by definition, sought to document changes in the estimates of the status of the stock by only considering newly available data for 2001 while not considering any new changes in the model structure or model assumptions. Two relatively strong incoming cohorts, the 1999 and 2000 year-classes, highlighted the 2001 data. The strength of these two year classes was evident not only in the traditional data sources such as the surveys of the continental shelf and slope, but also in the bycatch of the whiting fishery as documented by the Shoreside Whiting Observer Program. These year classes recruited into the population immediately following ten years of below average recruitment and correspond very well with environmental changes that have taken place in the North Pacific Ocean (often referred to as "regime shift"). A significant relationship between recruitment and sea level recorded at Crescent City, California was used to strength the previous theory that environmental factors were indeed critical to the recruitment process. The addition of the 2001 data increased the estimate of absolute spawning stock biomass but had little effect on the estimate of spawning stock biomass relative to virgin. While the estimate of B_{cur}/B_0 remained relatively the same as the previous assessment, the catch that would result from applying the '40:10' rule increased. This increase was due to a decrease in the re-estimated value of the slope survey Q, an estimate that has been associated with it a high degree of uncertainty. How much the catch could increase was dependent upon the level of future recruitment as well as the value of Q for the slope survey.

In 2005 (Schirripa and Colbert 2005) several changes from the last full assessment were introduced. Landings were either taken from written records or reconstructed back to the year 1900, the assumed model start date of the fishery. Inspections of length compositions from the two surveys lead to the conclusion that the surveys had different gear selectivities. Consequently, a separation of the data was maintained and the surveys used individually. Slope survey years of less than full coast coverage were omitted from the data. Sufficient observer data was available in which to estimate discards from all three fisheries. To compliment these discards rates, a release mortality function based on sea surface temperature was developed from which to estimate dead discards by each of the three fisheries. Sea level data was used as a proxy to describe oceanographic conditions that were used to augment estimates of recruitment deviations starting in 1925.

Current Model Description

Overview. Tag-recovery data support the hypothesis of three populations of sablefish through the North American range. Tag recoveries indicate that two of these populations mix off southwest Vancouver Island and northwest Washington, and to a lesser extent off southern Washington and Oregon. In this assessment, we assumed a single sablefish population extends from the Conception INPFC area through the U.S. Vancouver INPFC area. Including the INPFC area of Conception is new to this year's assessment and was made possible by the more geographically extensive survey data.

Information regarding the depth-specific distributional patterns for sablefish was used indirectly in this assessment to corroborate or refute particular hypotheses regarding stock dynamics; however, these patterns were not modeled explicitly. In efforts to interpret mixed signals generated from different sources of survey data, Methot (1994) began preliminary work towards incorporating depth-specific findings from pot surveys into an assessment model. Jacobson and Hunter (1993), Jacobson and Vetter (1995), and Jacobson et al. (1997) have also closely evaluated the bathymetric demography associated with slope species, such as Dover sole, thornyheads, and sablefish

Selectivity parameters used in this assessment are a function of both size and age. Assumptions used to develop size- and age-specific selectivity curves are generally described in Methot (1994). Youngest fish are cast as 100% selected through age 4 for the fisheries, thus we modeled all the selectivity dynamics for young/small sablefish in terms of size alone for these data sources. Small sablefish are not well-selected (or at least retained) by the fishery, thus creating a high observed size-at-age for young fish in the fishery and a low overall selectivity for young sablefish. Older fish tend to diffuse into deep water, where there is low fishing effort until later years. This caused an apparent decrease in selectivity to the fishery with advancing age. This age-specific pattern was extreme for the shelf trawl survey, which only extended to 200 fm. The slope trawl survey extended to 700 fm and thus, has 100% selectivity for older sablefish. There is also a potential for large sablefish to avoid survey and fishery gear, at least to some degree. This possibility was addressed by allowing selectivity to the fisheries and the slope trawl surveys to decline for larger-sized fish.

Some of the fishery selectivity parameters were allowed to change over time to address known changes in the characteristics of the fishery. Changes in market conditions, mesh size, and regulations were expected to change the selectivity of small sablefish to the fishery. These changes could not be calibrated external to the model and thus, the model was allowed to estimate time-varying parameters for the size at 50% selectivity to the fisheries. The movement of the trawl fishery into deep water (Brodziak 1997) was expected to change the apparent selectivity of old fish to the trawl fishery (Jacobson et al. 1997). Similar changes were likely to have occurred for the pot and longline fisheries, but inconsistent availability of logbook data from these fisheries precluded estimating the effect. The parameters that define the level of selectivity for the oldest age were allowed to change over time to track these changes in depth distribution of the fishery. The patterns of selectivity for the trawl fishery were generally similar to results from an independent research study (Jacobson et al. 1997).

The percent agreement between age readers (Kimura and Lyons 1990), commonly referred to as "double-read" analysis, was used to develop an 'ageing' error structure that was incorporated into modeling procedures to provide an estimate of precision associated with estimated age compositions. However, possible biases that may arise due to substantial differences in May 21, 2001 ageing criteria used by different laboratories were not accounted for in this assessment. That is, we have assumed that the assigned ages are unbiased estimates of true ages, but that there was substantial variability in the assigned ages.

Otoliths were analyzed by three different laboratories: Age and Growth Task Unit (NMFS, Alaska Fisheries Science Center) determined ages for specimens collected from all pot surveys (1983, 1986, 1989, and 1991) and the slope trawl survey in 1991; Tiburon Laboratory (NMFS, Southwest Fisheries Science Center) determined ages for specimens collected from the commercial fishery from 1987-90; and the Cooperative Ageing Program (NMFS/NWFSC/FRAM and Pacific States Marine Fisheries Commission) provided age data for fish collected from the commercial fishery from 1991 to 2003 and the slope trawl surveys in 1995 and 2004. In this assessment, we developed an ageing error structure based on percent-agreement distributions from two laboratories (Tiburon and Newport). In general, the percent agreement declines from 54% agreement at age 1, to 39% at age 3, and to below 10% for fish older than 10 years of age. It is important to note that conservative methods were used to estimate percent-agreement distributions, with 'agreement' defined as two estimated ages (i.e., an otolith that was read twice, each time by a different reader) that were exactly the same, rather than within a specified range, e.g., within two years of one another. Synthesis calculates a level of percent correct that corresponds to the level of observed percent agreement by taking into account the probability that two readers will agree on an age, but both be incorrect. As stated above, sablefish are a particularly difficult species to age definitively, which in effect, complicates the use of these data in age-structured modeling techniques. Ageing error was used in the model to 'blur' the expected, actual age composition before comparing the result to the observed age composition. Thus, the model may identify a year class as strong, even though the observed age composition reflected a broad mode. Within the model, ageing error also affects the observed size-at-age and is accounted for in the generation of expected values for mean size-at-age (Methot 1990). A separate study was conducted to determine the sensitivity of the model to assumptions of aging error (see Schirripa and Methot 2001, Appendix 1). Overall, the results of the study indicated that estimates of spawning stock biomass were quite insensitive to assumptions of aging error. Furthermore the study indicated that aging error associated with young fish was more critical than on older fish.

Biological Factors

Natural Mortality. The estimate of natural mortality (*M*) for sablefish has declined since the 1988 assessment, when the Stock Synthesis Model was first used to assess the population. In the 1988 assessment, it was noted that the observed maximum age indicated that *M* was 0.08. However, *M* of 0.15 was used in the assessment, because higher values of *M* provided better model fits to the data. In the 1989 assessment, changes in the model and additional fishery data resulted in a model that had its best fit to the fishery data at a low level of *M* (0.05). No usable age data from surveys were available in 1989. Final results in 1989 were obtained , an *M* of 0.0875, which was midway between two levels (0.075 and 0.100) that provided reasonable fits to some of the survey data. The 1990 assessment also used an *M* of 0.0875, although the maximum age of sablefish continued to suggest a lower value.

The estimate of *M* was reconsidered in the 1992 assessment, because of the availability of more age data from surveys and additional evidence that indicated the oldest fish generally reside in deep water. The maximum ages observed in the 1983, 1986, and 1989 pot surveys and the 1989 slope trawl survey were 51 years for females and 64 years for males.

According to Hoenig (1983), the average relationship between maximum observed age and total mortality is defined as,

$$\ln(Z) = alpha + beta(\ln(t_{max}))$$

where *Z* is the instantaneous rate of total mortality, *alpha* is 1.44 and *beta* is -0.982 (estimated regression coefficients used as constants in the formula), and *tmax* is the maximum age. Thus, the maximum ages indicated that *Z* was roughly 0.09 for females and 0.07 for males. These values for estimated *Z* were considered intermediate between *M* and true *Z*. An *M* of 0.07 has been used since the 1992 assessment.

Additional age data from the recent slope trawl surveys included females that were older than that observed in previous surveys, with a maximum age of 73 years being observed. Maximum ages observed in the commercial fishery data (1987-1997) were 68 years for males and 85 years for females. However, sablefish older than 75 years were very rare in the sample data we evaluated, as well as being uncommon in samples analyzed by other ageing laboratories on the Pacific coast of North America. It is very important to note that age determination of sablefish is extremely difficult and subject to a significant amount of uncertainty, e.g., the 85-yr old female presented above was estimated to be somewhere between 80 and 92 years of age, and possibly older. Utilizing these recent age data resulted in an estimate of *Z* = 0.05 for females (maximum age of 85 years) and *Z* = 0.07 for males (maximum age of 68 years). The long history of sablefish exploitation suggests that the fish may be close to true *Z*. However, the oldest sablefish found in deep water off the U.S. Pacific coast may have experienced little fishing mortality until fairly recently (1990s). An *M* value of 0.07 was used in this assessment, given we: (1) generally support the use of Hoenig's method above based on the maximum lifespan of a typical sablefish rather than the maximum age of a single specimen observed in the sample data; and (2) felt that changes to *M* based on limited information could compromise our ability to interpret model results from assessment to assessment.

Growth. Estimates of the maximum size of sablefish have declined as more size-at-age data have become available. In the 1988 assessment, the growth curve was based on some biased age data from the 1983 and 1985 pot surveys. In that assessment, the estimated mean maximum size was 77.5 cm for females and 64.5 cm for males. Subsequent assessments resulted in a decline in the estimated maximum size as more size-at-age data from the surveys and fisheries were included. Size-at-true-age is modeled as a normal distribution (Parma and Deriso 1990) around the von Bertalanffy growth model,

$$LA = Linf + (L1 - Linf)\ exp(K(1.66 - A))$$

where *LA* is length (cm) at age *A*, *Linf* is estimated in the model as 66.2 cm (females) and 55.8 cm (male), *L1* is 38.4 cm (at age 1.66 in August for both sexes), *K* is 0.246 (females) and 0.298 (males), and standard deviation of estimated length-at-age 1 is 1.93 (at age 1 in January for both sexes) and standard deviation of length-at-age 25 is 8.16 (females) and 5.74 (males). Actual values for *L* are based on estimation of size-at-age 25 as a model parameter.

There is a prevalence of very large fish in the size compositions observed in the pilot year of the pot survey (1971) and in early years of the longline fishery. In the 1997 assessment, a different *Linf* value was estimated for 1971-1972 in order to track this observation. This value was estimated to be 4.0 cm greater than *Linf* for later years. In the current assessment, this offset is not used. Instead the selectivity for the longline fishery is configured to more easily track this targeting on very large sablefish.

Because the exact position of the size mode for the age-1.5 sablefish greatly affected the model fit to the shelf trawl survey size composition, the model was allowed to estimate an offset to the *L1* parameter for several years that exhibited a high abundance of recruitment. These offsets were 0.16 cm in 1980, -0.96 in 1983, -0.44 in 1986, 2.06 in 1989, 1.06 in 1991, and 0.41 in 1995. Each cohort in the model followed its own growth trajectory, so these offsets at age 1 slightly affected the size-at-age for the identified cohort throughout its lifetime.

Length-weight Relationship. The length-weight relationship used in this assessment was based on data collected in the pot surveys. There is no apparent difference in the relationship between sexes (Phillips and Inamura 1954; Klein 1986; Fujiwara and Hankin 1988a). In this assessment, the following power function was used to estimate the relationship between length and weight,

$$W = alpha * (L) \wedge beta$$

where *W* is weight (kg), *alpha* is 0.0000024419 and *beta* is 3.3469 (estimated regression coefficients used as constants in the formula), and *L* is length (cm).

Maturity. Logistic response functions have been found to be appropriate and effective statistical tools to describe the proportion of sexually mature fish in a population (Hunter et al. 1990). The length of sablefish at 50% maturity was estimated by McDevitt (1987), from data presented in Phillips and Inamura (1954), to be approximately 67 cm. Mason et al. (1983) estimated the size at 50% maturity to be 58.3 cm; these fish were collected off Vancouver Island in 1980. Parks and Shaw (1983) estimated the value to be 56.3 cm for fish collected off California. In this assessment, we used a value of 55.3 cm for size at 50% maturity, which was estimated from female sablefish collected off Oregon and Washington in 1985 (Parks and Shaw 1987). In this assessment, the following logistic function was used to estimate the relationship between maturity and size,

$$M\% = 1 / (1 + exp(-beta(L - L50\%)))$$

where *M%* is percent mature, *beta* is 0.2491(estimated regression coefficient used as a constant in the formula), *L* is length (cm), and *L*50% is 55.3 cm (length at 50% maturity).

Recruitment and Survival. A Beverton-Holt stock-recruitment formulation was used to evaluate the degree to which density-dependent factors influence population size and to provide an attractor level for recruitments that were not well defined by the age and size composition data. The model was allowed to estimate the level of virgin recruitment in order to establish the magnitude of the initial population in the first model year.

Recruitment deviations were estimated either from 1971-2005, or from 1925 to 2006, depending on whether the long-term SSH data was used. The variance of the stock-recruit function (sigma-R) was estimated through iteration and matching the assumed variance to the resulting residual mean square error. The final sigma-R used was 0.60.

The three environmental variables, SSH, northern zooplankton, and southern zooplankton anomalies were considered as covariates for recruitment deviations from the fitted stock-recruit relation. The method employed in this assessment treats the natural log of the z-score of the environmental data in the same manner as all other survey data and is used as a tuning index for recruit deviations from the stock-recruitment function. The link between zooplankton and sablefish survival was first reported by McFarlane and Beamish (1992). To determine if these indices could be used to track changes in sablefish survival each was regressed against the recruitment deviations from the model that included none of the indices (Figure 16). While all three indices had highly significant ($p<0.05$) relations to recruitment deviations, the most variation was explained by the SSH time series ($p<0.0001$, $R^2 = 0.403$).

In late spring and early summer young-of-year sablefish have matured out of the larval stage, are free swimming and free feeding. At this stage they are searching for zooplankton and other food while moving onshore to nursery grounds. Low sea level and low values of the North Pacific Index suggest higher than expected recruitment. The tide gauge sea level data we use are not adjusted for barometric pressure, so they integrate both the atmospheric effects and the large-scale ocean conditions. That is, they integrate both the large-scale northeastern Pacific Ocean conditions with local upwelling and pressure. Sea level is also a good predictor of near-bottom ocean temperature along the shelf. Lower sea level is associated with colder than average water, more upwelling, stronger southward currents and lower salinity. All these factors provide better habitat conditions for young sablefish, as they inhabit the shelf at this time of year.

Most Recent Findings. A principal component analysis was conducted to determine if all three indices could be combined into index. The results of this analysis showed that 85% of the variance of the three variables could be explained by the first principal component (Figure 17). No further results from this work are available at this time.

This timing of the spring transition may be as critical as the SSH level itself. That is, the contribution of the April SSH may have more of an influence on sablefish survival than the contributions from May and/or June. To investigate this possibility, a stepwise multiple regression was conducted on the following model:

$$Recruit\ Deviation = \alpha + (April.SSHx_1) + (May.SSHx_2) + (June.SSHx_3)$$

Unlike the model that calculates the arithmetic mean of all three months, the above model allows each month to be weighted separately. The stepwise regression resulted in the June.SSH data being dropped and the April.SSH and May.SSH data being correlated at the relatively low value of –0.3862. Consequently, it is felt that the revision of the SSH index is justified as follows:

$$Recruit\ Deviation = 8.7799 + (April.SSH * -3.2599) + (May.SSH * -3.4086)$$

The revised model explained 43.96% of the variation in the recruitment deviations using only the April ($F = 18.16$, $p = 0.0001$) and May ($F = 6.15$, $p = 0.0189$) data. Any future analysis or forecasting beyond this document will strongly consider the revised SSH index.

Likelihood Components. The base-run model consisted of the following likelihood components: (1) hook-and-line fishery age distribution; (2) hook-and-line fishery size distribution; (3) hook-and-line fishery size-at-age; (4) hook-and-line discards; (5) pot fishery age distribution; (6) pot fishery size distribution; (7) pot fishery size-at-age; (8) pot fishery discards; (9) trawl fishery age distribution; (10) trawl fishery size distribution; (11) trawl fishery size-at-age; (12) trawl fishery discard; (13) SSH data; (14) shelf trawl survey size distribution; (15) shelf trawl survey age distribution; (16) shelf trawl survey biomass abundance index; (17) AFSC slope trawl survey size distribution; (18) AFSC slope trawl survey age distribution; (19) AFSC slope trawl survey size-at-age; (20) AFSC slope trawl survey biomass index; (21) NWFSC slope trawl survey size distribution; (22) NWFSC slope trawl survey age distribution; (23) NWFSC slope trawl survey size-at-age; (24) NWFSC slope trawl survey biomass index; (25) NWFSC shelf trawl survey size distribution; (26) NWFSC shelf trawl survey age distribution; (27) NWFSC shelf trawl survey size-at-age; (28) NWSC shelf trawl survey biomass index; (29) zooplankton anomalies;(30) stock-recruit relationship (annual recruitment deviations); (31) parameter priors; and (32) forecast recruitment. Likelihood estimates for the various data components were derived by comparing expected values from the model with the actual observations from the sample data based on maximum likelihood procedures in terms of negative log likelihood (i.e. -log(L)). Emphasis levels (lambdas) were set to 1.0 for each of the likelihood components above, except for size-at-age, which were de-emphasized to 0.1, primarily to minimize possible estimation biases associated with violating assumptions of statistical independence in situations when the same sample data are used to derive estimated likelihoods for more than one component in the model, and discards, data most of which were assumed values.

Model Parameters. The base-run model included definitions for 239 parameters. Only 129 of these were estimated within the model. The other parameters that were not estimated typically defined either: (1) factors held constant, such as natural mortality, or (2) elements of selectivity patterns that were fixed. The parameter file used in the base-run model is presented as Appendix 1.

Convergence Criterion. The iterative process for determining numerical solutions in the model was continued until the difference between successive likelihood estimates was minimized according to AD-Model Builder criteria. Fidelity of model convergence was briefly explored in a set of 10 model runs in which parameter values were randomly changed from the converged values.

Model Selection and Evaluation

A total of five model configurations were presented to the STAR Panel for consideration:

Configuration 0 – Bridge Model. To provide a link to the 2005 assessment, a model run was made with the new data and the new model but in the 2005 base-run model configuration. The indices used in this configuration were shelf survey biomass, north pot survey for med-large fish, south pot survey for med-large fish, logbook information from 1977-1988, and the AFSC slope survey, and the NWFSC slope survey (all indices with their associated length and age compositions). It was felt that this would be a useful tool for evaluating the impact of some of the changes made in the 2007 assessment driven only by the new data.

Configuration 1 – NoENV Model. This model configuration makes no attempt to explicitly model any environmental effect on sablefish recruitment. Furthermore, it does not include the use of either the logbook or the pot survey index. It does include (as do all subsequent configurations) the use of the AFSC shelf survey, the AFSC slope survey, the NWFSC slope survey, and the NWFSC shelf survey.

Configuration 2 – SSH Model. This model configuration assumes that there is an environmental effect on sablefish recruitment deviations and that it can be explicitly modeled using the SSH index (average monthly SSH for April, May, and June) for year in which there are "observed" recruitment deviations, 1972-2006.

Configuration 3 – Zooplankton Model. This model configuration assumes that there is an environmental effect on sablefish recruitment deviations and that it can be explicitly modeled using the zooplankton index for year in which there are overlapping data and "observed" recruitment deviations, 1979-2005.

Configuration 4 – Both.Env.Short Model. This model configuration assumes that there is an environmental effect on sablefish recruitment deviations and that it can be explicitly modeled using the SSH index *and* the zooplankton index as two separate indices within the SS2 model. As such, a certain amount of co-linearity between the two indices is assumed.

Configuration 5 – MultReg.SSH Model. This model configuration assumes that there is an environmental effect on sablefish recruitment deviations and that it can be explicitly modeled using the predicted values from a multiple regression of SSH index

$$Rec.Dev = intercept + (April*x_1) + (May*x_2)$$

for year in which there are "observed" recruitment deviation. As such, the effects of the monthly averages are assumed to be additive.

Selection of Base-Run Model I: Pre-STAR Panel Meeting

Model configuration #0, the "bridge model" between the 2005 and current assessment, produced results that were essentially identical to those presented in the 2005 assessment. However, it was not chosen as the base-run because of the issues associated with the manner in which the stock-recruitment function was constructed. In this model the deviations in survival caused by the environmental effects were modeled as variation *within* the variation accounted for in sigma-r. Consequently, including as environmental effect meant that the sigma-r had to be reduced to reflect the remaining variation not accounted for by the environmental effects. However, reducing sigma-r in this manner has the undesirable consequence of reducing the bias correction on B-zero as well. Simulation work confirmed that indeed B-zero will be under-estimated using this approach.

Model configuration #1 was used most to produce a set of recruitment deviations that could subsequently be regressed against the environmental covariates to explore the various fits (Figures 16 and 17). Given the high degree of variability explained by the various environmental factors, the model was seen as inferior to those that included the environmental data.

Model configuration #2 and #3 were set-up as competing data (as opposed to competing models) to determine which environmental index, the SSH index of the zooplankton anomalies, fit the remaining data within the model best. All factors within configurations #2 and #3 are exactly the same, except that #2 uses the SSH index and #3 uses the northern zooplankton anomalies. A comparison of the negative log-likelihood showed that model #3 (-Ln(L) = 3092 units) fit the rest of the data significantly better than model #2 (-Ln(L) = 3126 units). However, as Table 8 shows, this difference is made up entirely of the fit to the index itself.

Model configuration #4, which uses both the SSH index as well as the zooplankton data, was chosen as the STAT's pre-STAR base-run model. Because sablefish survival is a complex system that involves both physical oceanography as well as biological factors, it was felt that using both sources of environmental data was the best way to unify these two different aspects.

Model configuration #5 was also a very strong candidate for the base run model. A stepwise regression analysis revealed that the model

$$y = intercept + (April.SSH*x_1) + (May.SSH*x_2)$$

was in fact superior to the simple {average of April, May, and June} model used in configuration #2 (Overall Model F = 12.16, $R^2 = 0.4396$, $p = 0.0001$; *April.SSH* p = 0.0057, *May.SSH* p = 0.0188) . The correlation coefficient between the two variables was low (-0.3862), These results indicate that each month should be modeled individually and that something particular to April is accounting for the majority of the variance. My working theory at this time of this is that the timing of the spring transition may be one of the critical elements better described by the multiple regression model. The next step in this direction will be to include the date of the spring transition as a covariate in the step analysis. The model

$$y = intercept + (April.SSH*x_1) + (Northern.Zoo*x_2)$$

also had very high explanatory power (Overall Model F = 12.7, $R^2 = 0.5358$, $p = 0.0002$; *April.SSH* p = 0.0015, *Northern.Zoo* p = 0.0247). However, the model also showed that *April.SSH* and *Northern.Zoo* were not highly correlated (correlation coefficient = 0.2665). This suggests that the theory that a SSH index is merely a proxy for larval sablefish food is not accurate. Furthermore, given the lack of hard evidence for a direct link between larval survival and the zooplankton anomalies, it is felt that with this model has an increased probability of being spurious and over parameterized.

The overall conclusion is that more work needs to be done to directly link between the SSH index, the zooplankton anomalies, and sablefish larval survival can be drawn; and to add more biological credibility to the forecasts this work should be done. The manner in which these two data sources are used in configuration #4 is consistent with this conclusion. However, it is felt that the multiple regression model using April and May SSH (configuration #5) is no less a viable option for a current and future base model. Furthermore, there are practical trade-offs to consider. While the zooplankton data provides a starting point for a much needed biological mechanism, the data comes at a cost of ship time and many person-hours of work. On the other hand, the SSH data series is available in near real-time form via satellites and is a more complete time series. This makes forecasts of upcoming year-class strengths possible by the beginning of June of the very same year, rather than one full year later as is the case with the zooplankton data.

Selection of Base-Run Model II: Post-STAR Panel Meeting

As a result of the STAR Panel review, several changes were made to the base model as presented by the STAT. The final base model was a modification of the original STAT base model (configuration 4). The changes made were:

• Discard rates from Pikitch et al. 1988 and the EDCP data base were used and values interpolated as necessary. This change made virtually no difference in the model outcome.

• Discard rates from 2005 (made available during the meeting) were used in 2005 and later years (previously, 2004 rates were assumed to apply from 2005 onwards). This change made virtually no difference in the model outcome.

• The biomass time series for NWFSC slope survey was replaced by the “north of Point Conception” time series. This change was based on a cursory examination of catch rates north and south of Point Conception (but still within the Conception area proper). This change had a potentially significant impact on the model outcome.

• The zooplankton time series was excluded. The reason behind this change was not made clear. This change had no perceivable difference in the model outcome.

• The standard deviation for annual deviations on fishing selectivities was reduced from 1.0 to 0.35. This change was based on the original selectivity values varying “too much”. This change had a seemingly negligible effect on the model outcome.

• The NWFSC slope survey q was fixed at 0.56. This change was based on the belief that the original value of q being fixed at 1.0 was not reasonable. This change had a potentially significant effect on the model outcome.

• An alternative means of iterative re-weighting was applied to the age- and length-frequency data sets, after which the emphasis levels on the commercial fishery age and length frequencies were set to 0.1 (rather than 1.0).

Selectivity Fits

The fit of the various fishery and survey age and length based selectivities are shown in Figure 17 and 18. Overall, the STAT feels the lower standard deviation on the selectivity parameters as suggested by the STAR makes the age selectivities too constant from year to year and does not allow for the changes in selectivity that are believed to have occurred. The outlying fits are for those years where no data were available.

Model Diagnostics (Fits to indices and age/length compositions)

Observed and expected values of biomass for the various indices considered for model configuration number four are shown in Figure 19. A CV of 0.30 was assumed for both the SSH index and the zooplankton anomalies. As of yet, there has not been a satisfactory way in which to arrive at a more objective calculation of the uncertainty. Given the length of the two environmental time series and the fact that they index recruitment, these two indices probably contribute relatively more to the overall population trend than do the other indices.

Observed and expected length/age compositions are shown in Figures 20-40. The previous scaling issue with the NWFSC slope survey observed and expected biomass that was evident in the pre-STAR meeting model was resolved during the STAR Panel meeting by down-weighting of the fishery length- and age-composition data. Down-weighting that commercial age data was especially effect in this regard. Based on the large number of nuances associated with the commercial sampling data both the STAT and the STAR felt that this option was the best available at the time. However, it was recognized that the standard deviation on the selectivity deviations was already reduced from 1.0 to 0.30, which could have contributed to the overall problem deemed the "over the top" problem in the STAR Panel report. Fits to all other indices remained essentially the same.

Profile Analysis

The two parameters deemed most important in assessing the status of the sablefish stock were the steepness (*h*) of the stock-recruitment relation and the catchability coefficient (*Q*) of the slope survey. Steepness is an index of the productivity of the stock while survey catchability dictates the absolute magnitude of the stock size. To investigate Q, a profile analysis was conducted (Figure 41). The resulting response surface indicates that the data fit best at small values of *Q*. Indeed, when the model was allowed to estimate the value it was estimated at *Q* = 0.36. At this value however, the resulting ending year Spawning stock biomass was roughly 2 times the amount that was estimated in most previous assessments. Little credibility could be given to such a low value of *Q*, so *Q* was fixed at the prior estimated value of 0.56. .

A profile analysis was also conducted on the stock-recruitment steepness parameter (Figure 41). All previous assessments of sablefish were burdened by a steepness bounded at h = 0.20. This is the first assessment where steepness could be estimated rather than fixed at a presumed value. The base-run has an estimated steepness of 0.48 which, biologically speaking, is a highly credible estimate.

Population Trends

The sablefish stock of the West Coast has seemingly trended downward since the fishery began (Figure 42). However, this conclusion is highly dependent on the estimated catchability coefficient of the slope trawl surveys. Regardless, the contribution to the SSB from the 1999 and 2000 year-classes is made evident at the very end of the time series by the noticeable up-tick in the trend (Table 9). The estimated time series of total stock and spawning stock biomass are shown in Figure 42. The uptrend seen in the last five years is due to the strong 1999 and 2000 year-classes growing into the population as 5 and 6 year old fish. The estimated time series of exploitation and spawning stock depletion are shown in Figure 43. The ending depletion estimate is 38.3% which keeps the sablefish in the precautionary management zone. It should be noted that the recent uptrend, because it is dependent on the two afore mentioned year-classes, does not continue into the forecasts.

Stock-Recruitment

The estimated time series of recruitment (with 95% confidence intervals) and estimated stock-recruitment function are shown in Figure 44. Overall, the estimated function and fit is a vast improvement over past assessments as steepness is estimated at 0.43 rather than bounded at the minimum of 0.20. However, it does rely on a relatively short time series of data and as such may not capture the true nature of a species that persists in an environment that is known to under go decadal scale changes.

Sensitivity Analysis

Population trends pre- and post-STAR Panel, either absolute or relative, were very similar. The pre-STAR Panel model utilized the entire survey area and assumed a survey q = 1.0, while the post-STAR Panel model used biomass estimates only down to point conception but assumed a q = 0.54. The trend in spawning stock biomass for the base model with and without the environmental data is shown in Figure 45. Each of these two figures also show the three states of nature assumed for the decision table. The trend in recruitment is shown in Figure 46, and the trend in depletion is shown in Figure 47. For reference, trends in sablefish biomass from previous assessments conducted in 1992-2007 are shown in Figure 48.

DISCUSSION

At the time of this writing it is felt that the sablefish fishery is being supported to a large extent by the 1999 and 2000 year-classes that started entering the fishery around 2004. These fish are abundant and still relatively close to shore. While these year-classes are capable of supporting the fishery for the next few years, this stock structure is not the optimal circumstance for a long-lived species such as sablefish. Entering into their most highly reproductive years are some of the weaker year-classes observed in the early-to-late 1990's. The reproductive success of these year classes will help dictate the status the stock in next 5-10 years. The results of this assessment seem to indicate that the status of sablefish stock is hovering around target biomass, yet may require a few more years of spawning stock replenishment before it has reached its sustainable yield capacity. Also evident, however, is that management of the spawning stock biomass must take into consideration future climate change. The management community may well find that it is sitting in the driver seat on some issues, but the passenger seat on others.

There is little doubt at this point that sablefish larval survival is modulated, at least in part, by climate and the manner in which climate affects the annual strength of the California Current System. This was made evident as recent as 2005, which proved to be a remarkable year off the West Coast (Kosro 2006). In spring and early summer of 2005, the northern California Current System was anomalously warm, in part because the normal spring transition to wind-driven upwelling was delayed by 2-3 months. This delay in upwelling worked its way up the food chain and resulted in the zooplankton community off the West Coast being dominated by small, southern species of copepods, which are of relatively poor nutritional value. It is this chain of events that presumably led to, among other things, the poor sablefish recruitment in 2005. While one year does not go far to support a theory such as this, the significant regressions on recruitment deviations and zooplankton anomalies are quite convincing in this regard: as goes the climate, so goes sablefish recruitment. Furthermore, Figure 48 shows that SSH was well above average for the month of April, an early indication that 2005 survival would be low. The 2006 SSH data suggests conditions that were similar to those in 2005 (Figure 48). April SSH was well above average but eventually decreased to below average levels in May and June indicating that the spring transition was late in 2006. As a result, the 2006 year-class may in fact be below average in strength. Confirmation of this should be revealed by the 2007 shelf survey data. At the time of this writing the sea level index can be updated to May 2007 (Figure 49). The sea level index for 2007 is below average for April and May and the Spring Transition is presumed to have occurred early in the year, both of which would indicate a relatively strong 2007 year-class of sablefish. To make use of these results in a 2007 projection, an estimate of average sea level for June is needed as well. The June data point should be available within the month of July and could provide the data necessary to forecast the strength of the 2007 year-class within the existing model framework.

After all the STAR Panel recommendations were applied, it was noted that the original base model gave very similar results to the revised base model. This is very likely due to the original model using the entire survey area and a q = 1 assumption, while the revised model used only the 'north of Point Conception" area but a q = 0.54 assumption. The biggest concern was the lack of fit of the NWFSC Slope Trawl Survey biomass time series. This was remedied by down weighting the fishery length and (especially) age composition data. This result is consistent with the problems noted in the commercial catch sampling.

RECOMMENDATIONS

As indicated earlier, the most critical need is to determine the current level of absolute population abundance of sablefish. Quantitative assessment of the sablefish resource is hindered by a lack of consistent, long-term fishery-independent (e.g., research surveys) and fishery dependent (e.g., commercial fishery samples) data. Significant improvements in the assessments will require concerted efforts by all parties involved in marine fisheries on the U.S. Pacific coast, including commercial fishers, fish processors, fishery scientists, and fishery managers.

1. While the significant relation between the SSH index and sablefish age-0 survival demonstrates that this should be a reliable (at least near term) index, the zooplankton index may support the underlying biological mechanism as to exactly WHY this relationship is being observed. Investigations into the food habits of age-0 fish, especially during the spring months, could help with this understanding. Also, further research should be conducted to evaluate alternative methods for incorporating ecosystem metrics into the assessment. For example, should the two current indices be combined into one index by way of a principal component analysis or should the current (or similar) multivariate method be used. The simulation work conducted for the recent B-zero Workshop should be continued and should address issues of this nature.

2. Abundance surveys: The "combination" survey presently conducted by the NWFSC should be continued on an annual basis. It is critical that survey procedures, including number and types of vessels used, remain constant year-to-year to minimize variation. Fixed-gear surveys (such as pots and/or longline gear) could be used in studies that target non-trawlable habitat to test the assumption that sablefish densities are similar in and out of standard trawl survey areas. The usefulness of ichthyoplankton surveys as indices of spawning stock biomass should also be evaluated.

3. Gear catchability evaluations: Lack of information regarding the catchability (*Q*) of the slope trawl survey gear precludes straightforward interpretation of available fishery-independent data. Survey experiments are needed to: (1) better understand the dynamics of this survey gear; (2) substantiate or refute hypothesized values of *Q*; and ultimately, (3) develop scientific-based indices of population abundance that lead to reduced overall uncertainty in the assessment results. It is important to note that this research area is also applicable to other survey efforts, including the shelf trawl survey and potential fixed-gear surveys, see (1) above. Experience in areas where surveys have been consistently conducted over several years indicates that survey catchability can vary by "30%, or more, from year to year, which confounds determination of the actual catchability coefficient of a specific survey.

4. Expanded at-sea observer program data collection: Objective determination of the total harvest of sablefish, including discard-related catch, has been hindered in the past by the lack of information regarding discard rates for this fishery. Although the estimation of discard amounts is now routine, the usefulness and interpretation of these data would be enhanced by expanded sampling of fish lengths, weights, and time

sablefish remain on deck before being discarded.

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Table 1. Management regulations (1,000s of mt) and landed catch (1,000s of mt) for the sablefish fishery off the U.S. Pacific coast (1982-97). Table includes specifications for optimum yields (OY), acceptable biological catches (ABC), and harvest guidelines (HG).[a]

Year	OY	ABC	HG	Landed
1982	17.4	13.4	Na	18.6
1983_{b}	17.4	13.4	Na	14.7
1984_{b}	17.4	13.4	Na	14.1
1985_{b}	13.6	12.3	Na	14.3
1986	13.6	10.6	Na	13.3
1987	12	12	Na	12.8
1988	9.2 – 10.8	10	Na	10.9
1989_{c}	10.4 – 11.0	9	Na	10.5
1990_{c}	8.9	8.9	Na	9.2
1991_{c}	Na	8.9	8.9	9.5
1992_{c}	Na	8.9	8.9	9.4
$1993_{c,d}$	Na	5.0 – 7.0	7	8.1
$1994_{c,d}$	Na	7	7	7.6
$1995_{c,e}$	7.8	9.1	7.8	7.9
$1996_{c,e}$	7.8	9.1	7.8	8.3
$1997_{c,e}$	7.8	9.1	7.8	8
$1998_{c,e}$	5.2	5.2	5.2	4.4
$1998_{c,e}$	7.9	9.7	7.8	6.7
$2000_{c,e}$	7.9	9.7	7.8	6.2
2001	7	7.9		5.6
2002	4.6	5		3.8
2003	6.8	8.5		5.4
2004	7.8	8.5		5.7
2005	7.8	8.4		6.2
2006	7.6	8.2		5.9
2007	4.6	6.2		-
2008	5.9	6		-

[a] The abbreviation ‘na’ is not applicable, i.e., no specifications were in effect for that particular year.
[b] The ABCs for these years include a specific allocation of 2,500 mt for the Monterey INPFC area.
[c] Specifications for Washington Indian tribes are as follows:
1989: 22 mt (included in OY)
1990-94: 300 mt (included in HGs)
1995-97: 780 mt (included in HGs)
[d] Specifications for these years were for all INPFC areas except Conception INPFC area, which was allocated an ABC of 425 mt, with no HG.
[e] The ABCs for these years are based on 8,700 mt allocated to the U.S. Vancouver, Columbia, Eureka, and Monterey INPFC areas, and 425 mt allocated to the Conception INPFC area, with no HG. The ABC includes 900 mt of estimated discard, which along with the 425 mt allocated to the Conception area, were subtracted from 9,100 mt to determine the HG (7,800 mt).

Table 2. Sablefish catch (mt) by INPFC area, gear, and year harvested off the U.S. Pacific coast (1935-2000)

	INPFC area [a]																				
	Vancouver-Columbia				Eureka-Monterey				Conception				Unknown				Combined				
Year	HKL	POT	TWL	MISC	HKL	POT	TWL	MISC	HKL	POT	TWL	MISC	HKL	POT	TWL	MISC	HKL	POT	TWL	MISC	TOTAL
1935-52	1047	0	313	0	0	0	0	0	0	0	0	0	0	0	0	0	1047	0	313	0	1360
1956	748	0	1578	0	383	0	884	0	0	0	19	0	0	0	0	0	1131	0	2481	0	3612
1957	1629	0	347	0	423	0	557	0	0	0	10	0	0	0	0	0	2051	0	914	0	2965
1958	712	0	313	0	144	0	634	0	0	0	1	0	0	0	0	0	855	0	948	0	1803
1959	1291	0	507	0	108	0	760	0	0	0	6	0	0	0	0	0	1399	0	1273	0	2672
1960	1851	0	545	0	130	0	954	0	0	0	11	0	0	0	0	0	1980	0	1510	0	3491
1961	997	0	335	0	145	0	942	0	0	0	119	0	0	0	0	0	1142	0	1396	0	2538
1962	954	0	1028	0	156	0	818	0	0	0	101	0	0	0	0	0	1110	0	1947	0	3057
1963	873	0	308	0	67	0	726	0	0	0	167	0	0	0	0	0	940	0	1201	0	2141
1964	959	0	197	0	469	0	738	0	0	0	198	0	0	0	0	0	1428	0	1133	0	2562
1965	632	0	168	0	530	0	1058	0	0	0	147	0	0	0	0	0	1162	0	1373	0	2534
1966	282	0	185	0	717	0	367	0	0	0	139	0	0	0	0	0	999	0	691	0	1691
1967	1611	0	158	0	1963	0	715	0	0	0	60	0	0	0	0	0	3574	0	933	0	4508
1968	972	0	170	0	947	0	831	0	32	0	15	0	0	0	0	0	1951	0	1016	0	2967
1969	3033	0	191	0	1157	0	1288	0	0	0	26	0	0	0	0	0	4200	0	1505	0	5705
1970	1397	114	1099	0	0	0	1312	0	7	0	11	0	0	0	0	0	1404	114	2422	0	3940
1971	914	120	1096	0	598	73	1355	0	0	0	80	0	0	0	0	0	1512	193	2531	0	4236
1972	2137	1	1124	0	1360	353	2309	0	3	3	29	0	0	0	0	0	3500	357	3462	0	7319
1973	876	413	526	0	246	440	3260	0	4	25	14	0	0	0	0	0	1126	878	3800	0	5805
1974	2266	389	462	0	176	2854	2563	0	2	1	22	0	0	0	0	0	2444	3244	3047	0	8735
1975	1737	5280	464	0	0	416	2849	0	0	0	79	0	0	0	0	0	1737	5696	3392	0	10825
1976	1149	7803	609	0	76	9165	2845	0	0	2772	100	0	0	0	0	0	1225	19740	3554	0	24518
1977	1445	552	1164	0	0	2518	2450	0	0	1070	51	0	0	0	0	0	1445	4140	3665	0	9250
1978	1641	591	1752	0	75	2720	4182	0	6	2599	52	0	0	0	0	0	1722	5910	5986	0	13617
1979	3596	4299	2582	0	641	3302	4889	0	1	4971	92	0	0	0	0	0	4238	12572	7563	0	24373
1980	1097	2381	1546	0	298	595	2346	0	45	801	37	0	0	0	0	0	1440	3777	3929	0	9146

Table 2 (cont). Sablefish catch (mt) by INPFC area, gear, and year harvested off the U.S. Pacific coast (1935-2000)

INPFC area [a]

	Vancouver-Columbia				Eureka-Monterey				Conception				Unknown				Combined				
Year	HKL	POT	TWL	MISC	HKL	POT	TWL	MISC	HKL	POT	TWL	MISC	HKL	POT	TWL	MISC	HKL	POT	TWL	MISC	TOTAL
1981	1185	1548	1916	54	761	1850	3680	17	0	502	46	0	1	0	0	0	1947	3900	5642	71	11560
1982	1028	2886	4668	141	708	2722	5563	4	0	904	35	0	0	0	0	0	1736	6512	10266	145	18659
1983	754	2207	3805	192	379	1623	3472	344	0	1839	84	0	0	0	0	0	1133	5669	7361	536	14699
1984	972	2440	4642	375	67	456	3456	601	0	929	139	0	0	0	0	0	1039	3825	8237	976	14077
1985	2292	2365	3322	296	518	1485	3542	45	0	44	423	2	0	0	0	0	2810	3894	7287	343	14334
1986	2736	1447	2491	0	895	748	3676	740	3	43	302	209	0	0	0	0	3634	2238	6469	949	13290
1987	2893	996	3199	0	883	531	3012	47	13	21	347	6	0	36	4	0	3789	1584	6562	53	11988
1988	2759	1375	2672	0	405	733	2545	69	13	14	307	12	0	0	1	0	3177	2122	5525	81	10905
1989	2090	715	2725	0	357	971	2563	119	78	0	412	8	0	0	0	0	2525	1686	5700	127	10038
1990	1553	698	2438	0	558	647	2376	79	93	139	380	7	0	8	2	2	2204	1492	5196	88	8980
1991	2434	638	2500	0	883	326	2281	34	115	100	199	3	1	0	0	0	3433	1064	4980	37	9514
1992	1997	363	2649	0	989	249	2504	26	93	187	301	6	1	0	3	0	3079	798	5457	31	9366
1993	1743	613	2729	0	499	180	1965	10	85	55	266	2	1	0	0	0	2328	847	4959	12	8147
1994	1498	1048	2075	0	761	309	1582	11	115	13	161	1	0	0	4	0	2375	1370	3822	12	7579
1995	1982	749	1872	0	882	315	1761	12	115	2	213	2	0	0	2	0	2978	1065	3848	14	7905
1996	1920	522	2121	0	1309	227	1876	2	125	1	214	0	0	0	0	0	3354	750	4211	3	8318
1997	2105	356	1872	0	1372	227	1743	3	107	1	154	0	0	0	3	0	3585	584	3771	3	7943
1998	1190	384	1097	2	468	63	978	4	99	0	115	0	0	0	1	0	1757	448	2191	6	4401
1999	1909	628	1726	0	712	125	1365	1	96	2	83	0	0	0	1	0	2717	755	3175	1	6649
2000	1944	661	1449	0	683	190	1148	1	83	1	37	0	0	0	93	0	2711	852	2727	2	6291
2001	1634	508	1639	0	612	163	945	1	111	1	29	0	0	0	11	0	2357	672	2624	1	5655
2002	1173	307	830	0	444	154	715	2	128	11	50	1	0	0	3	0	1745	472	1597	3	3817
2003	1568	569	1226	0	609	219	1001	1	127	12	79	1	0	0	24	0	2304	799	2331	2	5435
2004	1933	527	1415	0	504	269	789	3	87	16	80	0	0	0	162	0	2524	811	2447	3	5785
2005	1995	649	1081	436	730	336	815	22	78	12	55	0	0	0	4	0	2803	996	1955	458	6212
2006	1657	678	1293	320	611	272	834	32	66	87	9	1	0	0	1	0	2334	1037	2137	353	5861

[a] INPFC areas are as follows: Van-Col is U.S. Vancouver-Columbia; Eur-Mon is Eureka-Monterey; Con is Conception; All is all INPFC areas. Gears are as follows: Hkl is hook-and-line (includes trolls); Twl is trawls (includes shrimp trawls); and Misc is miscellaneous gears other than Hkl, Pot, or Twl (e.g., net gear).

Table 3. Sablefish catch (mt) by year, gear, and state, 1981-2006. Year 2006 gear specific catches are incomplete.

California					**Oregon**				**Washington**			
Year	HKL	POT	TWL	MSC	HKL	POT	TWL	MSC	HKL	POT	TWL	MSC
1981	747	2353	3594	1	652	275	1322	18	365	1250	538	26
1982	611	3439	5503	3	523	1376	2948	0	250	1607	1707	142
1983	219	3175	3247	2	520	1319	2762	0	213	1443	1305	168
1984	52	1573	3199	10	225	1540	2783	0	502	986	2247	374
1985	422	1110	3571	37	484	1771	2865	0	1274	706	743	234
1986	743	1469	3799	165	994	1343	2156	0	1142	21	558	0
1987	866	337	3108	47	961	1504	2552	0	1338	0	834	0
1988	404	690	2642	63	662	1097	2173	0	1191	180	627	0
1989	374	882	2597	111	399	897	2626	0	1018	163	462	0
1990	564	716	2319	70	360	782	2533	0	725	86	345	0
1991	778	348	2180	37	607	667	2465	0	1195	0	321	0
1992	789	353	2507	31	746	348	2521	0	870	4	383	0
1993	462	198	1929	12	553	551	2366	0	758	0	437	0
1994	574	185	1409	9	674	877	1808	0	603	8	295	0
1995	863	308	1622	14	526	527	1669	0	920	72	272	0
1996	1207	203	1768	3	478	402	1868	0	985	26	265	0
1997	1155	206	1571	3	605	262	1700	0	1033	32	270	0
1998	456	57	922	4	279	271	966	0	597	31	147	1
1999	648	114	1214	1	518	484	1608	0	881	6	208	0
2000	709	175	993	2	532	496	1450	0	832	19	161	0
2001	564	163	792	1	429	332	1449	0	762	38	206	0
2002	484	145	660	2	243	236	755	0	582	11	99	0
2003	548	215	861	1	422	293	1220	0	783	135	134	0
2004	421	279	709	2	488	445	1453	0	977	33	154	0
2005	526	342	760	3	634	492	1336	0	1031	113	170	0
2006	448	358	39	4	486	514	59	0	892	93	5	0

Table 4. Sample sizes for length (top) age (middle) and number of trips (bottom) associated with biological data collected from commercial fisheries for sablefish, 1986-2006.

Sum of CountOfLEN	Gear Code			
Sample Year	HKL	POT	TWL	Grand Total
1986	976	724	4787	6487
1987	1742	733	5082	7557
1988	797	440	3833	5070
1989	665	1650	4744	7059
1990	868	813	4964	6645
1991	2798	531	4840	8169
1992	1075		987	2062
1993	5506	773	5110	11389
1994	4070	305	4137	8512
1995	3288	449	3797	7534
1996	2656	432	3264	6352
1997	3962	683	3806	8451
1998	3234	402	3254	6890
1999	4716	573	3970	9259
2000	4491	665	3919	9075
2001	2933	311	4473	7717
2002	2714	245	4300	7259
2003	3654	392	4245	8291
2004	2149	470	4072	6691
2005	3407	347	3552	7306
2006	5309	470	3378	9157
Grand Total	61010	11408	84514	156932

Sum of CountOfAGE	Gear Code			
Sample Year	HKL	POT	TWL	Grand Total
1986	234	139	1285	1658
1987	371	156	1100	1627
1988	222	72	1474	1768
1989	55	229	1239	1523
1990	101	79	1125	1305
1991	262	309	1787	2358
1992			694	694
1993	48	122	817	987
1994	97	60	657	814
1995	175	143	444	762
1996	539	344	1017	1900
1997	1204	543	2020	3767
1998	291		600	891
1999	781	290	750	1821
2000	480	300	1605	2385
2001	619	224	1528	2371
2002	423	165	1046	1634
2003	270	176	685	1131
2004	148	94	825	1067
2005			305	305
2006			1189	1189
Grand Total	6320	3445	22192	31957

Sum of CountOfLandi	Gear Code			
Sample Year	HKL	POT	TWL	Grand Total
1986	46	33	174	253
1987	81	34	171	286
1988	32	13	122	167
1989	18	59	156	233
1990	31	35	173	239
1991	75	26	159	260
1992	20		19	39
1993	199	24	184	407
1994	147	14	142	303
1995	109	20	119	248
1996	94	22	113	229
1997	170	32	149	351
1998	142	19	143	304
1999	190	28	168	386
2000	212	33	158	403
2001	148	18	169	335
2002	117	17	156	290
2003	156	21	172	349
2004	98	26	142	266
2005	158	21	147	326
2006	213	31	152	396
Grand Total	2456	526	3088	6070

Table 5. Assumed discard mortality rate and estimated biomass of sablefish encountered, discarded dead, and retained by year and gear type.

	HKL				POT				TWL			
YEAR	DiscMort	Encounter	Dead	Retained	DiscMort	Encounter	Dead	Retained	DiscMort	Encounter	Dead	Retained
1970	0.10	4256	4206	4200	0.10	115	114	114	0.50	2614	2518	2422
1971	0.10	1423	1406	1404	0.10	194	193	193	0.50	2732	2632	2531
1972	0.10	1533	1514	1512	0.10	359	357	357	0.50	3738	3600	3462
1973	0.10	3548	3505	3500	0.10	883	878	878	0.50	4112	3956	3800
1974	0.10	1142	1128	1126	0.10	3263	3246	3244	0.50	3358	3202	3047
1975	0.10	2485	2448	2444	0.10	5733	5700	5696	0.50	3726	3559	3392
1976	0.10	1767	1740	1737	0.10	19866	19753	19740	0.50	3908	3731	3554
1977	0.10	1247	1227	1225	0.10	4168	4143	4140	0.50	4047	3856	3665
1978	0.10	1472	1448	1445	0.10	5950	5914	5910	0.50	6620	6303	5986
1979	0.10	1755	1725	1722	0.10	12656	12580	12572	0.50	8274	7918	7563
1980	0.10	4312	4245	4238	0.10	3801	3779	3777	0.50	4289	4109	3929
1981	0.10	1464	1442	1440	0.10	3921	3899	3897	0.50	6147	5896	5646
1982	0.10	1997	1969	1966	0.10	6548	6515	6511	0.50	11114	10696	10278
1983	0.10	1763	1740	1738	0.10	5993	5964	5961	0.50	7934	7649	7363
1984	0.10	1202	1188	1186	0.10	4427	4407	4405	0.50	8833	8535	8237
1985	0.10	1064	1052	1051	0.10	3926	3910	3908	0.50	7747	7483	7219
1986	0.10	2913	2881	2878	0.10	2963	2949	2947	0.50	7109	6827	6546
1987	0.10	3697	3650	3645	0.10	2079	2077	2077	0.50	7189	6886	6583
1988	0.10	4146	4124	4122	0.10	2135	2133	2133	0.50	6071	5801	5531
1989	0.10	3195	3186	3185	0.10	2049	2047	2047	0.50	6160	5934	5708
1990	0.10	2590	2578	2577	0.10	1669	1668	1668	0.50	5608	5410	5212
1991	0.10	2247	2239	2238	0.10	1065	1064	1064	0.50	5390	5185	4980
1992	0.10	3487	3438	3433	0.10	799	798	798	0.50	5951	5704	5457
1993	0.10	3227	3094	3079	0.10	848	847	847	0.50	5054	5007	4959
1994	0.10	2351	2330	2328	0.10	1371	1370	1370	0.50	3858	3840	3822
1995	0.10	2387	2376	2375	0.10	1066	1065	1065	0.50	3892	3870	3848
1996	0.10	2987	2979	2978	0.10	751	750	750	0.50	4256	4234	4211
1997	0.10	3366	3355	3354	0.10	585	584	584	0.50	4003	3887	3771
1998	0.10	3608	3587	3585	0.10	448	448	448	0.50	2212	2201	2191
1999	0.10	1760	1757	1757	0.10	756	755	755	0.50	3180	3178	3175
2000	0.10	2723	2718	2717	0.10	854	852	852	0.50	2733	2730	2727
2001	0.10	2720	2712	2711	0.10	673	672	672	0.50	3011	2818	2624
2002	0.10	2366	2358	2357	0.10	473	472	472	0.50	1809	1703	1597
2003	0.10	1750	1746	1745	0.10	800	799	799	0.50	2394	2363	2331
2004	0.10	2312	2305	2304	0.10	812	811	811	0.50	2487	2467	2447
2005	0.10	2528	2524	2524	0.10	997	996	996	0.50	1958	1956	1955
2006	0.10	2807	2803	2803	0.10	1038	1037	1037	0.50	2148	2142	2137
2007	0.10	2337	2334	2334	0.10	1038	1037	1037	0.50	2146	2142	2137

Table 6. Estimated biomass and sample size for NWFSC "shelf survey" (tows from the combined Survey that were less than 100 fathom).

			Area Name					
Survey Year	Max Strata Depth	Data	VANCOUVER	COLUMBIA	EUREKA	MONTEREY	CONCEPTION	Grand Total
2003	182.88	Sum of Biomass (kg)	18,115,290	26,891,786	3,358,297	1,456,598	274,809	50,096,781
		Average of Biomass CV	0.5344	0.5987	0.3133	0.3491	0.6532	0.4897
		Sum of Abundance (Numbers)	9842427	17343246	2261883	2491289	1030470	32969315
		Sum of N (Stratum Bio)	48	46	35	44	41	214
		Sum of N (Stratum Bio Positive)	36	31	23	21	7	118
		Sum of N (Stratum Lengths)	36	31	23	21	7	118
2004	182.88	Sum of Biomass (kg)	1,959,595	9,209,288	1,897,111	3,215,283	38,867	16,320,143
		Average of Biomass CV	1	0	0	1	1	0
		Sum of Abundance (Numbers)	1,023,216	8,341,311	1,440,560	3,167,897	223,020	14,196,004
		Sum of N (Stratum Bio)	29	80	20	58	46	233
		Sum of N (Stratum Bio Positive)	17	51	18	26	7	119
		Sum of N (Stratum Lengths)	16	50	18	26	7	117
2005	182.88	Sum of Biomass (kg)	713,884	3,125,886	1,710,806	2,104,846	43,726	7,699,147
		Average of Biomass CV	0	0	0	0	1	0
		Sum of Abundance (Numbers)	659,531	3,699,704	1,464,067	2,075,318	115,320	8,013,940
		Sum of N (Stratum Bio)	21	119	37	78	54	309
		Sum of N (Stratum Bio Positive)	11	78	23	25	1	138
		Sum of N (Stratum Lengths)	11	78	23	25	1	138
2006	182.88	Sum of Biomass (kg)	194,992	2,963,774	501,312	671,576	1,294	4,332,947
		Average of Biomass CV	1	0	0	0	1	1
		Sum of Abundance (Numbers)	200,549	1,919,051	241,390	576,560	8,091	2,945,641
		Sum of N (Stratum Bio)	24	112	23	60	48	267
		Sum of N (Stratum Bio Positive)	7	47	9	11	1	75
		Sum of N (Stratum Lengths)	7	46	9	11	1	74

Table 7. Estimated biomass and sample size for NWFSC "slope survey" (tows from the combined Survey that were deeper than 100 fathom).

			Area Name					
Survey Yea	Max Strata Depth	Data	VANCOUVER	COLUMBIA	EUREKA	MONTEREY	CONCEPTION	Grand Total
1998	548.64	Sum of Biomass (kg)	510,891	3,730,705	1,292,219	822,271	2,672,344	9,028,431
		Average of Biomass CV	0.2553	0.1359	0.2482	0.2626	0.3889	0.2582
		Sum of Abundance (Numbers)	248,852	1,768,298	982,347	581,022	1,538,923	5,119,442
		Sum of N (Stratum Bio)	6	57	29	43	10	145
		Sum of N (Stratum Bio Positive)	5	46	23	26	5	105
		Sum of N (Stratum Lengths)	5	39	16	20	4	84
	1280.16	Sum of Biomass (kg)	1,160,664	8,147,687	4,553,063	6,222,988	40,620,277	60,704,680
		Average of Biomass CV	0.3034	0.1293	0.1892	0.1593	0.1963	0.1955
		Sum of Abundance (Numbers)	549,888	3,403,764	1,334,104	2,587,407	25,214,994	33,090,157
		Sum of N (Stratum Bio)	7	44	29	57	17	154
		Sum of N (Stratum Bio Positive)	6	42	28	56	15	147
		Sum of N (Stratum Lengths)	6	35	19	39	13	112
1998 Sum of Biomass (kg)			1,671,555	11,878,392	5,845,282	7,045,260	43,292,621	69,733,110
1998 Average of Biomass CV			0.2793	0.1326	0.2187	0.2109	0.2926	0.2268
1998 Sum of Abundance (Numbers)			798,740	5,172,062	2,316,451	3,168,429	26,753,917	38,209,599
1998 Sum of N (Stratum Bio)			13	101	58	100	27	299
1998 Sum of N (Stratum Bio Positive)			11	88	51	82	20	252
1998 Sum of N (Stratum Lengths)			11	74	35	59	17	196
1999	548.64	Sum of Biomass (kg)	402,540	5,981,255	1,538,952	5,385,459	3,619,017	16,927,223
		Average of Biomass CV	0.6378	0.1523	0.2808	0.7134	0.2533	0.4075
		Sum of Abundance (Numbers)	215,122	3,097,469	782,862	3,119,270	2,841,678	10,056,401
		Sum of N (Stratum Bio)	6	55	29	46	13	149
		Sum of N (Stratum Bio Positive)	3	49	23	37	12	124
		Sum of N (Stratum Lengths)	3	49	23	37	12	124
	1280.16	Sum of Biomass (kg)	731,098	10,173,304	6,312,016	7,953,582	30,303,020	55,473,020
		Average of Biomass CV	0.2428	0.1218	0.1291	0.1734	0.2009	0.1736
		Sum of Abundance (Numbers)	305,725	4,846,307	3,223,221	3,867,470	17,809,861	30,052,584
		Sum of N (Stratum Bio)	9	63	39	48	14	173
		Sum of N (Stratum Bio Positive)	8	62	38	47	14	169
		Sum of N (Stratum Lengths)	8	62	38	47	14	169
1999 Sum of Biomass (kg)			1,133,638	16,154,560	7,850,968	13,339,042	33,922,036	72,400,243
1999 Average of Biomass CV			0	0	0	0	0	0
1999 Sum of Abundance (Numbers)			520,847	7,943,776	4,006,083	6,986,740	20,651,539	40,108,985
1999 Sum of N (Stratum Bio)			15	118	68	94	27	322
1999 Sum of N (Stratum Bio Positive)			11	111	61	84	26	293
1999 Sum of N (Stratum Lengths)			11	111	61	84	26	293
2000	548.64	Sum of Biomass (kg)	652,667	11,420,260	1,428,521	1,854,545	8,282,559	23,638,552
		Average of Biomass CV	0.3657	0.2586	0.1514	0.2425	0.1836	0.2404
		Sum of Abundance (Numbers)	264,647	5,172,436	996,113	2,130,250	8,860,197	17,423,643
		Sum of N (Stratum Bio)	8	49	27	53	16	153
		Sum of N (Stratum Bio Positive)	6	45	25	43	15	134
		Sum of N (Stratum Lengths)	6	44	25	42	15	132
	1280.16	Sum of Biomass (kg)	1,839,429	11,227,443	6,214,008	6,586,912	40,807,238	66,675,029
		Average of Biomass CV	0.3130	0.1826	0.1397	0.1918	0.2573	0.2169
		Sum of Abundance (Numbers)	730,926	5,484,364	2,853,452	3,175,343	22,765,109	35,009,194
		Sum of N (Stratum Bio)	10	53	38	51	16	168
		Sum of N (Stratum Bio Positive)	9	51	38	49	15	162
		Sum of N (Stratum Lengths)	9	51	38	49	15	162
2000 Sum of Biomass (kg)			2,492,096	22,647,703	7,642,529	8,441,456	49,089,797	90,313,581
2000 Average of Biomass CV			0	0	0	0	0	0
2000 Sum of Abundance (Numbers)			995,573	10,656,800	3,849,565	5,305,593	31,625,306	52,432,837
2000 Sum of N (Stratum Bio)			18	102	65	104	32	321
2000 Sum of N (Stratum Bio Positive)			15	96	63	92	30	296
2000 Sum of N (Stratum Lengths)			15	95	63	91	30	294
2001	548.64	Sum of Biomass (kg)	882,779	5,332,739	2,299,981	2,168,097	8,672,998	19,356,593
		Average of Biomass CV	0.3790	0.1141	0.1320	0.1803	0.2585	0.2128
		Sum of Abundance (Numbers)	627,688	2,962,069	1,767,747	2,322,364	13,099,868	20,779,736
		Sum of N (Stratum Bio)	11	61	28	44	19	163
		Sum of N (Stratum Bio Positive)	9	57	28	42	16	152
		Sum of N (Stratum Lengths)	9	56	28	41	16	150
	1280.16	Sum of Biomass (kg)	1,156,291	5,528,259	4,327,589	8,074,689	36,543,267	55,630,095
		Average of Biomass CV	0.3029	0.1434	0.2204	0.1362	0.1750	0.1956
		Sum of Abundance (Numbers)	551,349	2,682,373	2,059,937	4,154,160	21,175,025	30,622,844
		Sum of N (Stratum Bio)	8	49	37	58	17	169
		Sum of N (Stratum Bio Positive)	6	44	33	56	16	155
		Sum of N (Stratum Lengths)	6	42	33	55	16	152
2001 Sum of Biomass (kg)			2,039,070	10,860,998	6,627,569	10,242,786	45,216,265	74,986,689
2001 Average of Biomass CV			0	0	0	0	0	0
2001 Sum of Abundance (Numbers)			1,179,037	5,644,442	3,827,684	6,476,524	34,274,893	51,402,580
2001 Sum of N (Stratum Bio)			19	110	65	102	36	332
2001 Sum of N (Stratum Bio Positive)			15	101	61	98	32	307
2001 Sum of N (Stratum Lengths)			15	98	61	96	32	302

Table 7 (cont). Estimated biomass and sample size for NWFSC "slope survey" (tows from the combined Survey that were deeper than 100 fathom).

			Area Name					
Survey Year	Min Stratum Depth	Data	VANCOUVER	COLUMBIA	EUREKA	MONTEREY	CONCEPTION	Grand Total
2002	182.88	Sum of Biomass (kg)	1,284,671	8,456,613	2,689,552	3,248,156	6,931,337	22,610,329
		Average of Biomass CV	0.4191	0.1253	0.1454	0.1709	0.2475	0.2216
		Sum of Abundance (Numbers)	595,068	5,075,062	1,849,840	2,895,174	7,123,366	17,538,510
		Sum of N (Stratum Bio)	6	63	30	57	47	203
		Sum of N (Stratum Bio Positive)	6	61	30	55	34	186
		Sum of N (Stratum Lengths)	6	61	30	55	34	186
	548.64	Sum of Biomass (kg)	1,534,542	6,596,526	5,838,897	8,182,951	21,797,698	43,950,615
		Average of Biomass CV	0.3265	0.1316	0.1482	0.1338	0.1470	0.1774
		Sum of Abundance (Numbers)	717,268	3,199,399	3,641,831	4,393,708	12,867,640	24,819,846
		Sum of N (Stratum Bio)	8	55	41	60	55	219
		Sum of N (Stratum Bio Positive)	7	51	39	54	45	196
		Sum of N (Stratum Lengths)	7	51	39	54	45	196
2002 Sum of Biomass (kg)			2,819,213	15,053,139	8,528,449	11,431,108	28,729,035	66,560,943
2002 Average of Biomass CV			0.3728	0.1284	0.1468	0.1524	0.1972	0.1995
2002 Sum of Abundance (Numbers)			1,312,336	8,274,461	5,491,671	7,288,882	19,991,006	42,358,356
2002 Sum of N (Stratum Bio)			14	118	71	117	102	422
2002 Sum of N (Stratum Bio Positive)			13	112	69	109	79	382
2002 Sum of N (Stratum Lengths)			13	112	69	109	79	382
2003	182.88	Sum of Biomass (kg)	1,292,426	19,729,561	4,292,204	3,436,677	3,831,445	32,582,314
		Average of Biomass CV	0.3012	0.3349	0.2122	0.1896	0.1906	0.2457
		Sum of Abundance (Numbers)	661636	8852518	2563337	2937943	4428821	19444255
		Sum of N (Stratum Bio)	16	40	36	30	54	176
		Sum of N (Stratum Bio Positive)	14	37	36	29	37	153
		Sum of N (Stratum Lengths)	13	36	36	29	37	151
	548.64	Sum of Biomass (kg)	1,040,245	9,966,814	12,405,669	14,248,742	16,917,640	54,579,110
		Average of Biomass CV	0.1589	0.1240	0.5628	0.3365	0.2930	0.2950
		Sum of Abundance (Numbers)	451743	5149827	6388354	7542345	9655255	29187524
		Sum of N (Stratum Bio)	21	60	33	26	28	168
		Sum of N (Stratum Bio Positive)	19	58	33	26	19	155
		Sum of N (Stratum Lengths)	19	58	33	26	19	155
2003 Sum of Biomass (kg)			2,332,671	29,696,376	16,697,874	17,685,420	20,749,085	87,161,424
2003 Average of Biomass CV			0.2301	0.2295	0.3875	0.2631	0.2418	0.2704
2003 Sum of Abundance (Numbers)			1,113,379	14,002,345	8,951,691	10,480,288	14,084,076	48,631,779
2003 Sum of N (Stratum Bio)			37	100	69	56	82	344
2003 Sum of N (Stratum Bio Positive)			33	95	69	55	56	308
2003 Sum of N (Stratum Lengths)			32	94	69	55	56	306
2004	182.88	Sum of Biomass (kg)	4,664,736	10,803,414	17,011,262	23,875,806	5,593,362	61,948,579
		Average of Biomass CV	0.3102	0.1705	0.5330	0.8482	0.3759	0.4475
		Sum of Abundance (Numbers)	1,988,954	5,095,457	10,269,190	20,070,060	4,330,273	41,753,934
		Sum of N (Stratum Bio)	8	50	12	17	46	133
		Sum of N (Stratum Bio Positive)	7	46	12	15	21	101
		Sum of N (Stratum Lengths)	7	44	12	15	21	99
	548.64	Sum of Biomass (kg)	4,840,276	9,116,318	9,286,015	8,611,347	29,650,785	61,504,743
		Average of Biomass CV	0.4932	0.1803	0.1739	0.1901	0.1574	0.2390
		Sum of Abundance (Numbers)	1,937,362	4,684,414	4,587,450	5,564,875	19,417,079	36,191,180
		Sum of N (Stratum Bio)	6	26	25	21	53	131
		Sum of N (Stratum Bio Positive)	6	26	25	21	44	122
		Sum of N (Stratum Lengths)	6	26	25	21	43	121
2004 Sum of Biomass (kg)			9,505,012	19,919,732	26,297,277	32,487,153	35,244,147	123,453,322
2004 Average of Biomass CV			0.4017	0.1754	0.3534	0.5191	0.2666	0.3433
2004 Sum of Abundance (Numbers)			3926316	9,779,871	14,856,640	25,634,935	23,747,352	77,945,114
2004 Sum of N (Stratum Bio)			14	76	37	38	99	264
2004 Sum of N (Stratum Bio Positive)			13	72	37	36	65	223
2004 Sum of N (Stratum Lengths)			13	70	37	36	64	220
2005	182.88	Sum of Biomass (kg)	3,453,857	11,347,528	4,319,333	3,300,422	9,823,041	32,244,182
		Average of Biomass CV	0.3861	0.1882	0.1801	0.2322	0.2114	0.2396
		Sum of Abundance (Numbers)	1,431,558	5,574,763	2,024,810	2,396,162	9,278,892	20,706,185
		Sum of N (Stratum Bio)	14	51	23	21	75	184
		Sum of N (Stratum Bio Positive)	14	48	23	19	53	157
		Sum of N (Stratum Lengths)	14	48	23	18	53	156
	548.64	Sum of Biomass (kg)	1,169,016	12,237,201	12,025,395	14,490,560	29,105,405	69,027,577
		Average of Biomass CV	0.2637	0.1776	0.1373	0.2287	0.1763	0.1967
		Sum of Abundance (Numbers)	573,728	6,267,260	6,644,004	8,342,827	19,514,288	41,342,107
		Sum of N (Stratum Bio)	8	53	28	20	72	181
		Sum of N (Stratum Bio Positive)	7	51	28	20	57	163
		Sum of N (Stratum Lengths)	7	49	28	20	57	161
2005 Sum of Biomass (kg)			4,622,873	23,584,729	16,344,728	17,790,983	38,928,446	101,271,759
2005 Average of Biomass CV			0.3249	0.1829	0.1587	0.2305	0.1938	0.2182
2005 Sum of Abundance (Numbers)			2,005,286	11,842,023	8,668,814	10,738,989	28,793,180	62,048,292
2005 Sum of N (Stratum Bio)			22	104	51	41	147	365
2005 Sum of N (Stratum Bio Positive)			21	99	51	39	110	320
2005 Sum of N (Stratum Lengths)			21	97	51	38	110	317
2006	182.88	Sum of Biomass (kg)	1,883,783	12,267,731	4,908,413	4,575,151	6,198,732	29,833,810
		Average of Biomass CV	0.3423	0.1992	0.1602	0.1524	0.2309	0.2170
		Sum of Abundance (Numbers)	980,692	5,123,684	2,099,831	2,433,086	4,254,525	14,891,818
		Sum of N (Stratum Bio)	7	63	19	32	72	193
		Sum of N (Stratum Bio Positive)	7	59	18	31	35	150
		Sum of N (Stratum Lengths)	7	59	18	31	35	150
	548.64	Sum of Biomass (kg)	2,587,720	11,833,504	10,767,466	12,974,668	27,973,688	66,137,047
		Average of Biomass CV	0.2948	0.1033	0.1118	0.2443	0.1273	0.1763
		Sum of Abundance (Numbers)	1,195,892	5,974,557	5,624,383	6,689,976	17,041,067	36,525,875
		Sum of N (Stratum Bio)	14	42	28	37	70	191
		Sum of N (Stratum Bio Positive)	14	41	28	37	57	177
		Sum of N (Stratum Lengths)	14	41	28	37	57	177
2006 Sum of Biomass (kg)			4,471,503	24,101,236	15,675,879	17,549,819	34,172,420	95,970,856
2006 Average of Biomass CV			0	0	0	0	0	0
2006 Sum of Abundance (Numbers)			2,176,584	11,098,241	7,724,214	9,123,062	21,295,592	51,417,693
2006 Sum of N (Stratum Bio)			21	105	47	69	142	384
2006 Sum of N (Stratum Bio Positive)			21	100	46	68	92	327
2006 Sum of N (Stratum Lengths)			21	100	46	68	92	327

Table 8. Likelihood values for the revised base run model.

	Revised Base Model
TOTAL LIKELIHOOD	1766.61
indices	-13.76
discard	-72.73
length_comps	734.47
age_comps	508.53
size-at-age	552.16
mean_body_wt	19.75
Equil_catch	0.00
catch	0.00
Recruitment	-0.49
Parm_priors	28.13
Parm_devs	17.70
penalties	0.00
Forecast_Recruitment	-7.15
FLEET 1 - HKL	
surv_lambda	1.00
surv_like	0.00
disc_lambda	0.10
disc_like	-363.29
length_lambda	0.10
length_like	466.01
age_lambda	0.10
age_like	534.27
sizeage_lambda	0.10
sizeage_like	548.76
FLEET 2 - POT	
surv_lambda	1.00
surv_like	0.00
disc_lambda	0.10
disc_like	-218.29
length_lambda	0.10
length_like	213.74
age_lambda	0.10
age_like	298.12
sizeage_lambda	0.10
sizeage_like	349.08
FLEET 3 - TWL	
surv_lambda	1.00
surv_like	0.00
disc_lambda	0.10
disc_like	-145.76
length_lambda	0.10
length_like	821.82
age_lambda	0.10
age_like	727.46
sizeage_lambda	0.10
sizeage_like	2771.60
FLEET 4 - SSH	
surv_lambda	1.00
surv_like	-1.79
FLEET 5 - AFSC Shelf	
surv_lambda	1.00
surv_like	-0.67
length_lambda	1.00
length_like	171.40
age_lambda	1.00
age_like	58.65
sizeage_lambda	0.10
sizeage_like	87.99
FLEET 6 - AFSC Slope	
surv_lambda	1.00
surv_like	-6.49
length_lambda	1.00
length_like	130.48
age_lambda	1.00
age_like	54.50
sizeage_lambda	0.10
sizeage_like	1186.80
FLEET 7 - NWFSC Slope	
surv_lambda	1.00
surv_like	-7.88
length_lambda	1.00
length_like	205.94
age_lambda	1.00
age_like	196.26
sizeage_lambda	0.10
sizeage_like	495.82
FLEET 8 - NWFSC Shelf	
surv_lambda	1.00
surv_like	3.07
length_lambda	1.00
length_like	76.49
age_lambda	1.00
age_like	43.14
sizeage_lambda	0.10
sizeage_like	81.50
FLEET 9 - Zooplankton	
surv_lambda	0.00
surv_like	0.00

Table 9. Revised base run model time series of beginning year total biomass (age 1+), beginning year summary biomass (age 2+), spawning stock biomass, numbers of recruits, exploitation, yield, depletion, SPR and YPR.

YEAR	BGTOTBIO	BGSUMBIO	SPAWN	RECRUIT	EXPLOIT	YIELD	DEPLETE	SPR	YPR
Virgin	470069	464394	244797	17635					
Equil	470069	464394	244797	17635					
1950	424439	418974	219302	16975	0.0043	1809	0.896	0.912	0.109
1951	423904	418443	218963	16966	0.0069	2861	0.894	0.863	0.167
1952	422342	416885	218178	16944	0.0039	1637	0.891	0.919	0.099
1953	422016	416564	217941	16937	0.0025	1024	0.890	0.949	0.063
1954	422374	416923	218034	16940	0.0044	1822	0.891	0.912	0.109
1955	421997	416547	217823	16934	0.0044	1822	0.890	0.912	0.109
1956	421638	416189	217625	16928	0.0088	3612	0.889	0.824	0.206
1957	419308	413864	216626	16900	0.0072	2965	0.885	0.858	0.173
1958	417721	412285	215788	16877	0.0044	1803	0.881	0.908	0.110
1959	417274	411844	215484	16868	0.0065	2672	0.880	0.868	0.158
1960	416002	410576	214826	16849	0.0086	3490	0.878	0.831	0.203
1961	413932	408514	213786	16819	0.0063	2538	0.873	0.872	0.153
1962	412799	407389	213160	16801	0.0076	3057	0.871	0.846	0.182
1963	411138	405735	212325	16777	0.0053	2141	0.867	0.890	0.131
1964	410472	405075	211899	16765	0.0064	2561	0.866	0.871	0.155
1965	409474	404082	211327	16748	0.0063	2535	0.863	0.871	0.154
1966	408519	403131	210803	16733	0.0042	1690	0.861	0.913	0.105
1967	408499	403115	210687	16729	0.0112	4507	0.861	0.790	0.257
1968	405801	400423	209315	16689	0.0074	2967	0.855	0.853	0.178
1969	404569	399201	208608	16668	0.0143	5705	0.852	0.738	0.318
1970	400678	395322	206644	16610	0.0101	3940	0.844	0.801	0.234
1971	398352	393012	205435	16573	0.0109	4236	0.839	0.787	0.251
1972	395182	390426	204089	12226	0.0189	7319	0.834	0.663	0.397
1973	391681	384789	201302	34501	0.0152	5804	0.822	0.713	0.335
1974	386943	378195	199088	16780	0.0232	8735	0.813	0.611	0.469
1975	386578	380112	194958	24812	0.0286	10825	0.796	0.557	0.536
1976	381925	374689	191487	19181	0.0650	24519	0.782	0.300	0.833
1977	366158	359802	182509	20564	0.0259	9250	0.746	0.596	0.486
1978	364010	358036	181322	15722	0.0383	13618	0.741	0.475	0.616
1979	358280	352447	178571	21553	0.0692	24373	0.729	0.273	0.829
1980	339605	333618	170687	14419	0.0276	9146	0.697	0.581	0.500
1981	336951	332106	168855	15959	0.0350	11509	0.690	0.504	0.578
1982	329806	325291	166347	12870	0.0576	18527	0.680	0.324	0.752
1983	314440	310962	160174	7880	0.0472	14510	0.654	0.389	0.695
1984	301275	298454	155054	10025	0.0465	13693	0.633	0.379	0.692
1985	287311	283756	149662	14217	0.0497	14005	0.611	0.340	0.737
1986	272517	268482	142833	10160	0.0495	13138	0.583	0.320	0.753
1987	258955	255509	135740	13137	0.0502	12782	0.555	0.371	0.780
1988	246472	242926	128070	10344	0.0447	10849	0.523	0.412	0.741
1989	237596	233769	121875	13130	0.0443	10332	0.498	0.416	0.730
1990	229066	224875	116672	13523	0.0406	9118	0.477	0.450	0.685
1991	223217	219595	112358	7319	0.0433	9477	0.459	0.425	0.698
1992	216790	214457	108787	5685	0.0439	9334	0.444	0.427	0.695
1993	208964	207239	105902	4903	0.0394	8134	0.433	0.474	0.654
1994	201810	199705	103341	8815	0.0378	7567	0.422	0.496	0.647
1995	194524	191297	100408	11752	0.0409	7891	0.410	0.467	0.694
1996	186808	184112	96349	3070	0.0451	8315	0.394	0.426	0.733
1997	179332	178471	91846	2104	0.0448	7940	0.375	0.423	0.735
1998	171330	169836	88184	8833	0.0257	4396	0.360	0.613	0.530
1999	168212	163198	86070	27388	0.0395	6647	0.352	0.476	0.723
2000	165004	156707	82138	25358	0.0382	6290	0.336	0.485	0.725
2001	167174	160731	78034	16790	0.0352	5653	0.319	0.499	0.661
2002	175264	170389	76036	9735	0.0224	3814	0.311	0.642	0.478
2003	183246	180820	79136	4752	0.0297	5434	0.323	0.587	0.568
2004	191030	187805	83707	17506	0.0304	5782	0.342	0.610	0.534
2005	193299	189558	88531	2627	0.0298	5754	0.362	0.637	0.510
2006	197016	195837	91607	5278	0.0280	5508	0.374	0.660	0.473
2007	196884	194615	93831	9581	0.0234	5508	0.383	0.705	0.402

Table 10. Revised base run model time series of sablefish numbers at age, 1975-2007.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1975	24812	15643	29626	9397	11329	10094	9090	8264	7567	6997	6516	6120	5770	5447	5133	75276
1976	19181	23131	14390	26370	8220	9856	8780	7940	7268	6709	6255	5869	5548	5258	4983	74168
1977	20564	17881	21167	12289	21680	6676	7990	7161	6546	6073	5687	5375	5105	4875	4659	71510
1978	15722	19171	16446	18905	10810	18982	5846	7027	6339	5841	5461	5149	4895	4670	4476	70401
1979	21553	14656	17503	14381	16167	9182	16132	5002	6075	5546	5169	4884	4644	4444	4260	68944
1980	14419	20090	13265	14663	11549	12805	7268	12898	4065	5034	4687	4447	4265	4105	3965	66603
1981	15959	13442	18452	11811	12849	10071	11170	6370	11387	3620	4520	4239	4047	3900	3768	65222
1982	12870	14877	12275	16188	10151	10974	8607	9610	5536	10012	3219	4060	3839	3688	3570	63682
1983	7880	11996	13384	10290	13103	8133	8811	6999	7963	4684	8641	2826	3613	3450	3338	61642
1984	10025	7345	10854	11452	8557	10807	6718	7350	5924	6852	4094	7656	2531	3262	3134	59668
1985	14217	9344	6613	9258	9440	6996	8856	5569	6196	5088	5988	3631	6870	2291	2970	57747
1986	10160	13251	8444	5575	7556	7609	5646	7232	4629	5255	4399	5265	3236	6186	2078	55816
1987	13137	9470	11916	7083	4506	6040	6085	4571	5965	3901	4521	3853	4680	2909	5605	53271
1988	10344	12245	8663	10546	6056	3791	5053	5103	3865	5102	3376	3956	3404	4165	2604	53295
1989	13130	9642	11233	7700	9175	5174	3219	4299	4369	3340	4454	2976	3515	3045	3744	50758
1990	13523	12239	8811	10021	6678	7859	4399	2742	3688	3782	2921	3932	2647	3147	2738	49473
1991	7319	12606	11223	7875	8736	5736	6728	3774	2369	3215	3328	2592	3514	2380	2841	47520
1992	5685	6823	11534	9876	6796	7441	4865	5730	3239	2054	2816	2943	2311	3154	2146	45878
1993	4903	5300	6224	10197	8493	5792	6315	4143	4921	2810	1801	2494	2628	2077	2848	43779
1994	8815	4570	4869	5542	8899	7321	4981	5445	3595	4308	2483	1604	2238	2371	1882	42590
1995	11752	8218	4212	4366	4888	7766	6353	4331	4757	3162	3818	2216	1441	2020	2148	40614
1996	3070	10955	7598	3797	3833	4238	6692	5472	3752	4152	2784	3390	1982	1297	1826	39055
1997	2104	2861	10085	6781	3303	3277	3605	5702	4691	3247	3629	2457	3018	1776	1168	37234
1998	8833	1961	2626	8997	5905	2834	2788	3073	4890	4058	2838	3202	2186	2704	1600	35008
1999	27388	8235	1827	2414	8141	5280	2518	2474	2734	4371	3647	2564	2907	1992	2472	33692
2000	25357	25530	7676	1680	2157	7122	4564	2171	2139	2382	3843	3234	2292	2615	1802	33058
2001	16790	23638	23798	7127	1513	1898	6193	3954	1886	1869	2098	3411	2891	2061	2363	31797
2002	9735	15652	21801	21626	6376	1331	1657	5400	3458	1659	1655	1871	3062	2609	1868	31227
2003	4752	9076	14493	20025	19709	5760	1194	1483	4841	3110	1498	1501	1704	2797	2389	30494
2004	17506	4430	8458	13412	18205	17703	5125	1057	1315	4309	2783	1348	1358	1548	2551	30228
2005	2627	16321	4127	7790	12233	16383	15829	4568	942	1176	3872	2513	1223	1236	1414	30152
2006	5278	2449	15214	3830	7128	11104	14732	14192	4094	846	1060	3506	2285	1116	1131	29075
2007	9581	4920	2281	14061	3507	6459	10019	13249	12774	3693	765	963	3196	2089	1023	27841

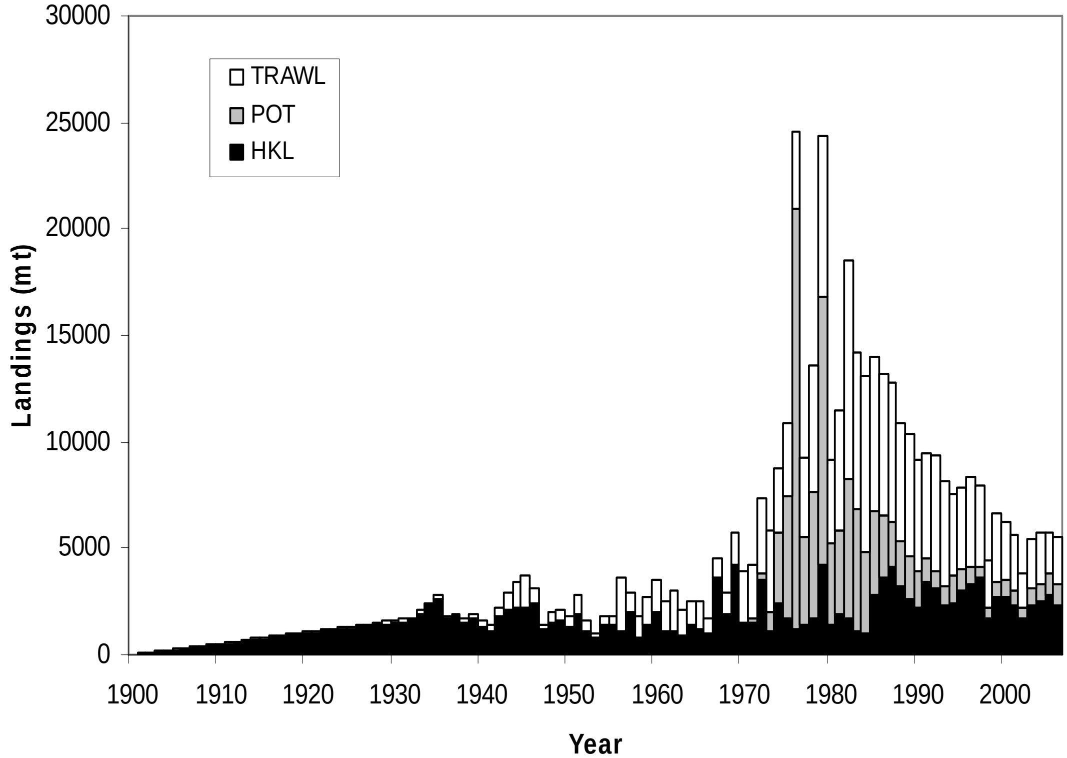


Figure 1. *Landings, including foreign catch, by year and gear of west coast sablefish, 1900-2006.*

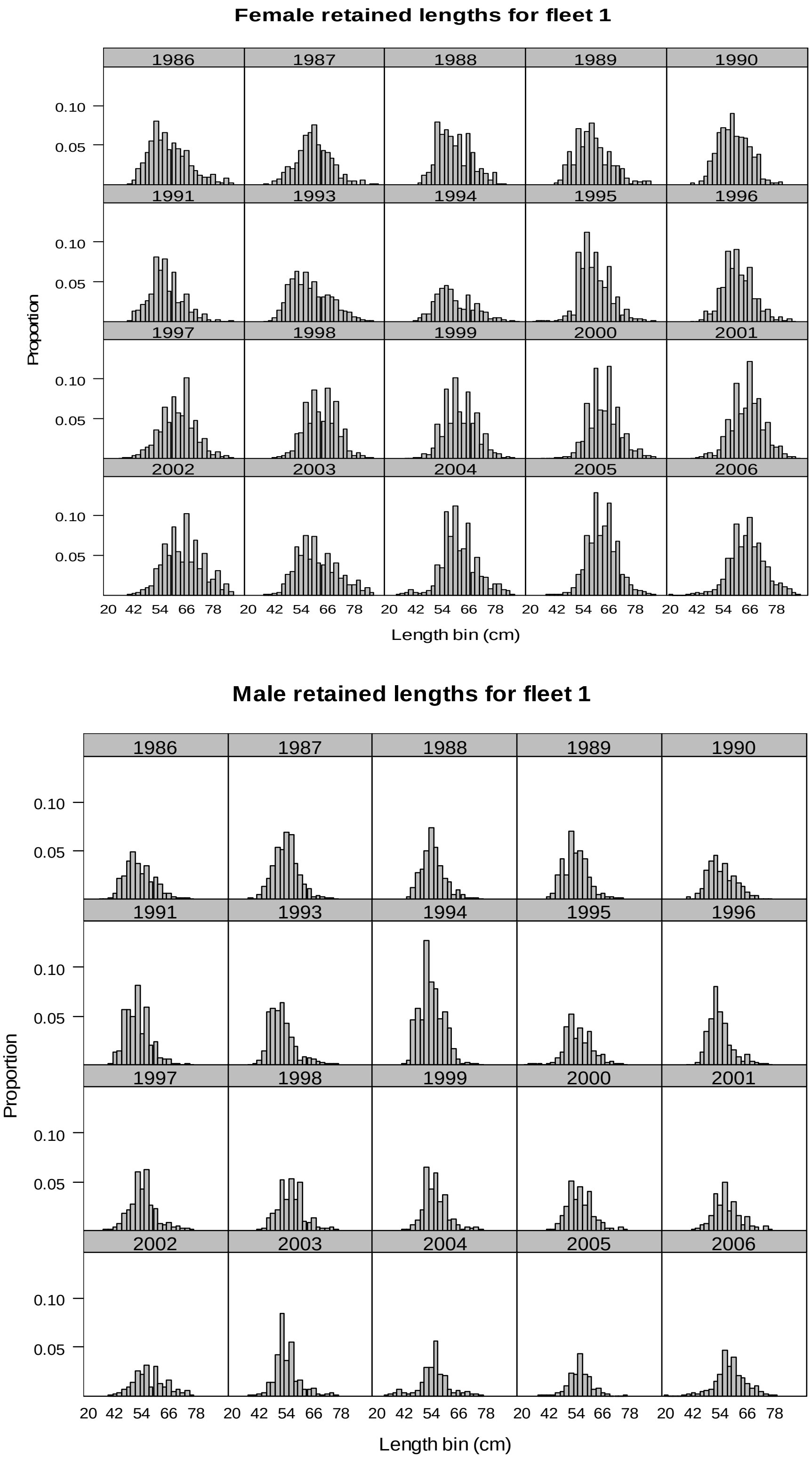


Figure 2. *Length frequencies for female (top) and male (bottom) sablefish caught with hook-and-line gear off the U.S. west coast, 1986-2006.*

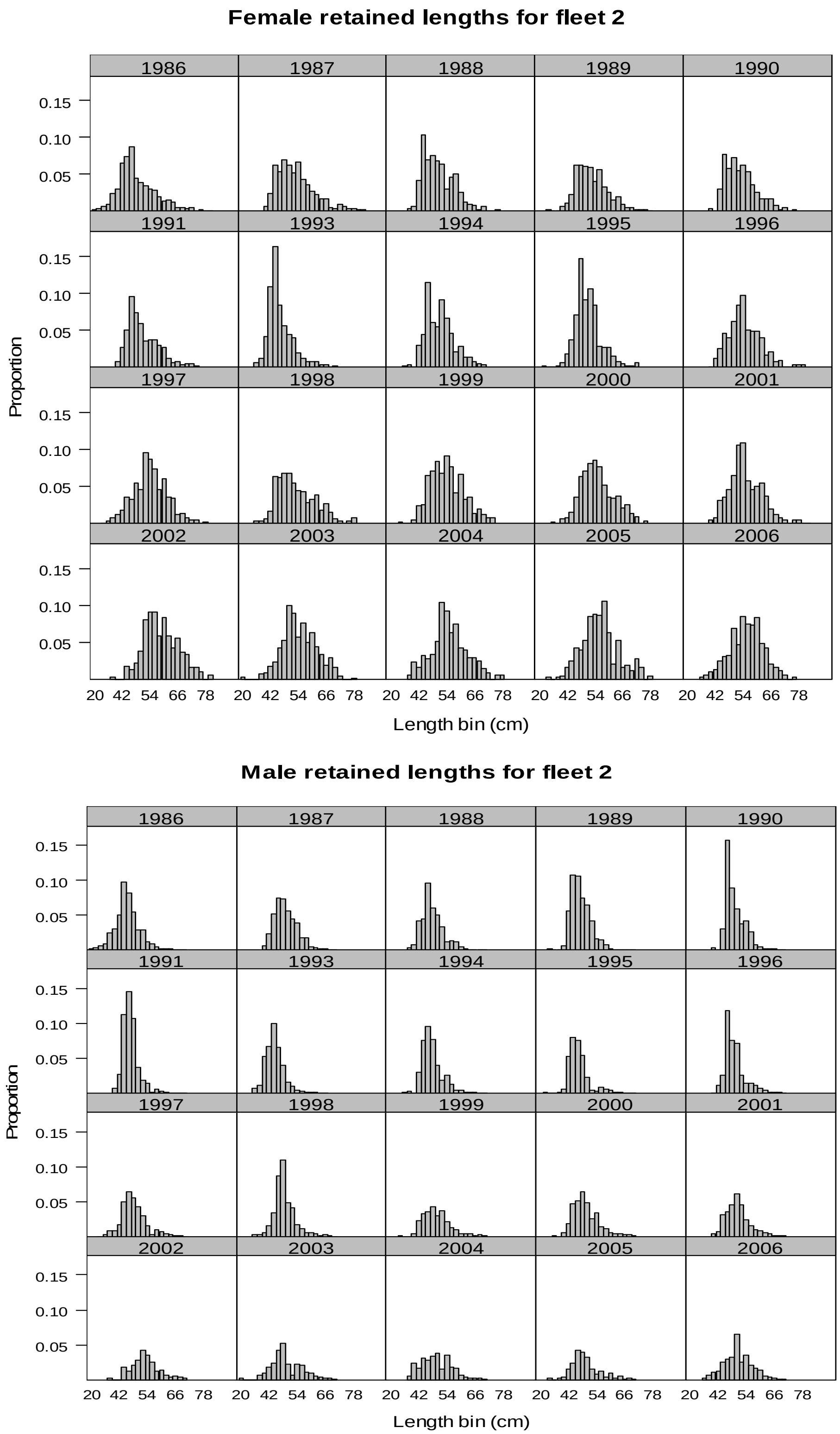


Figure 3. *Length frequencies for female (top) and make (bottom) sablefish caught with pot gear off the U.S. west coast, 1986-2006.*

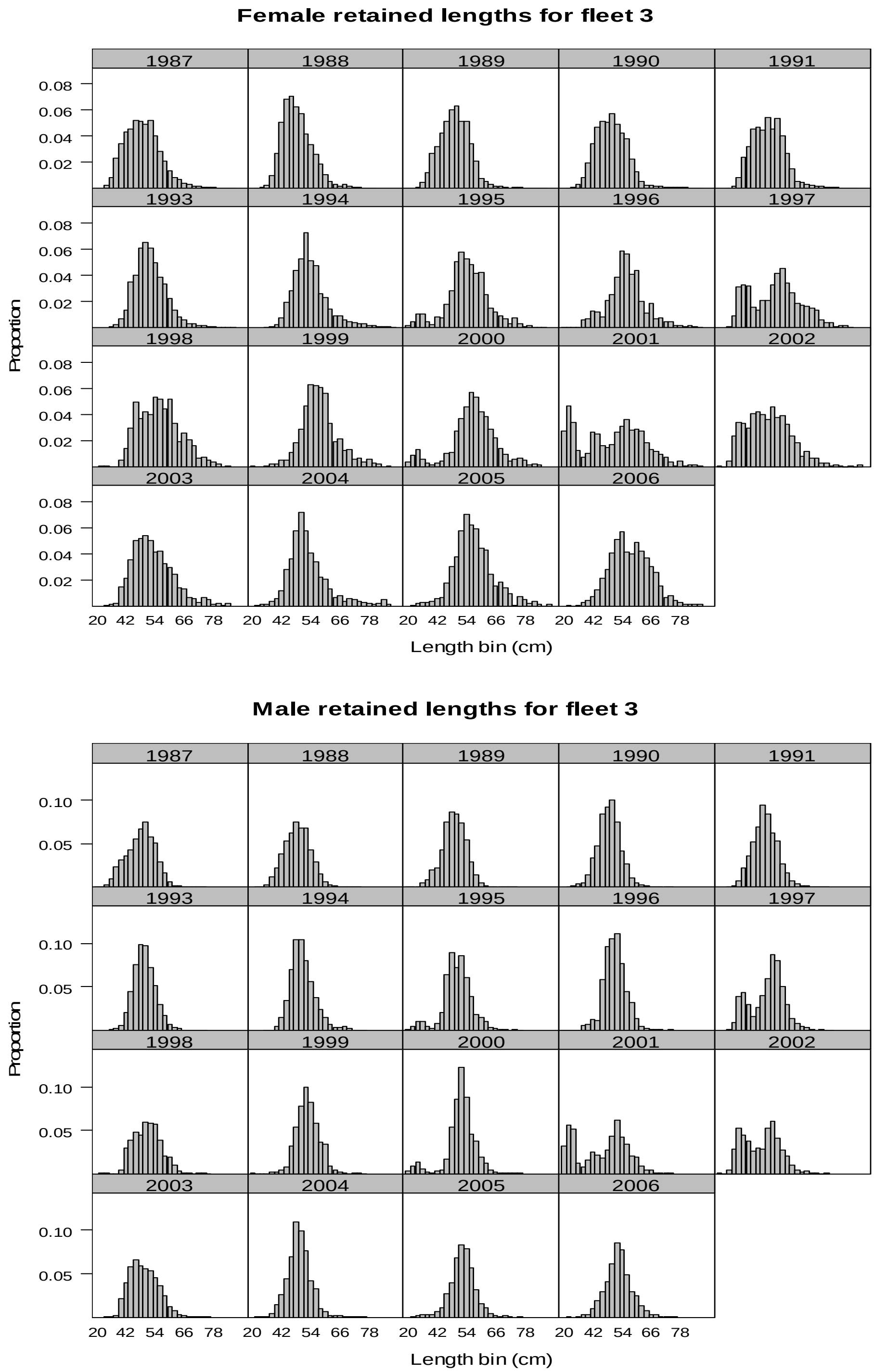


Figure 4. *Length frequencies for female (top) and make (bottom) sablefish caught with trawl gear off the U.S. west coast, 1986-2006.*

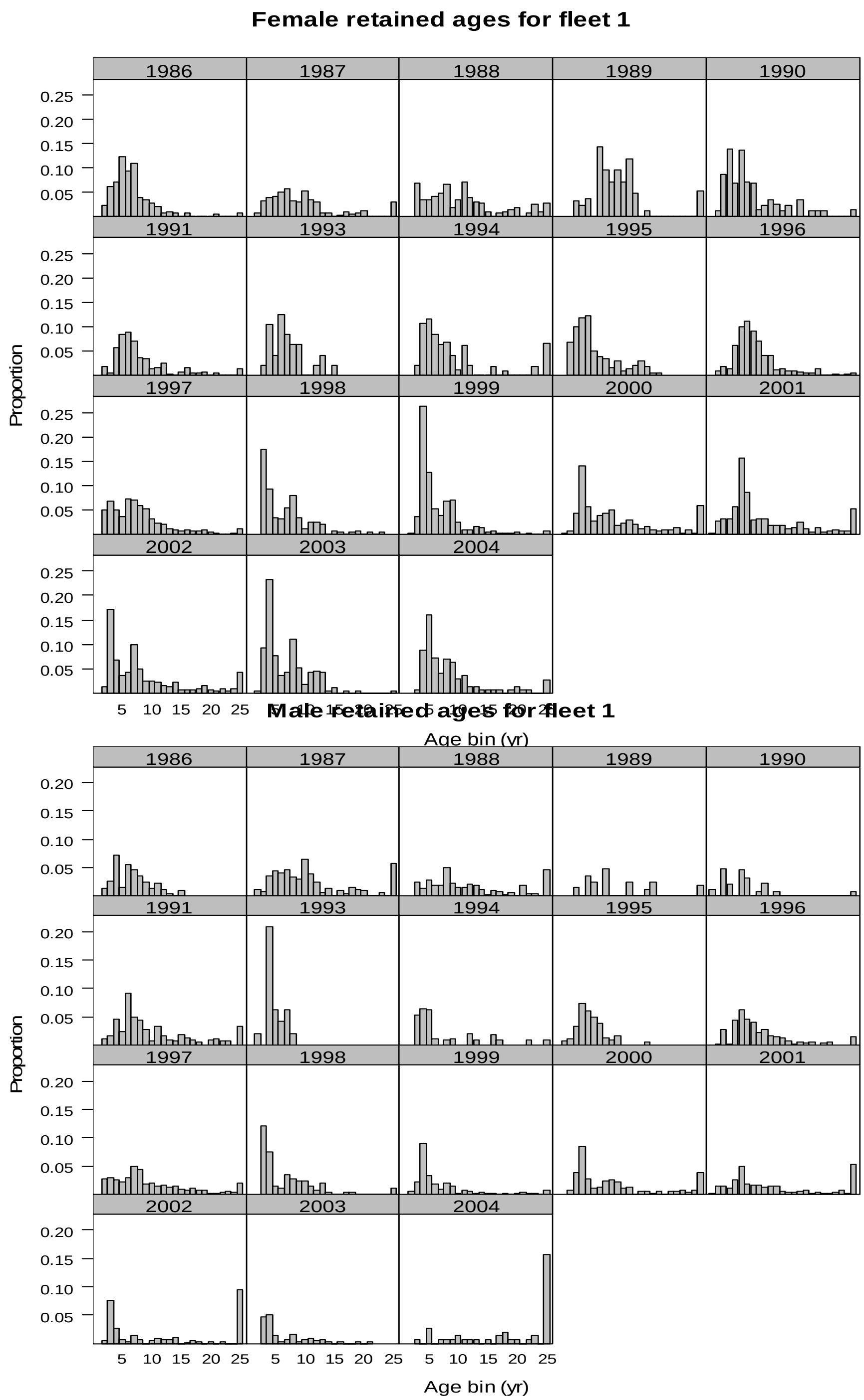
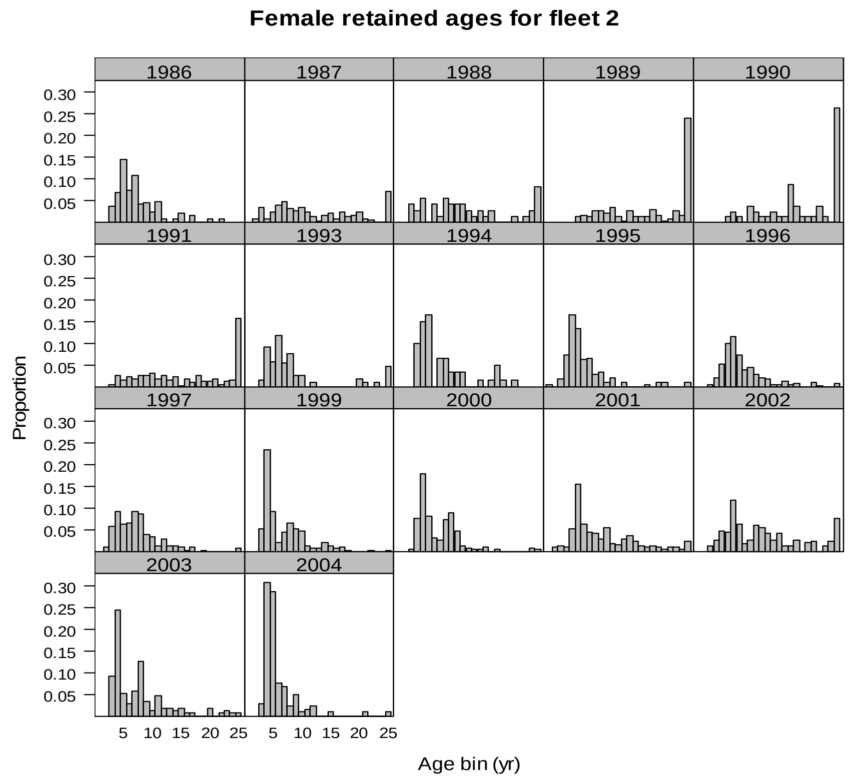


Figure 5. *Age frequencies for female (top) and male (bottom) sablefish caught with hook-and-line gear off the U.S. west coast, 1986-2004.*



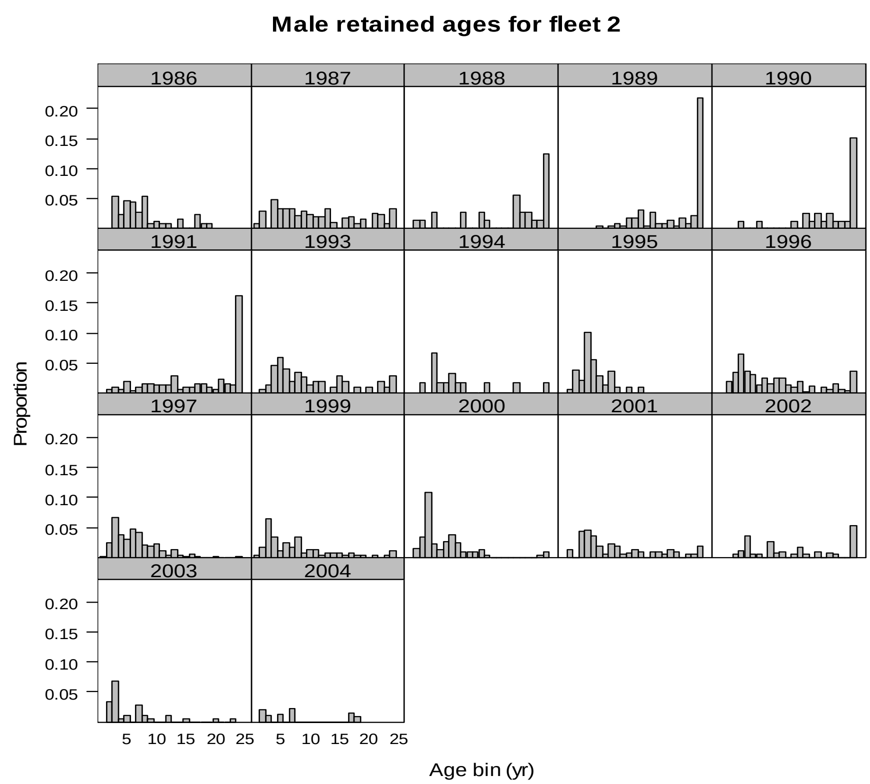


Figure 6 *. Age frequencies for female (top) and male (bottom) sablefish caught with pot gear off the U.S. west coast, 1986-2004.*

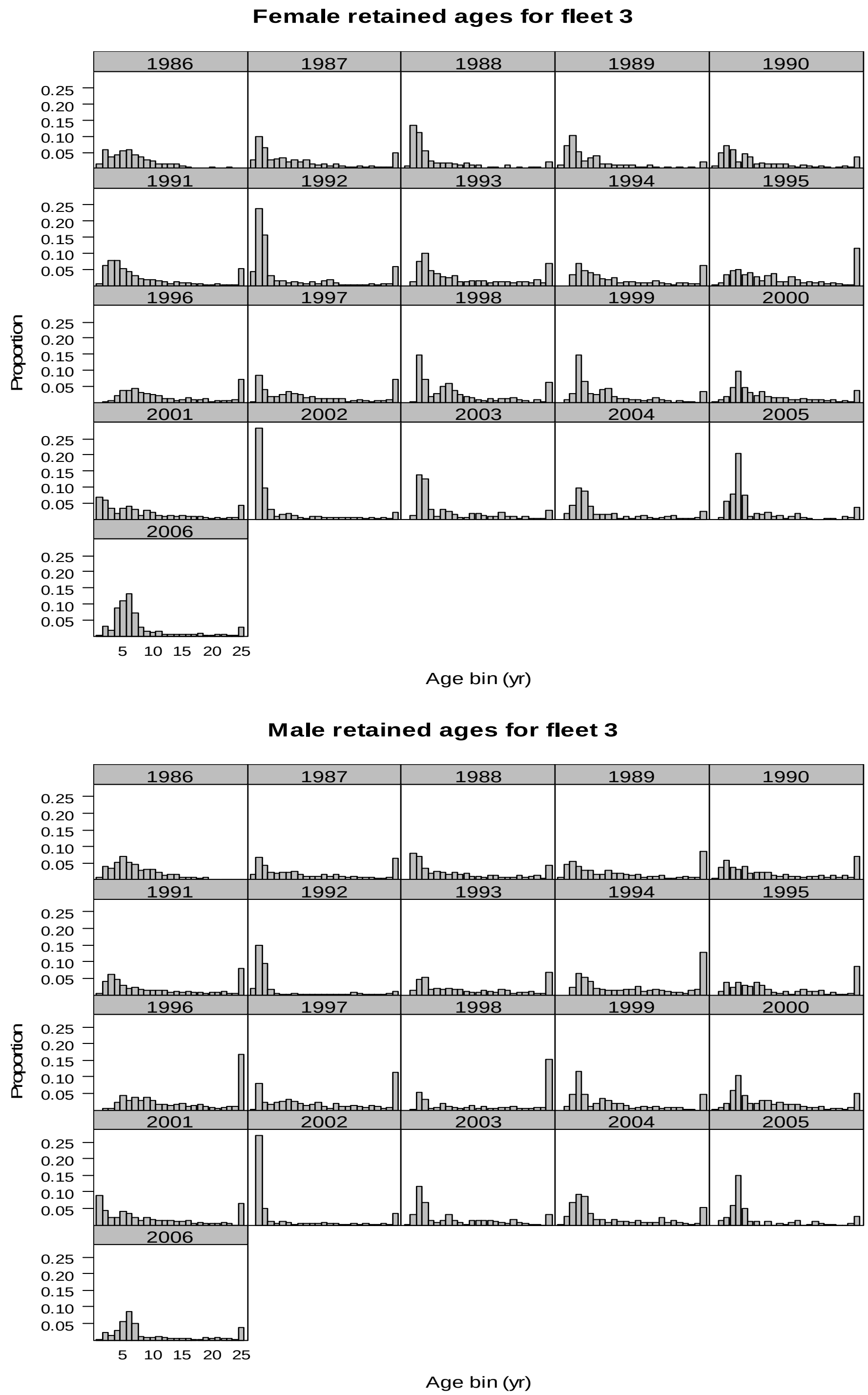


Figure 7*. Age frequencies for female (top) and male (bottom) sablefish caught with pot gear off the U.S. west coast, 1986-2004.*

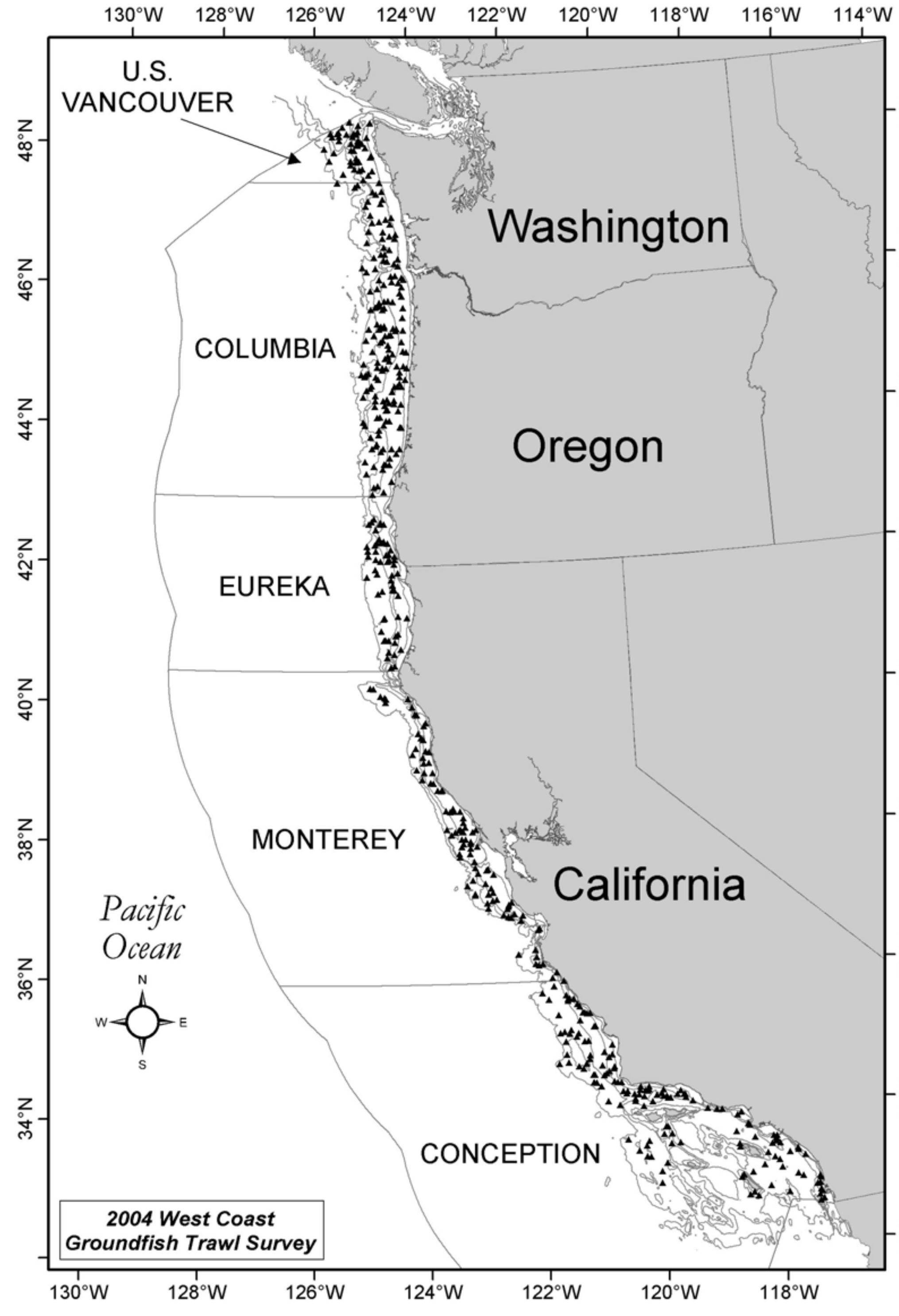


Figure 8. *Area of consideration for west coast sablefish assessment, outline of INPFC areas, and typical station design for the NWFSC slope-shelf survey.*

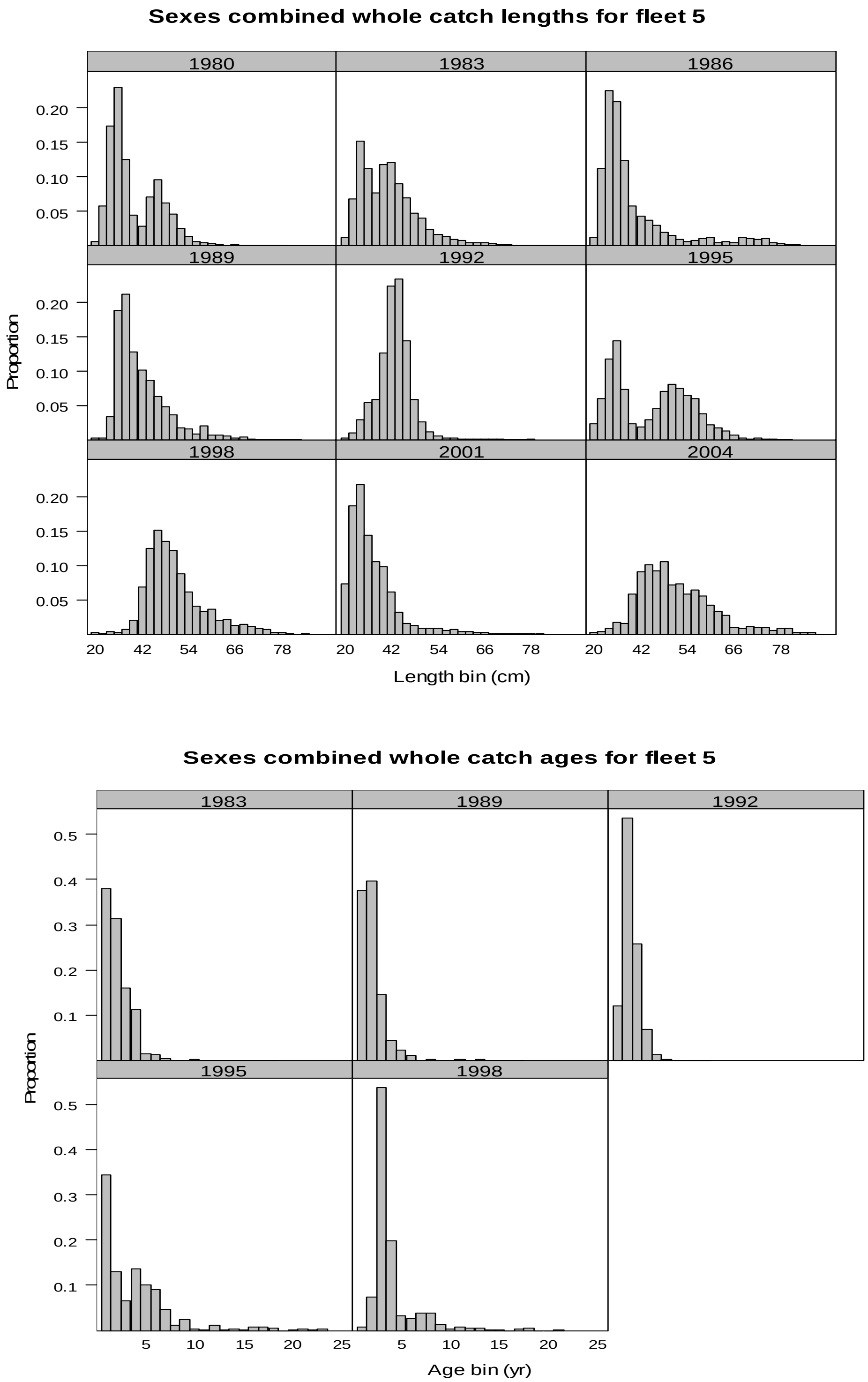
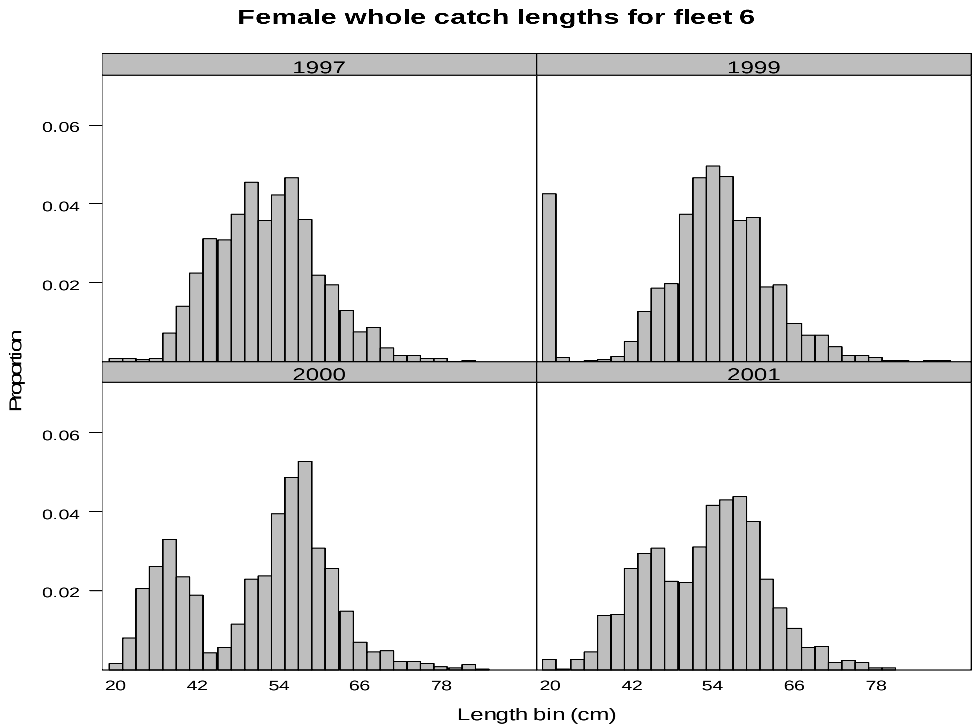


Figure 9. *Length (top) and age (bottom) frequencies for sablefish caught in the AFSC shelf trawl survey.*



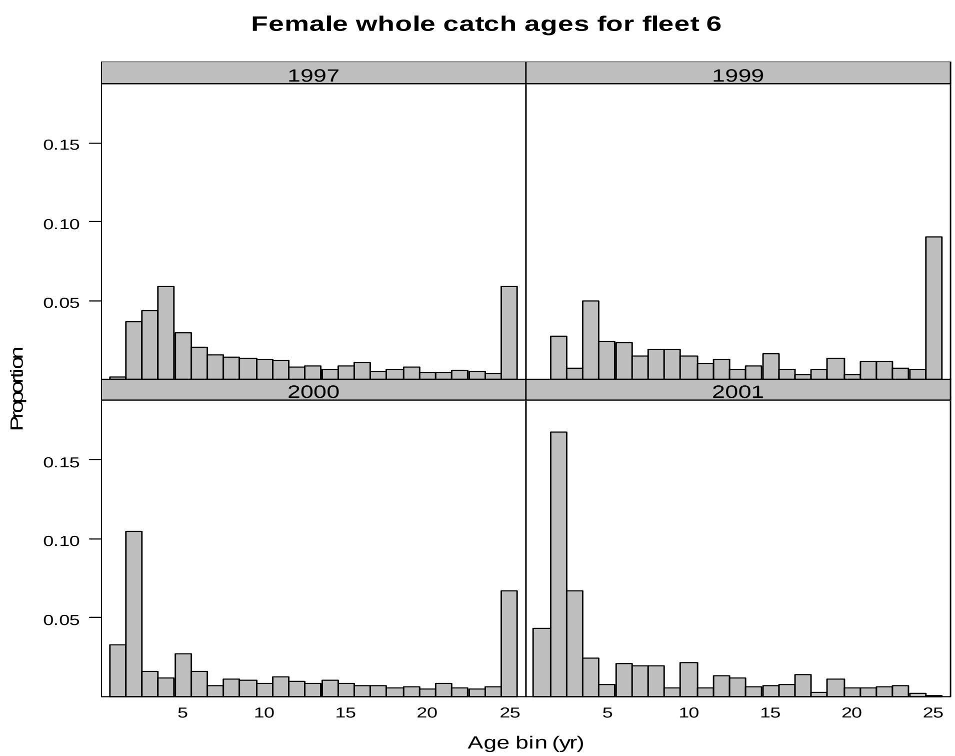
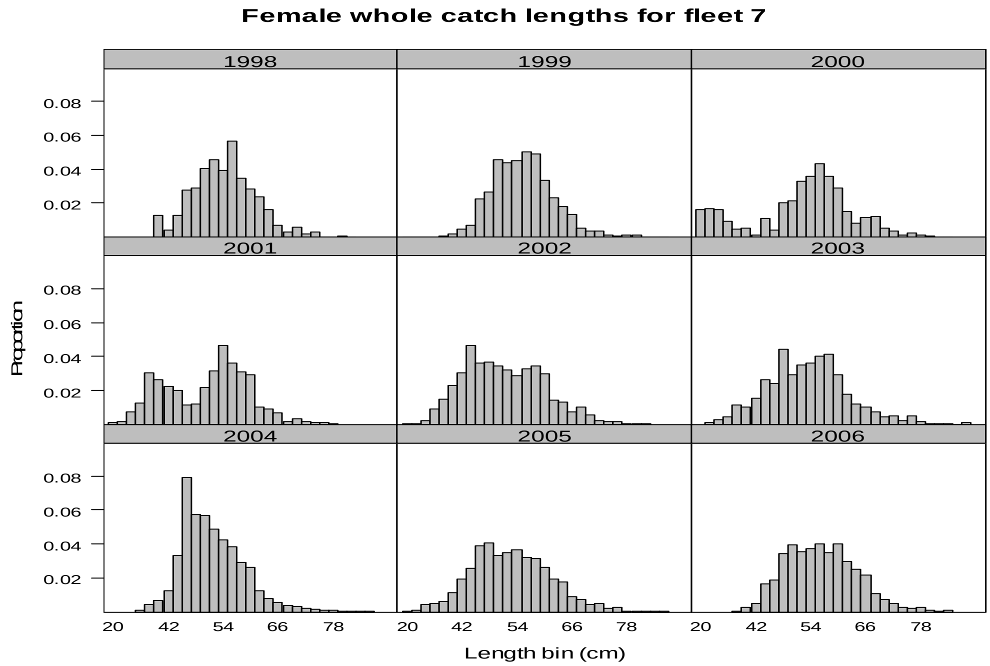


Figure 10. *Length (top) and age (bottom) frequencies for sablefish caught in the AFSC slope trawl survey.*



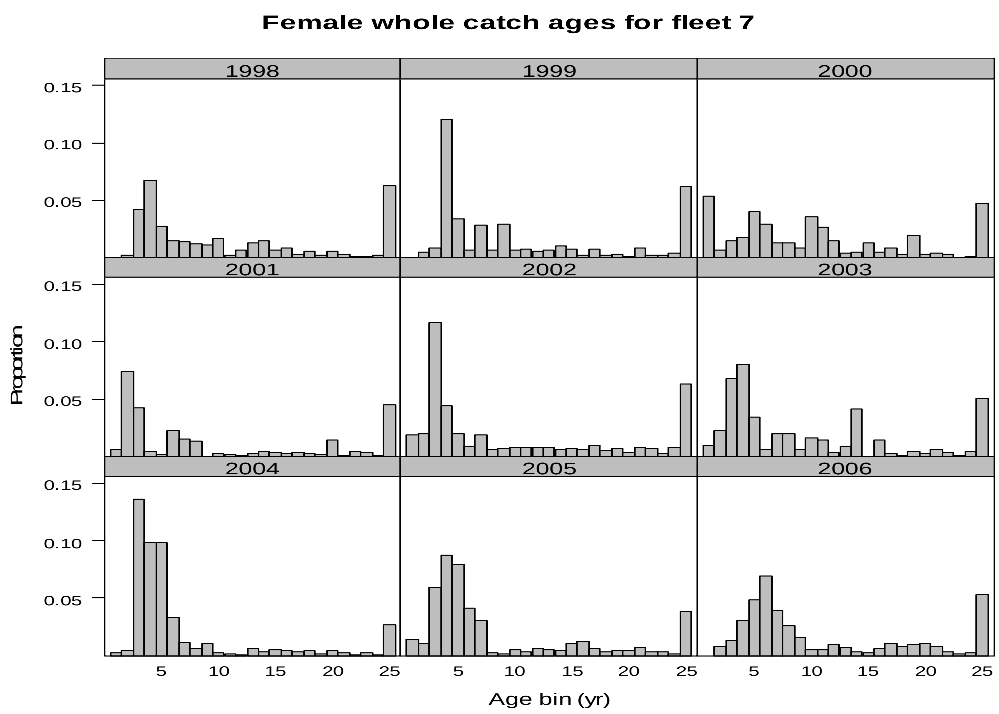


Figure 11. *Length (top) and age (bottom) frequencies for sablefish caught in the NWFSC slope trawl survey.*

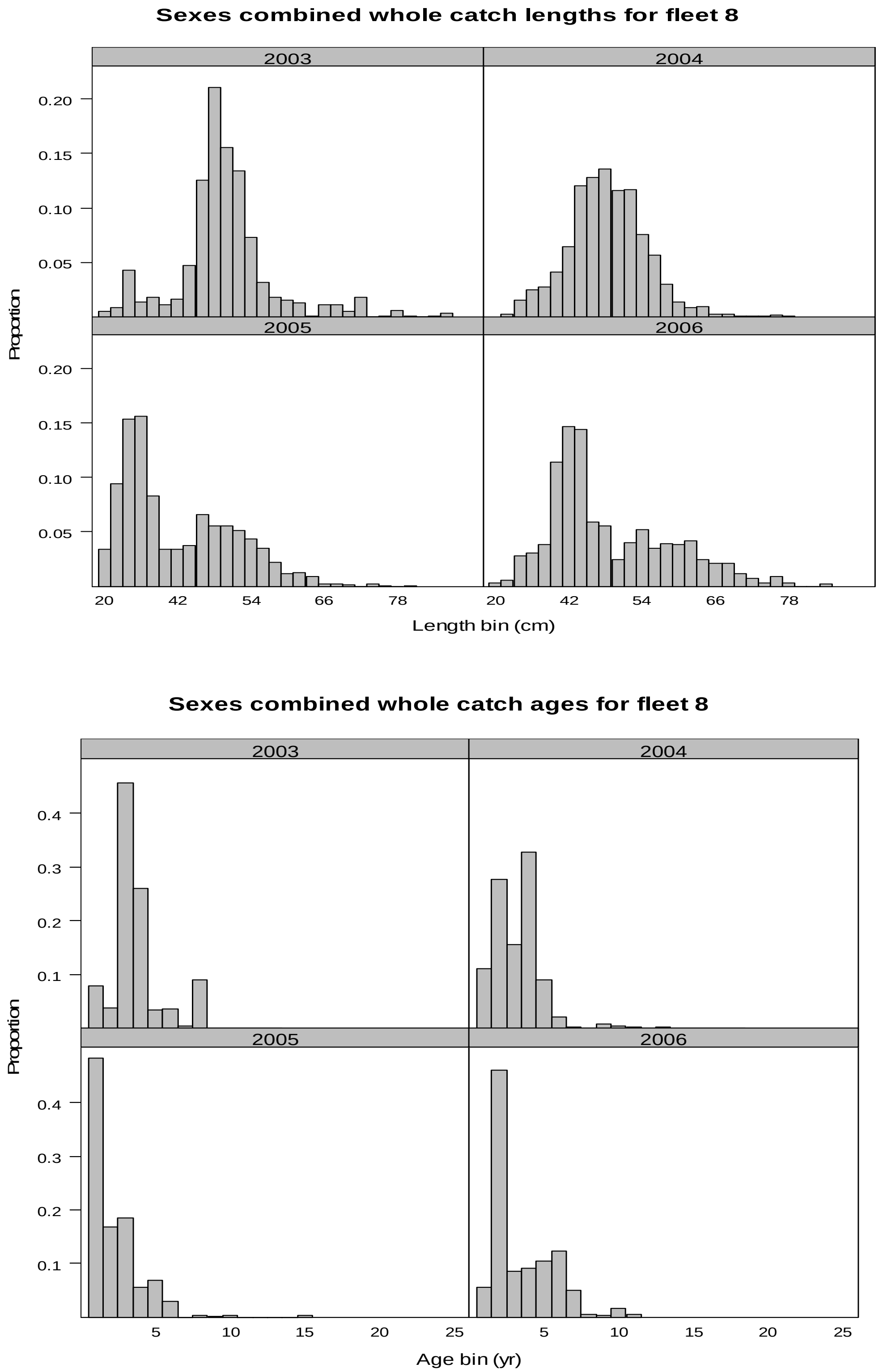


Figure 12. *Length (top) and age (bottom) frequencies for sablefish caught in the NWFSC shelf trawl survey.*

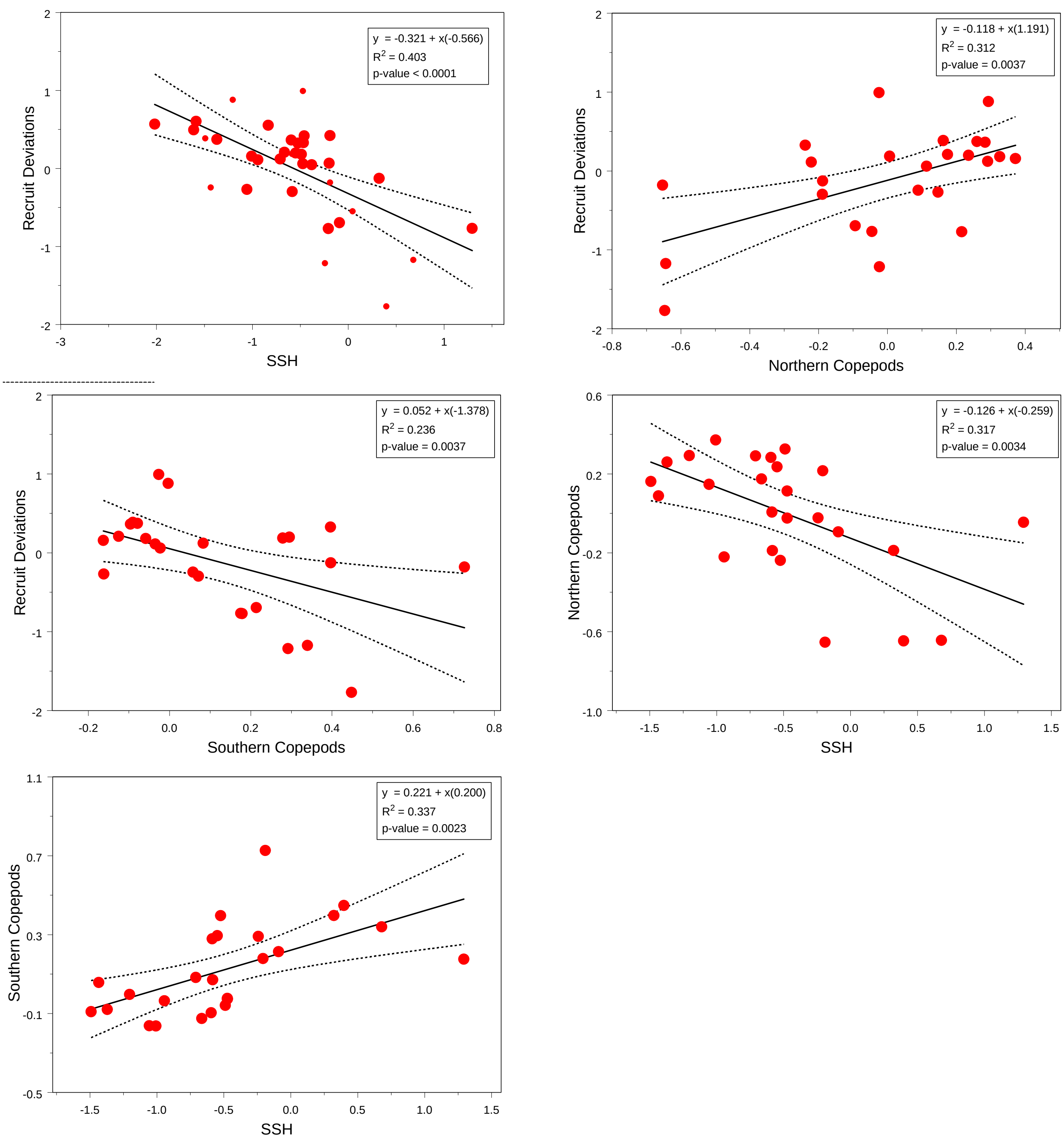


Figure 13. *Linear regression fits (with 95% CI's) to recruitment deviations from model configuration number 1 (no environment indices) and the various environmental indices that were considered and the first principal component of {SSH, northern copepods, and southern copepods}(Bottom right).*

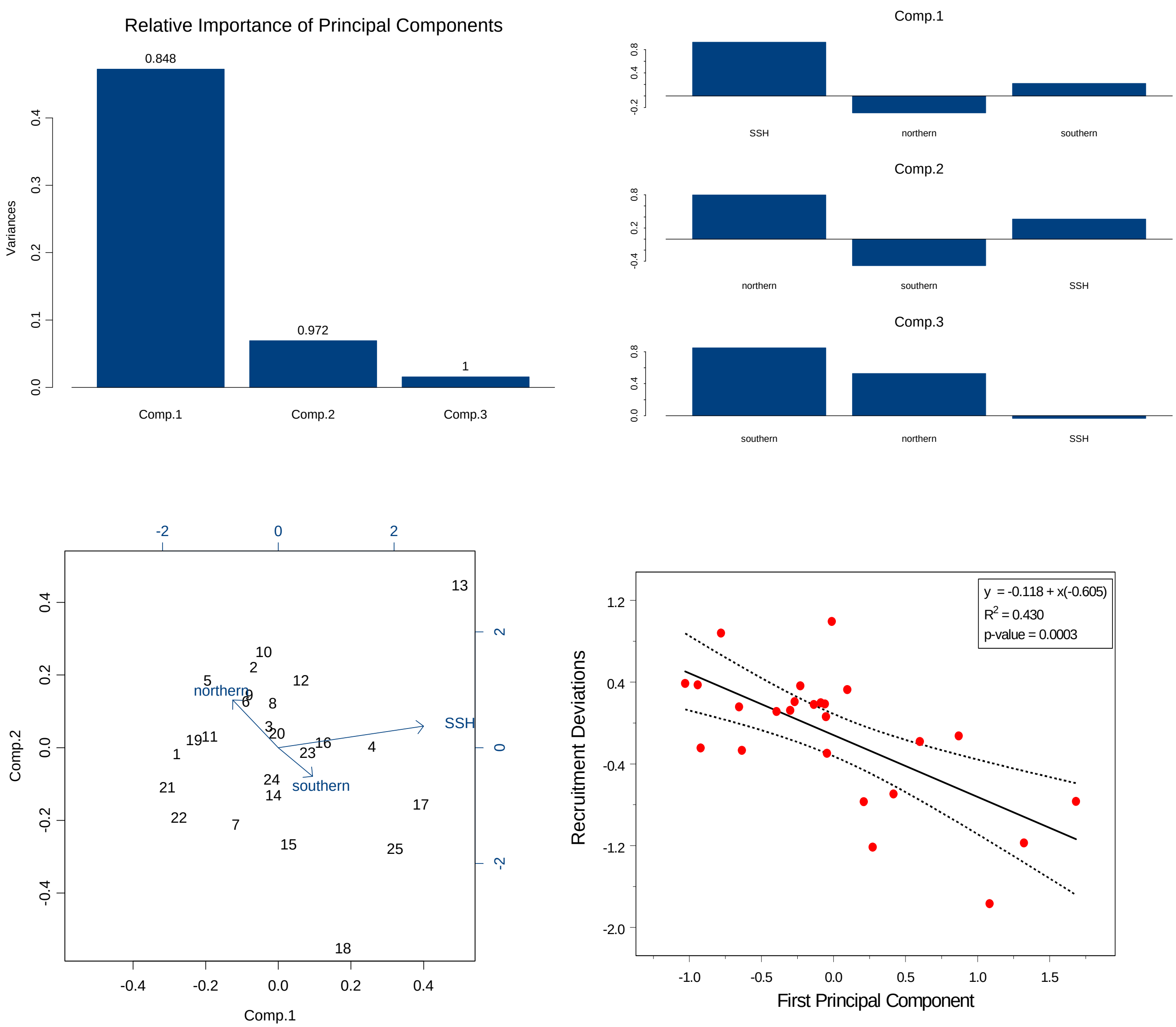


Figure 14 . *Results of Principal Component Analysis conducted on SSH, northern copepods, and southern copepods; linear regression fits to recruitment deviations and the first principal component of {SSH, northern copepods, and southern copepods}(Bottom right)*

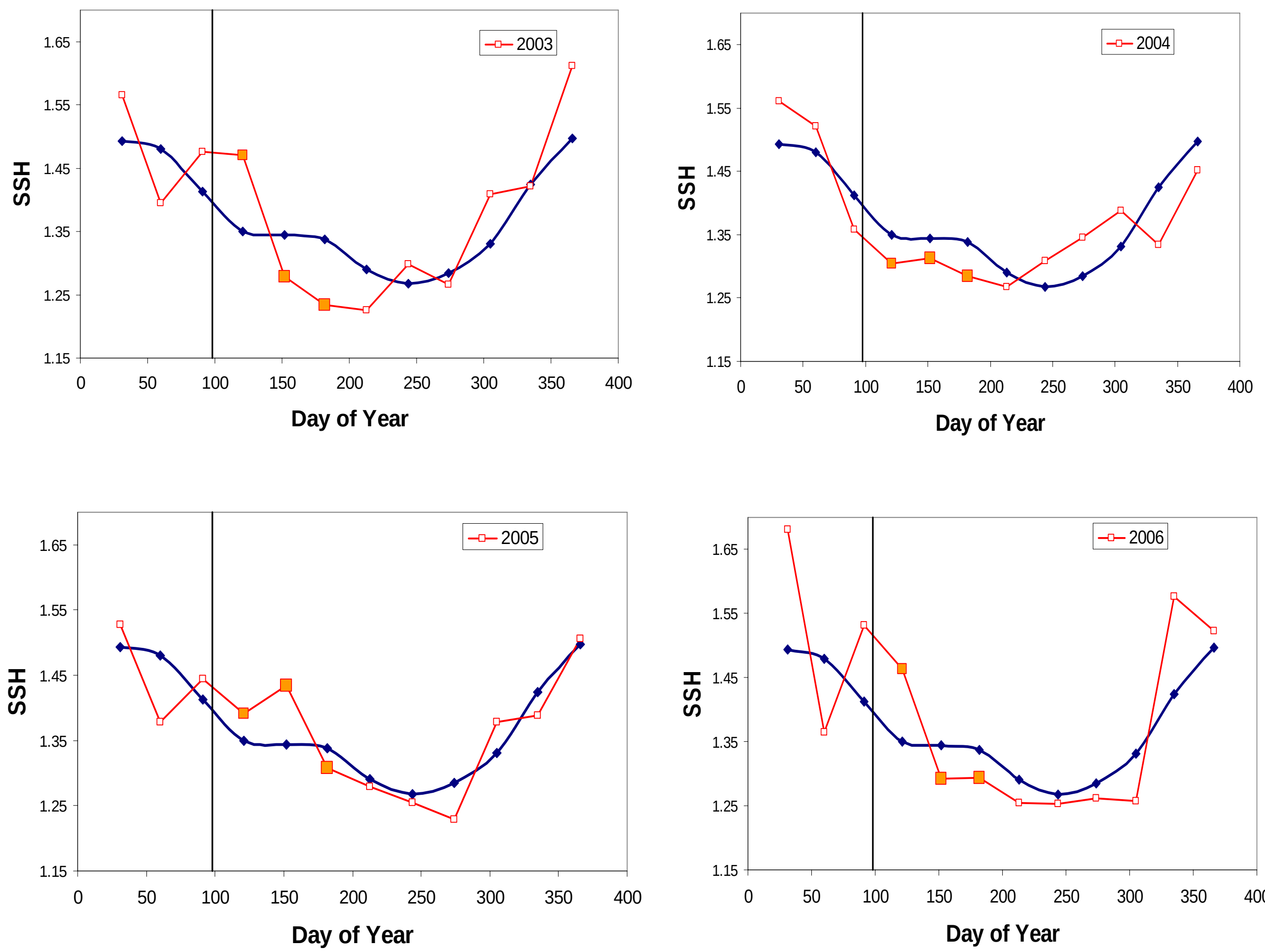
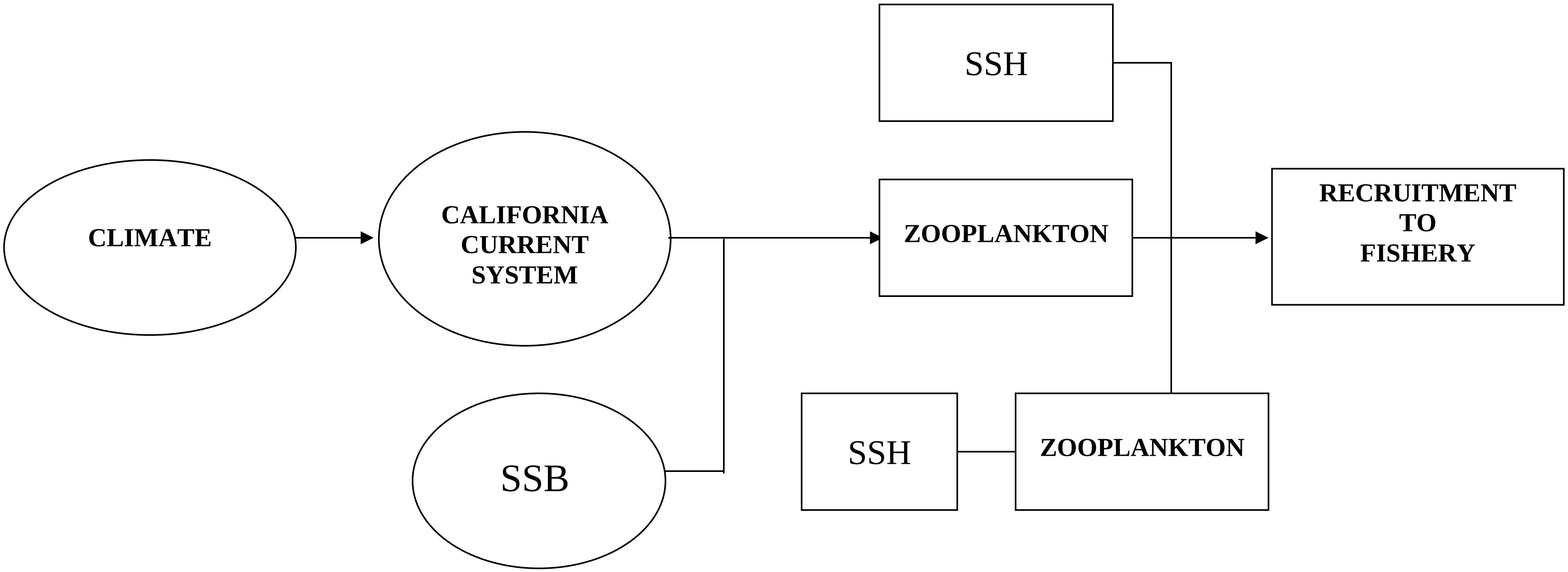


Figure 15. *Sea surface height for 48-50 degrees Latitude by year and month. Vertical line depicts the beginning of the critical period for sablefish larval/juveniles phases. 2004 was an above average year class strength (lower than average SSH for April, May, and June) while 2005 was below average in strength (higher than average SSH for April, May, and June).*

Figure 16. *Simplified conceptual model of sablefish recruitment process*



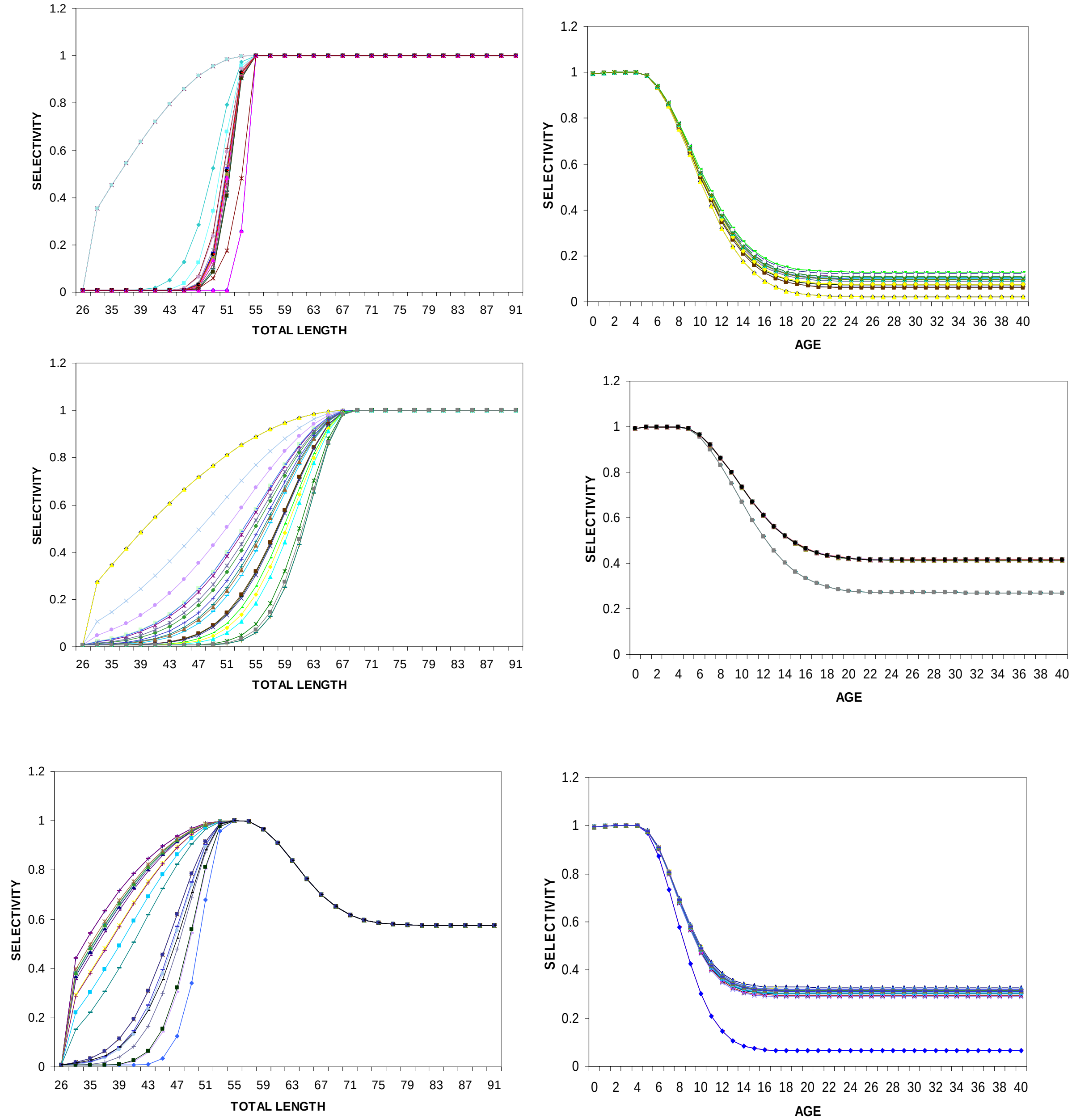


Figure 17. *Length (left) and age (right) based selectivities for hook-and-line (top), pot (middle), and trawl gear (bottom) for post-STAR STAT model.*

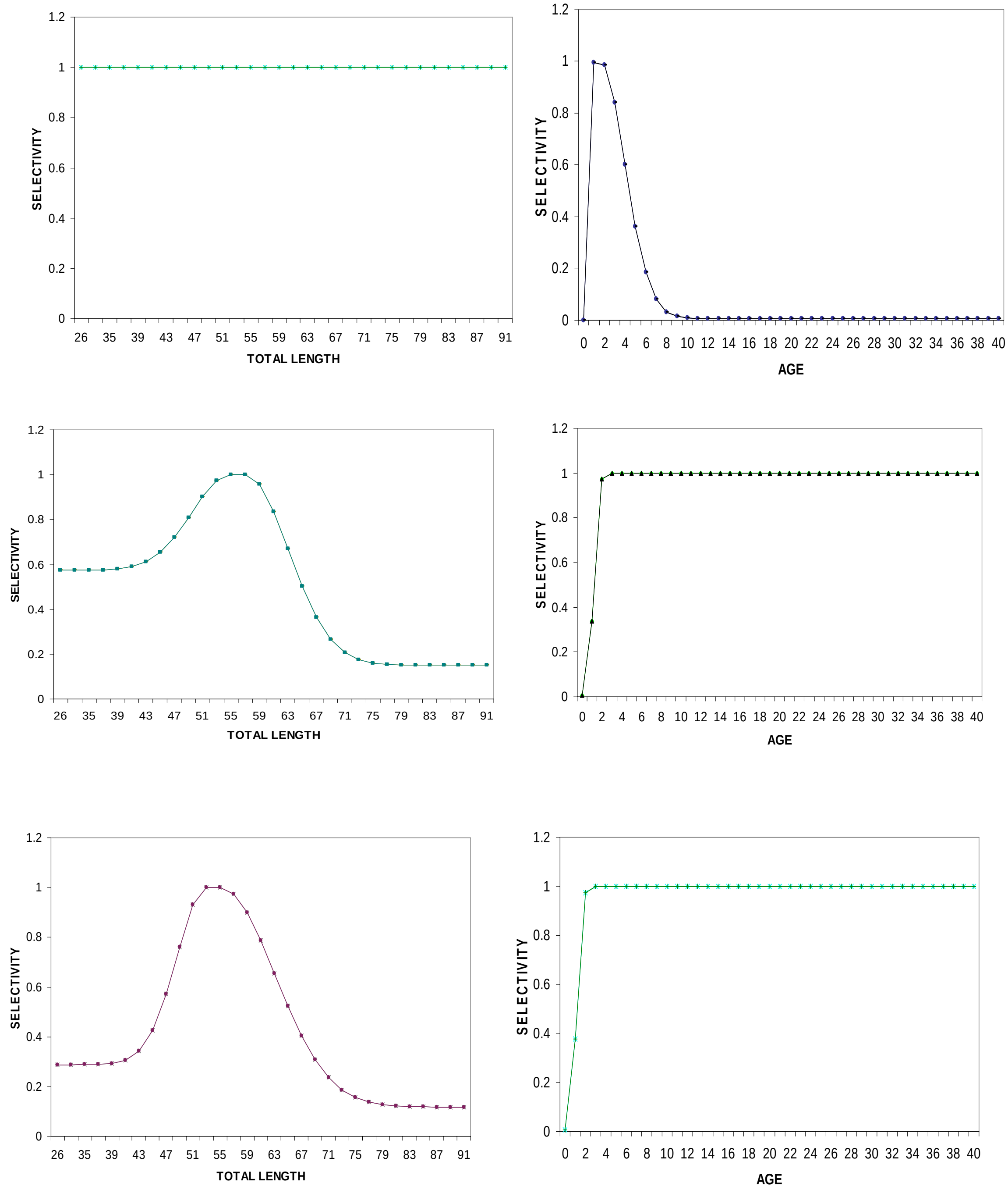


Figure18. *Length (left) and age (right) based selectivities for AFSC shelf survey (top), AFSC slope survey (middle), and NWFSC combined/slope survey (bottom) for post-STAR STAT model.*

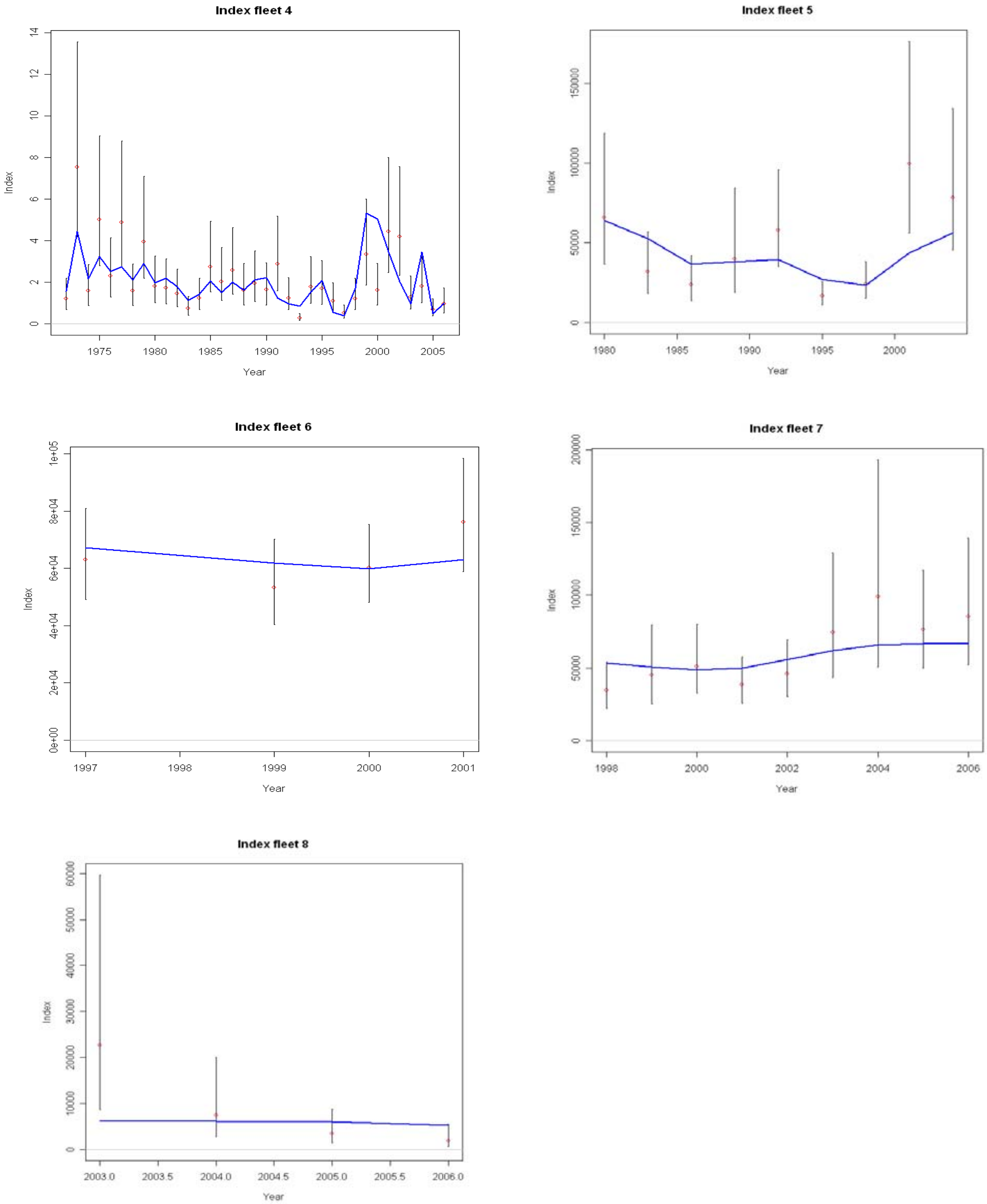
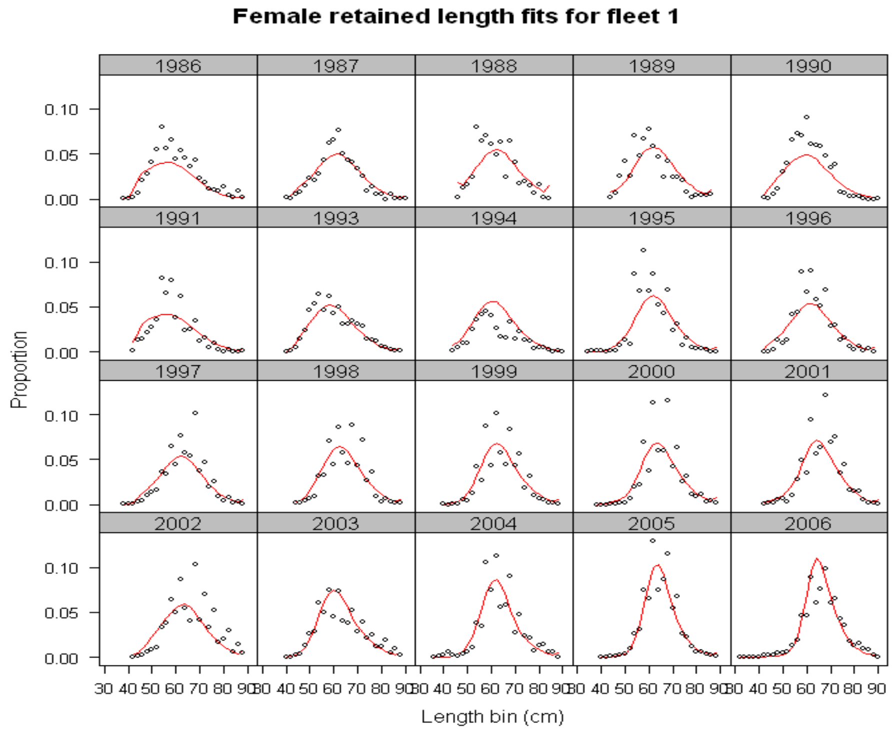


Figure 19. *Observed and expected CPUE for SSH index (upper left), AFSC shlef survey (upper right), AFSC slope survey (middle left), NWFSC combined/slope survey (middle right), and NWFSC combined/shelf survey (bottom left).*



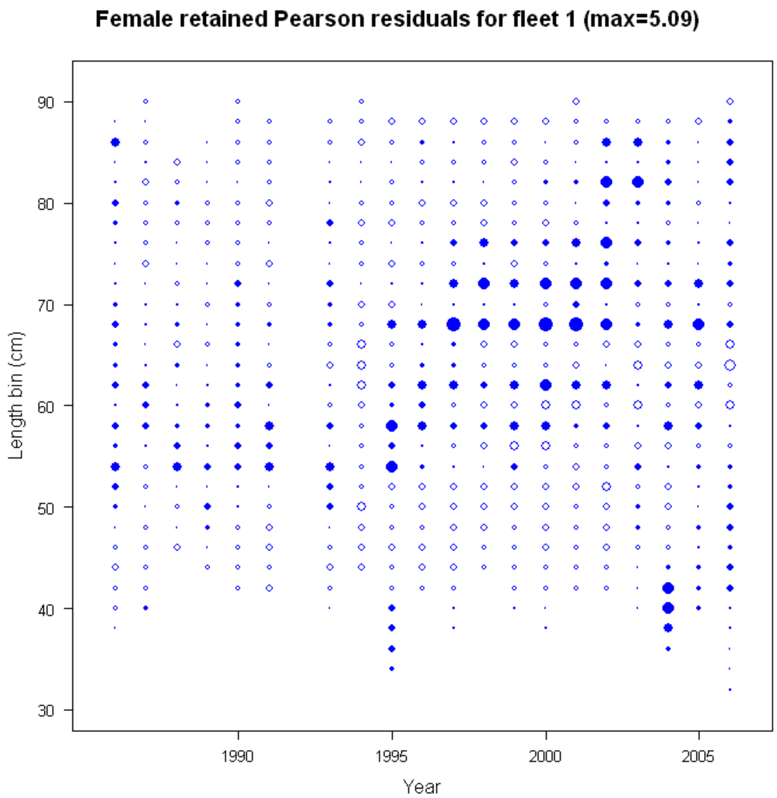


Figure 20. *Observed and expected female length compositions and residuals for hook-and-line fihsery for the post-STAR STAT model.*

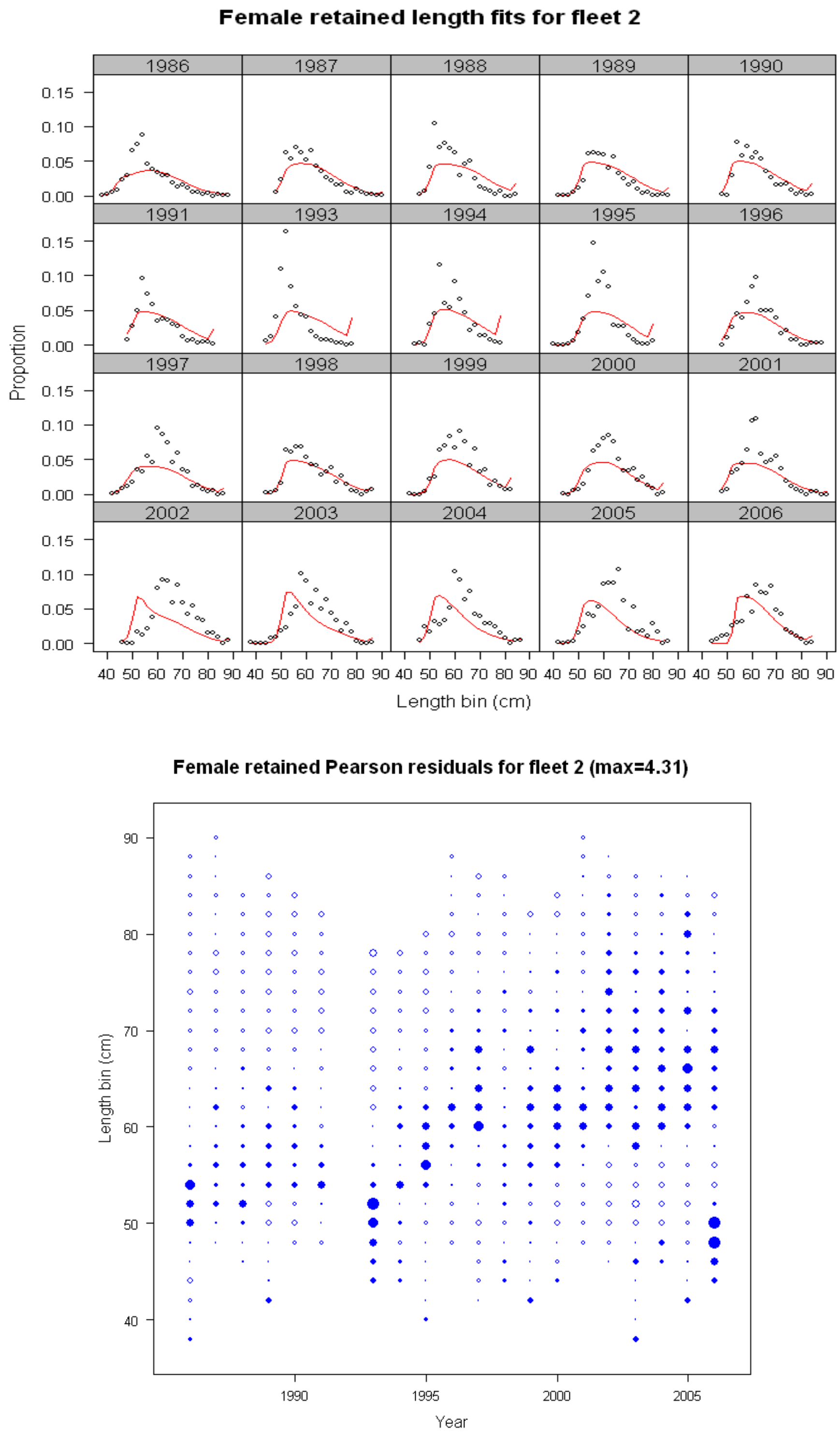


Figure 21. *Observed and expected female length compositionsand residuals for pot fihsery for the post-STAR STAT model.*

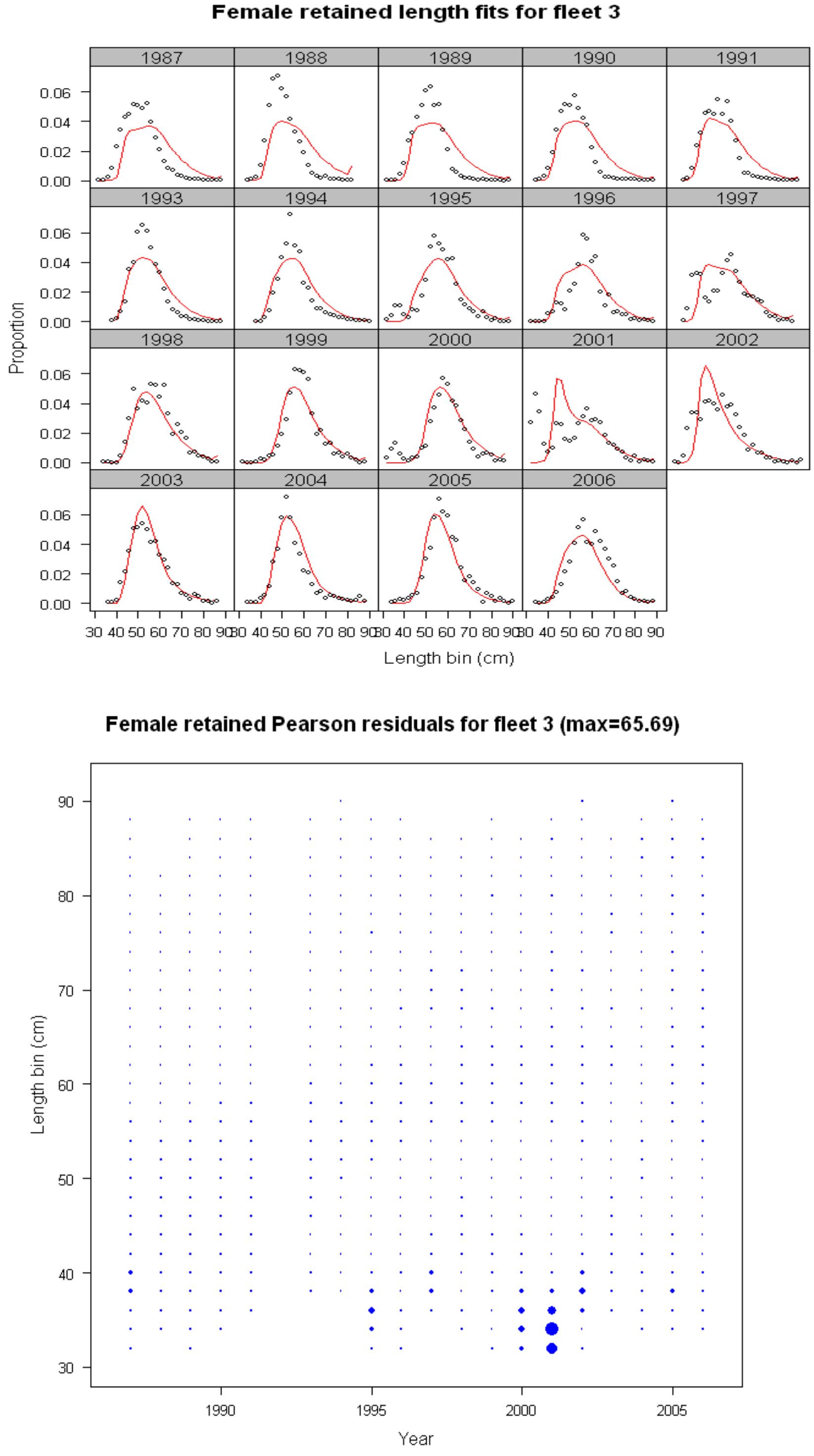


Figure 22. *Observed and expected female length compositions and residuals for trawl fishery for the psot-STAR STAT model.*

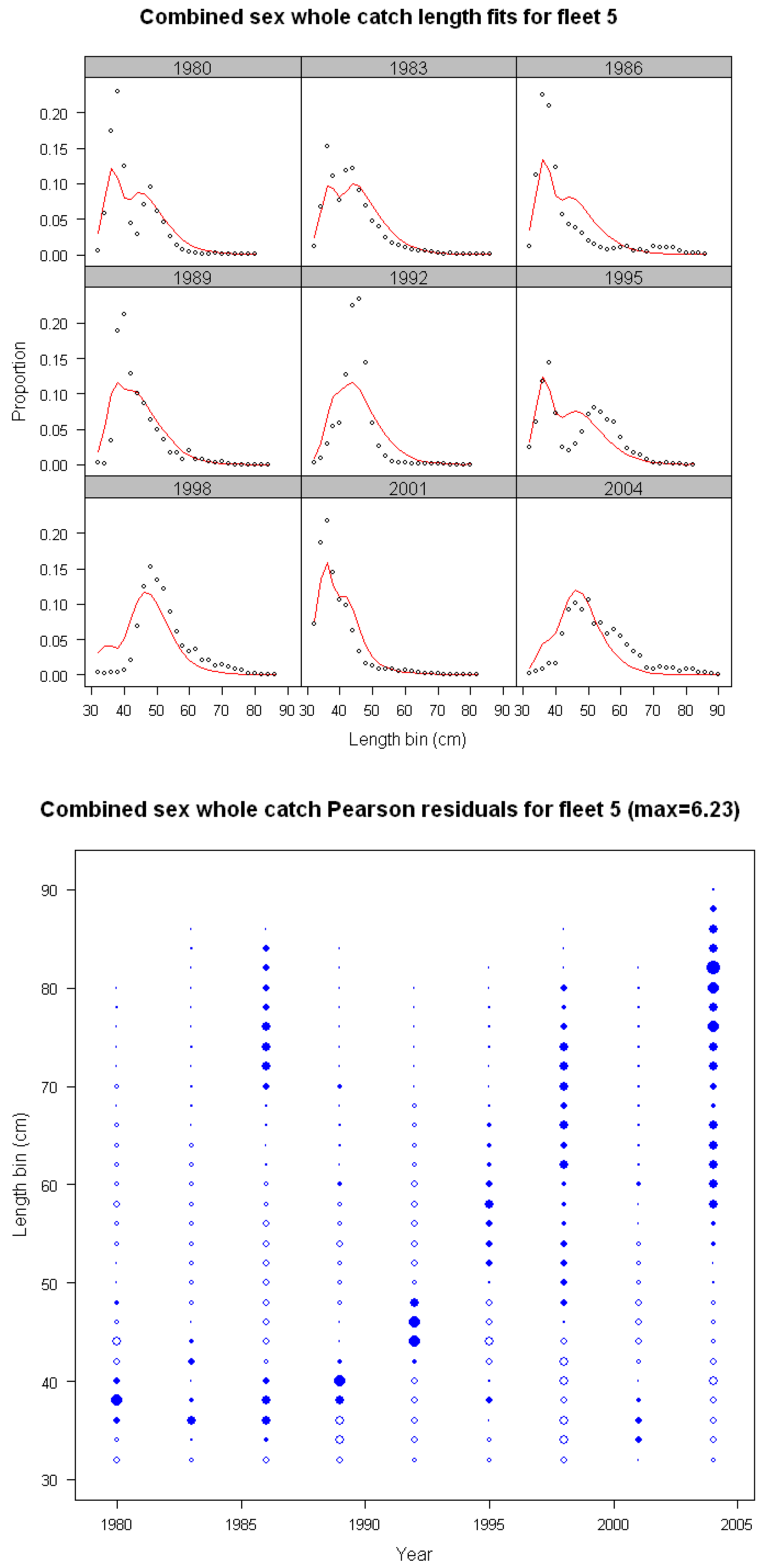


Figure 23. *Observed and expected female length compositions and residuals forAFSC shelf survey for the psot-STAR STAT model*

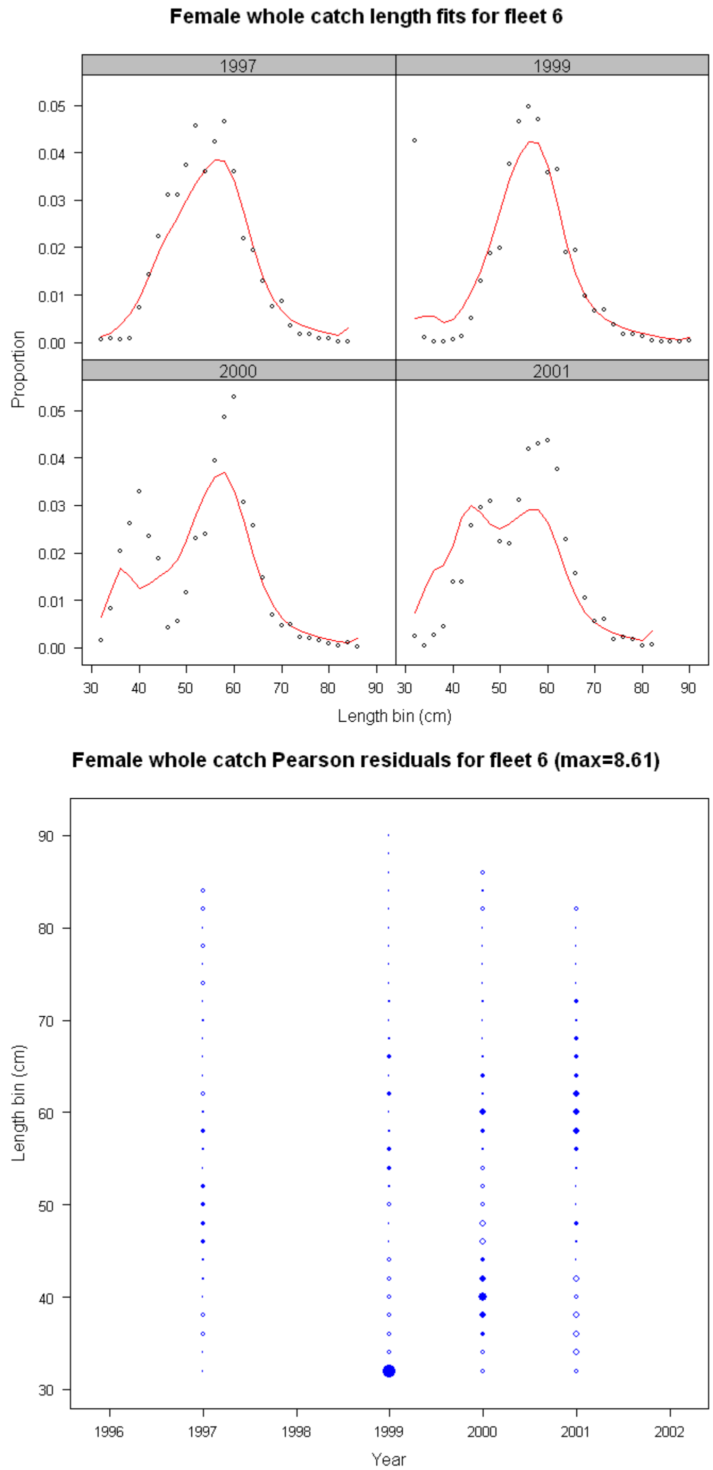
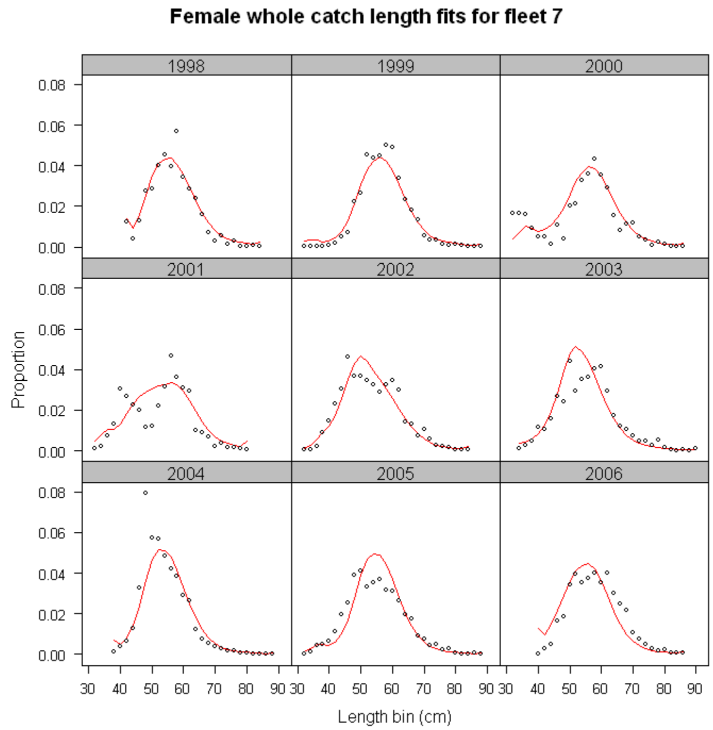


Figure 24. *Observed and expected female length compositions and residuals for AFSC slope survey for the psot-STAR STAT model*



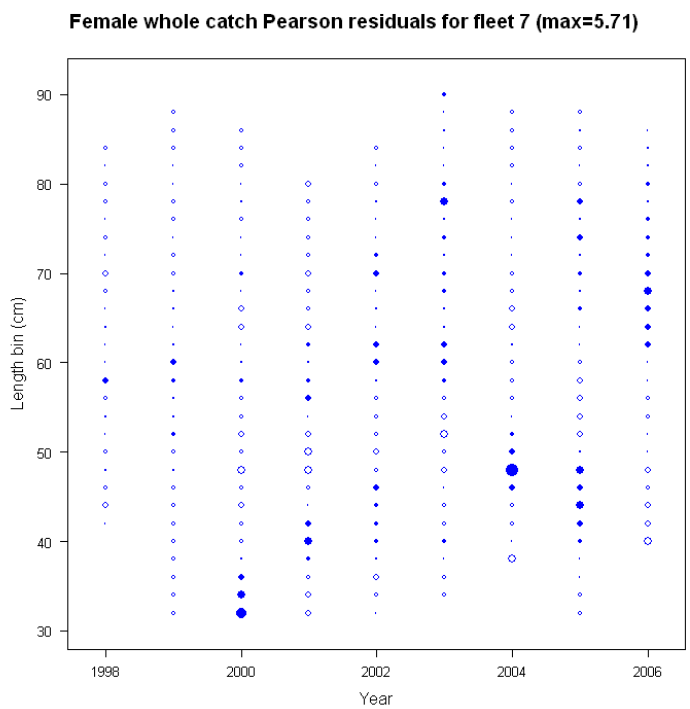


Figure 25. *Observed and expected female length compositions and residuals for NWFSC combined/slope survey for the psot-STAR STAT model*

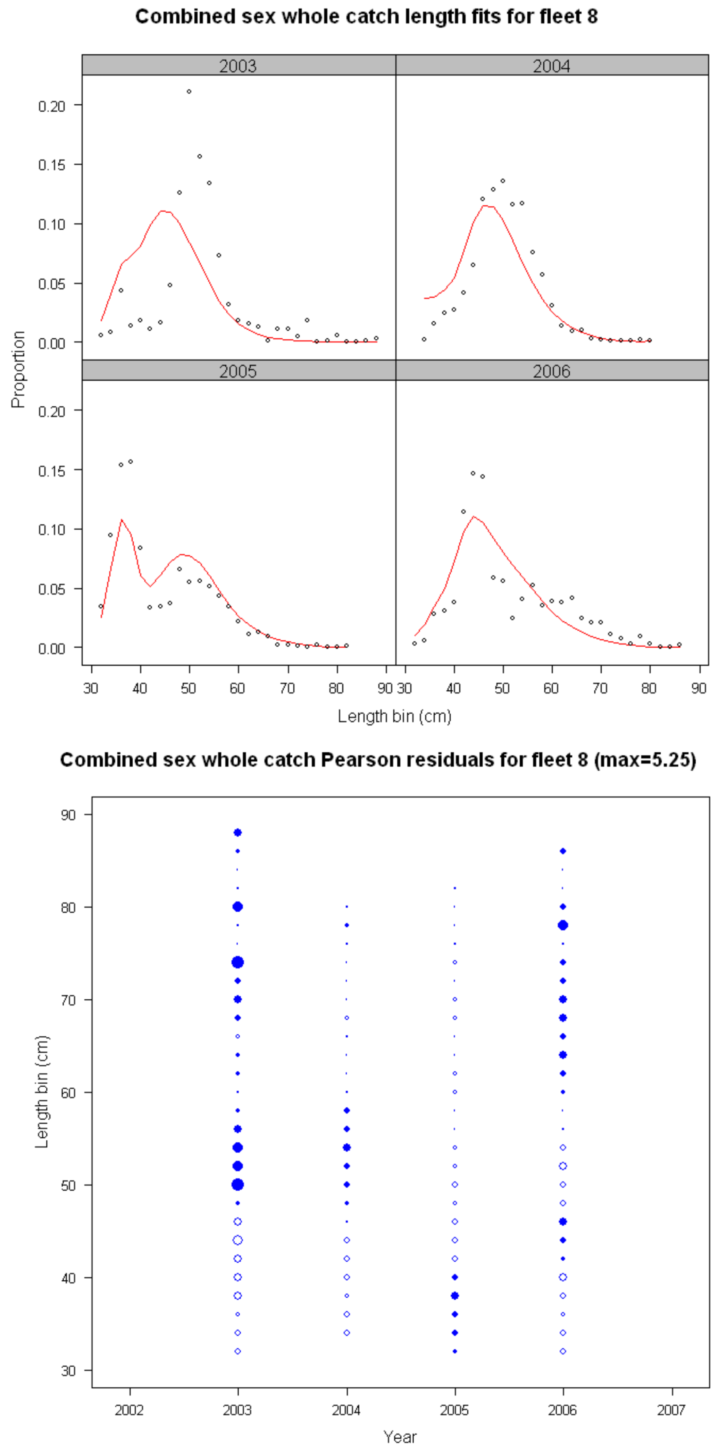


Figure 26. *Observed and expected length compositions and residuals for NWFSC combined/shelf survey for the psot-STAR STAT model*

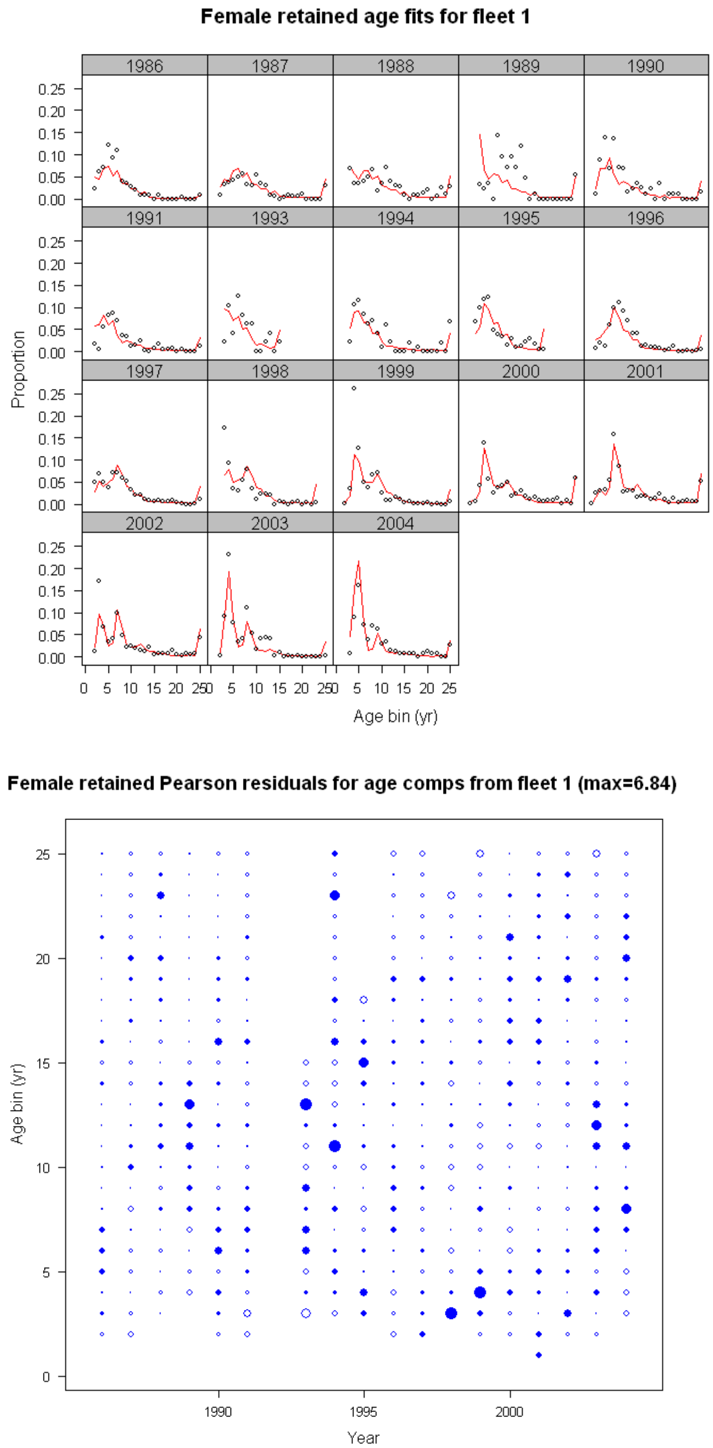
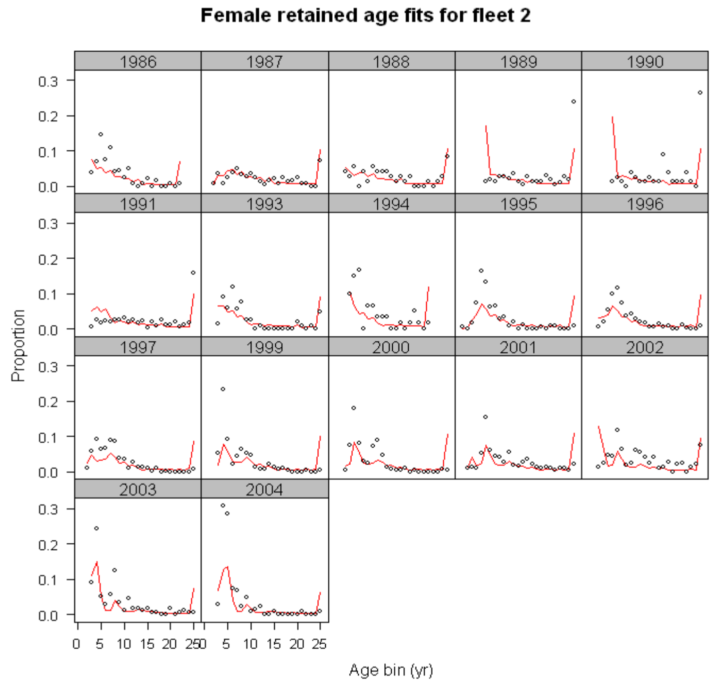


Figure 27. *Observed and expected female age compositions and residuals for hook-and-line fihsery for the post-STAR STAT model.*



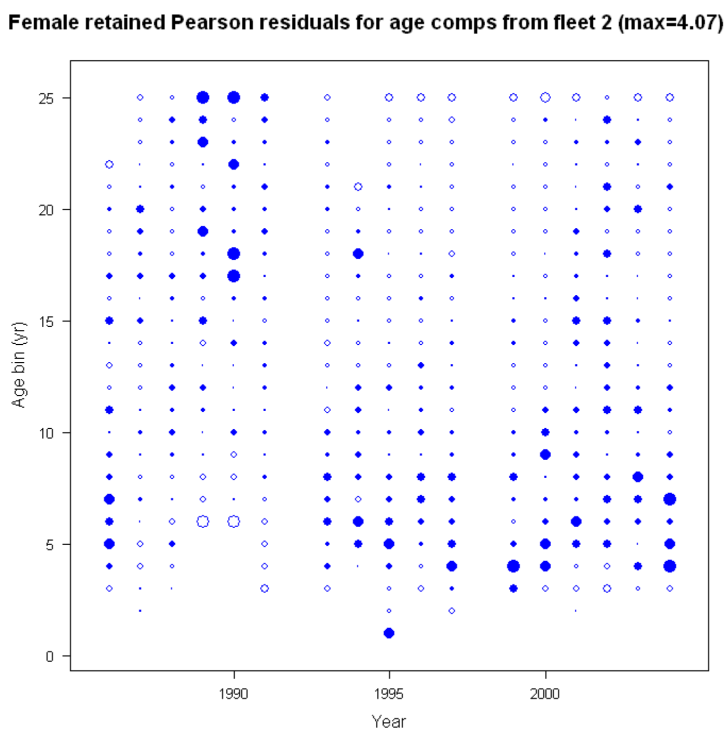
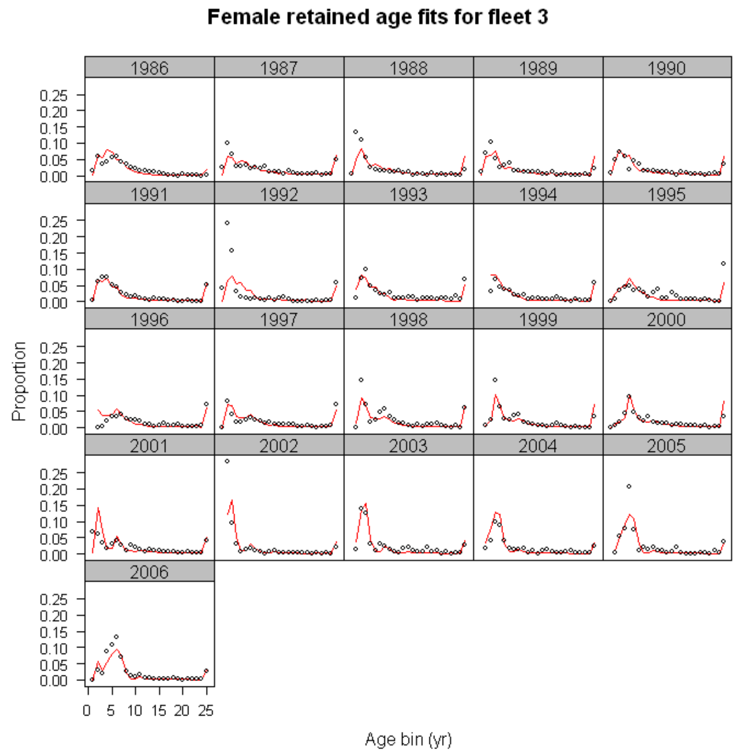


Figure 28. *Observed and expected female age compositions and residuals for pot fihsery for the post-STAR STAT model.*



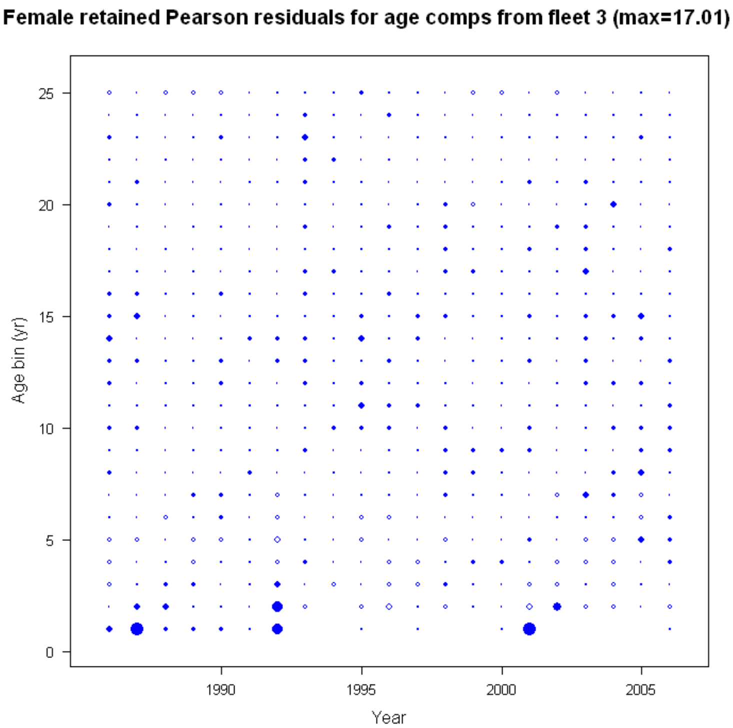
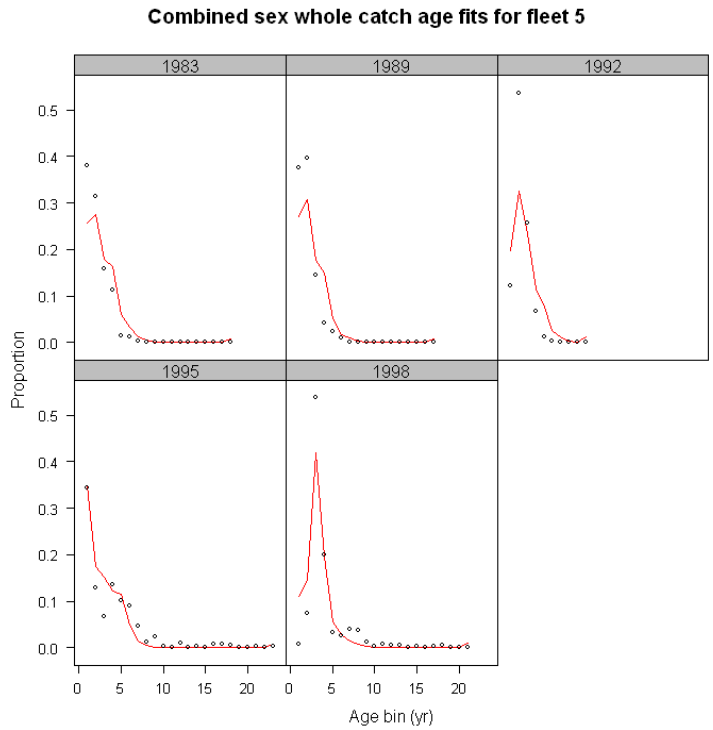


Figure 29. Observed and expected female age compositions and residuals for trawl fihsery for the post-STAR STAT model.



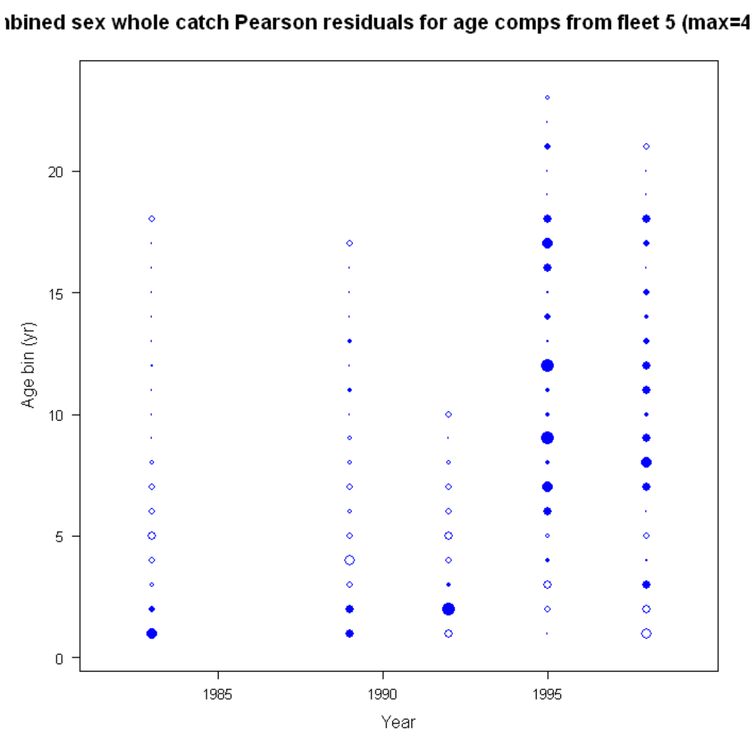
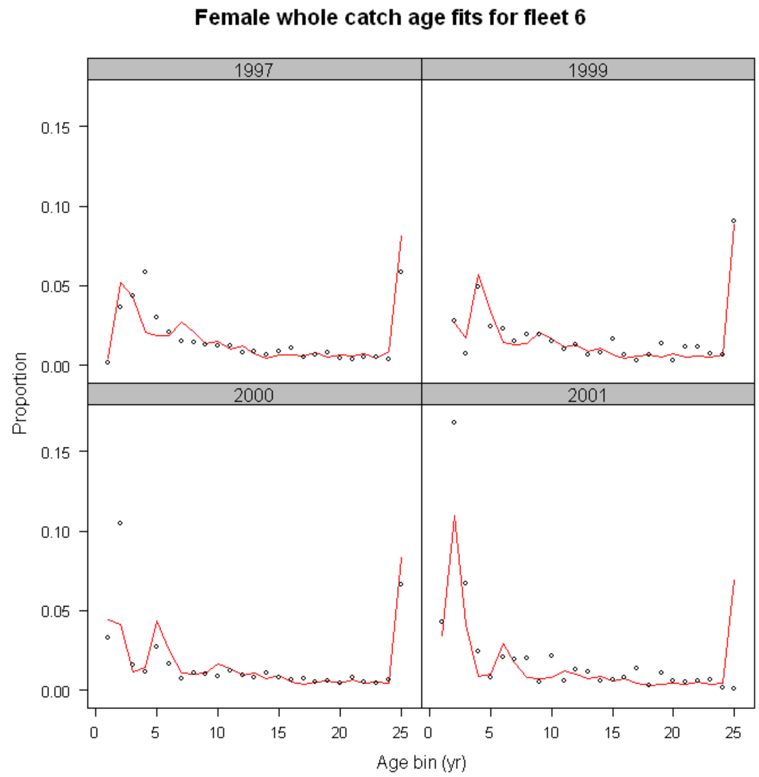


Figure 30. *Observed and expected age compositions and residuals for AFSC shelf survey for the post-STAR STAT model.*



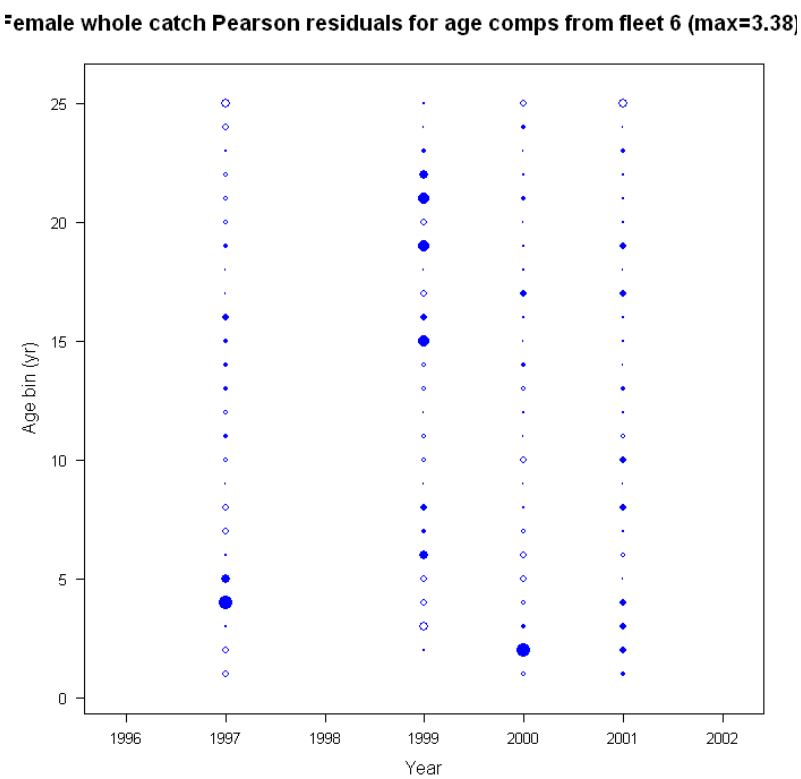
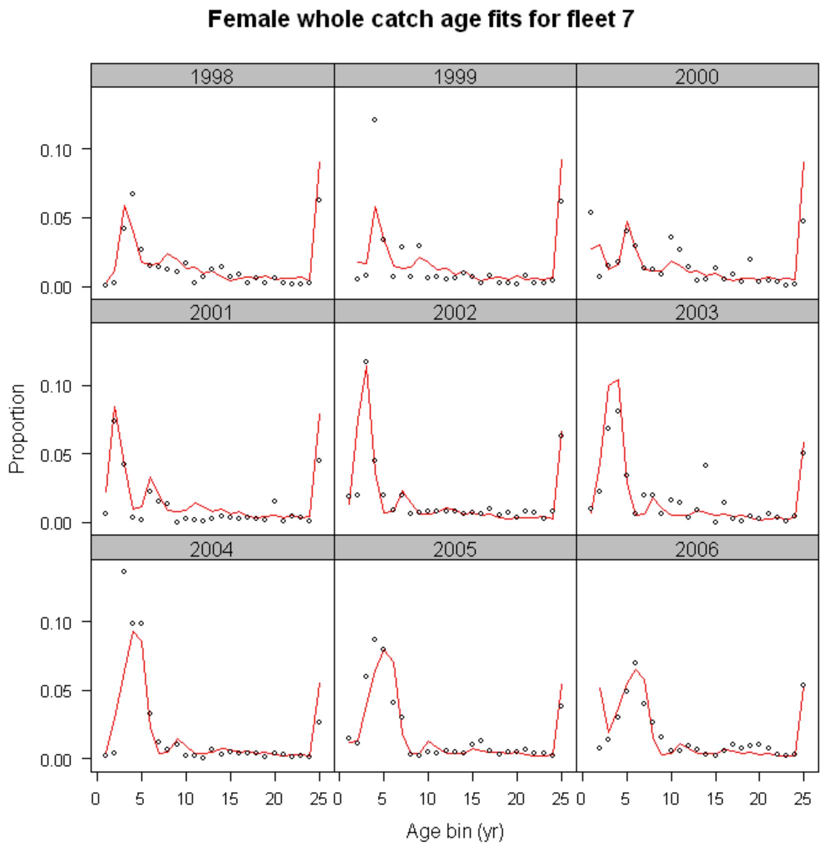


Figure 31. *Observed and expected age compositions and residuals for AFSC slope survey for the post-STAR STAT model.*



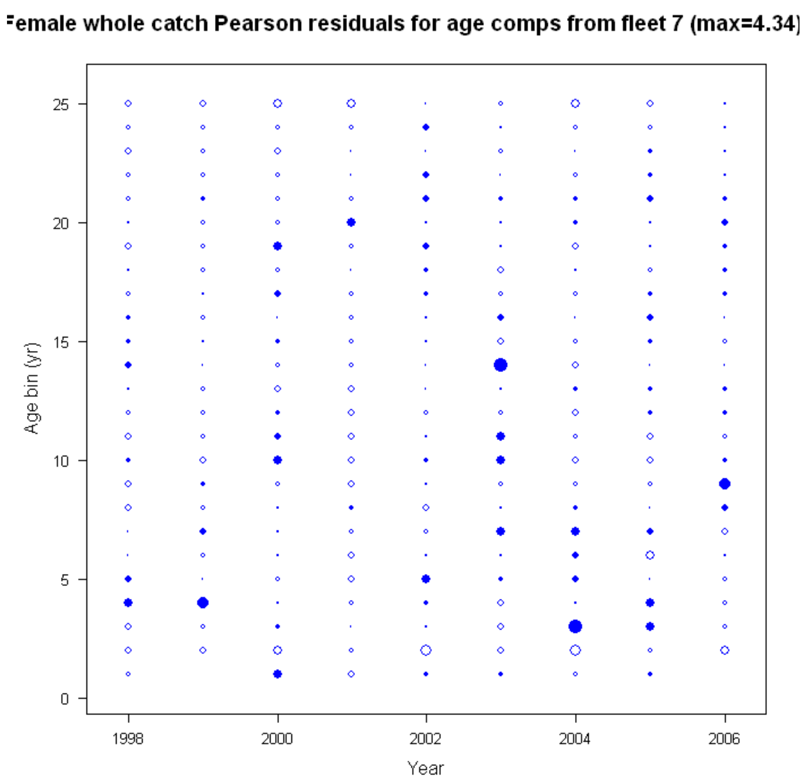
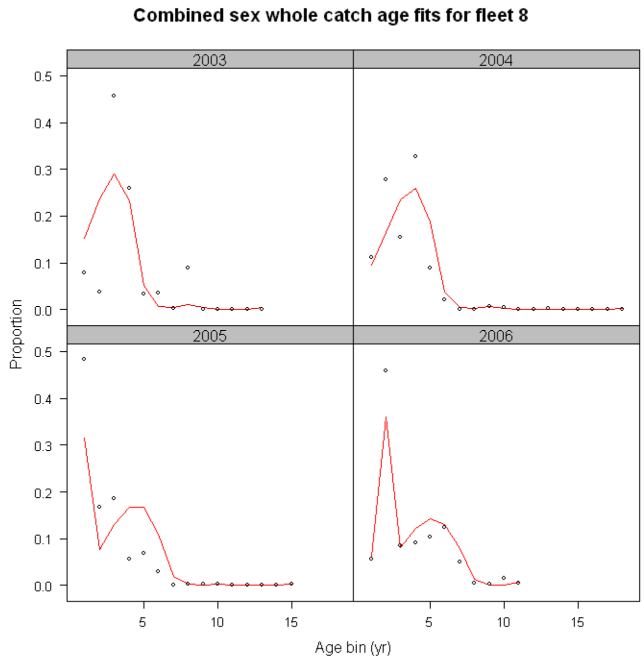


Figure 32. *Observed and expected age compositions and residuals for NWFSC combined/slope survey for the post-STAR STAT model.*



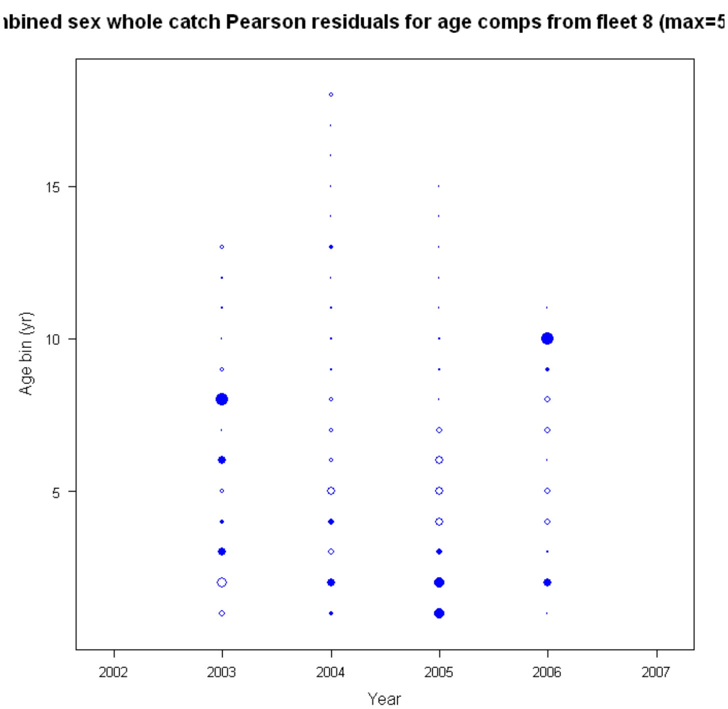
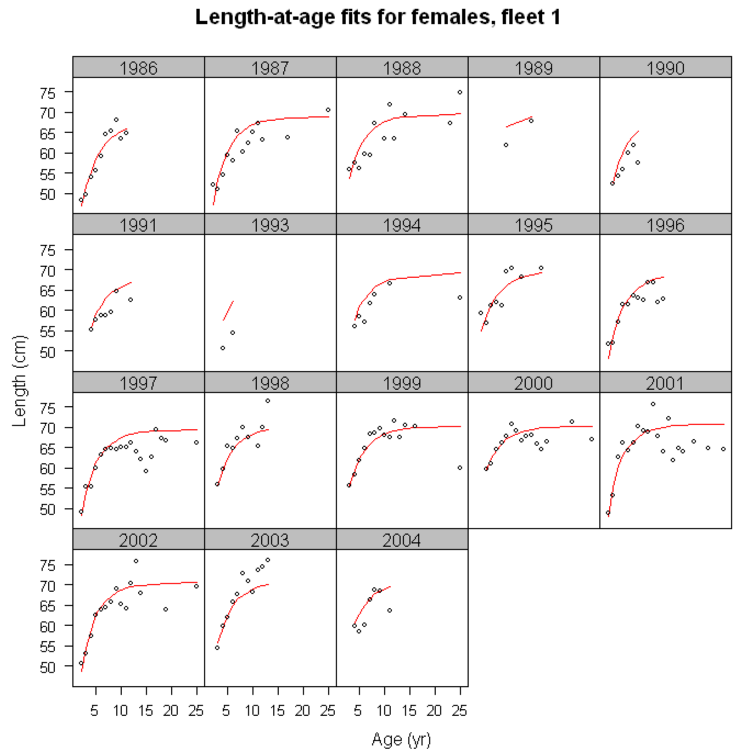


Figure 33. *Observed and expected age compositions and residuals for NWFSC combined/shelf survey for the post-STAR STAT model.*



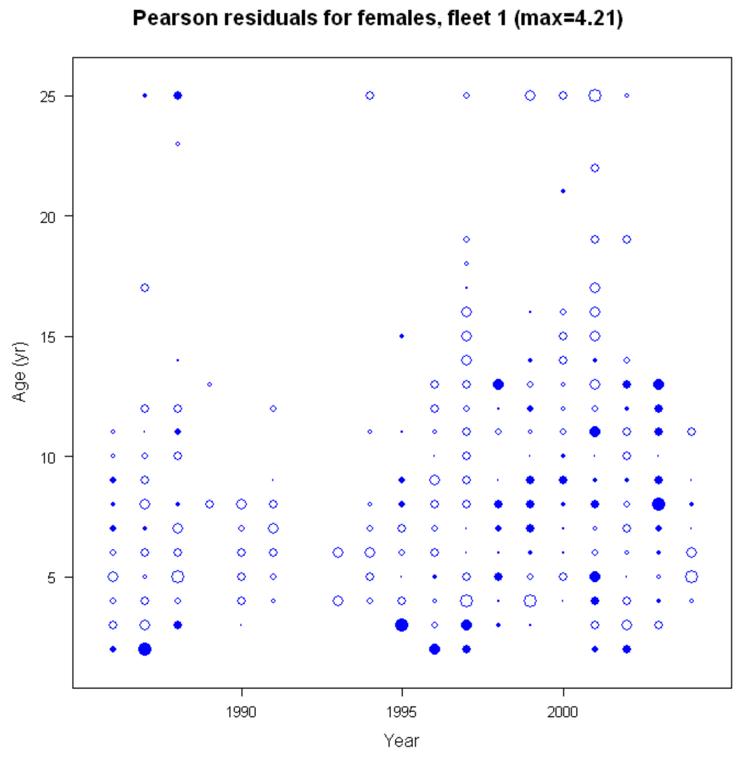


__Figure 34.__ Observed and expected female length-at-age and residuals forhook-and-line fihsery for the post-STAR STAT model.

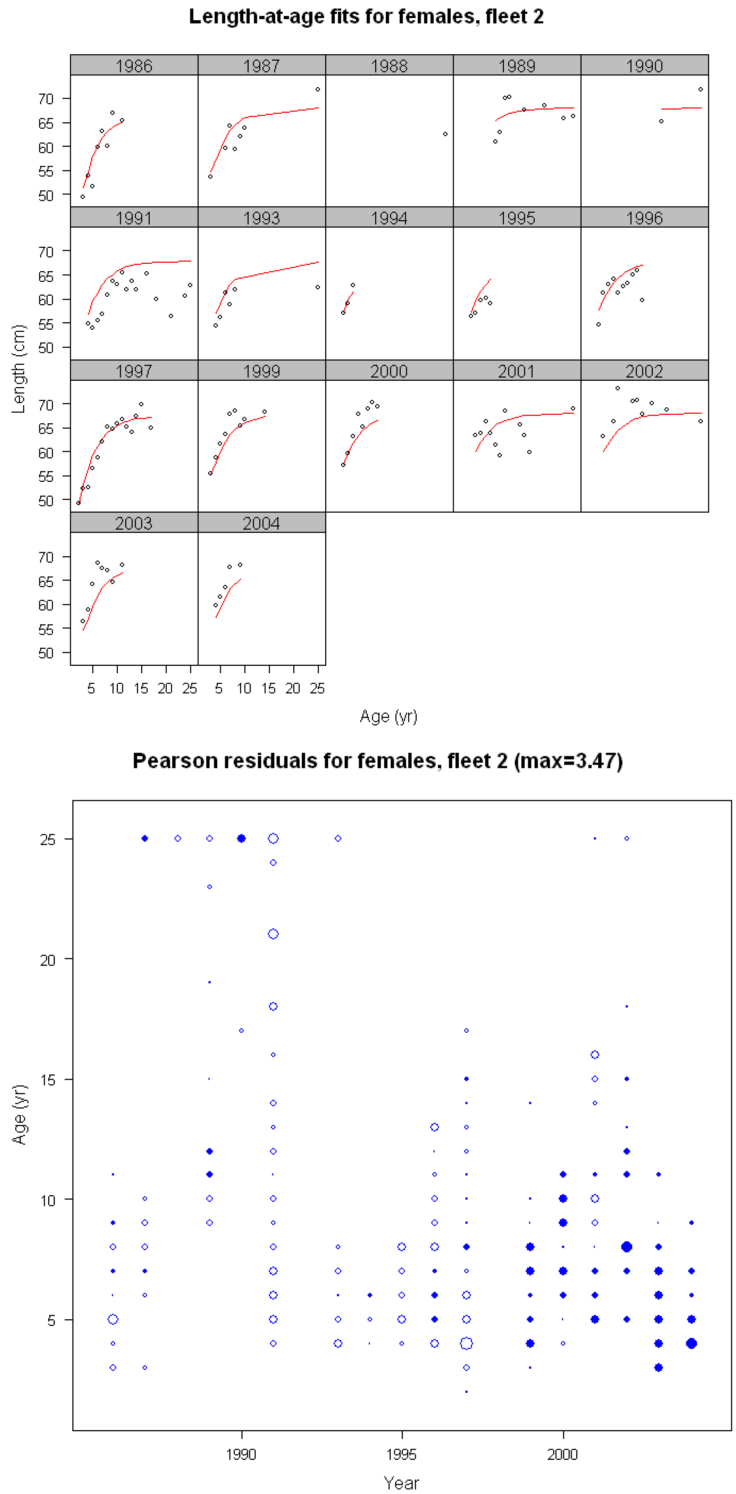
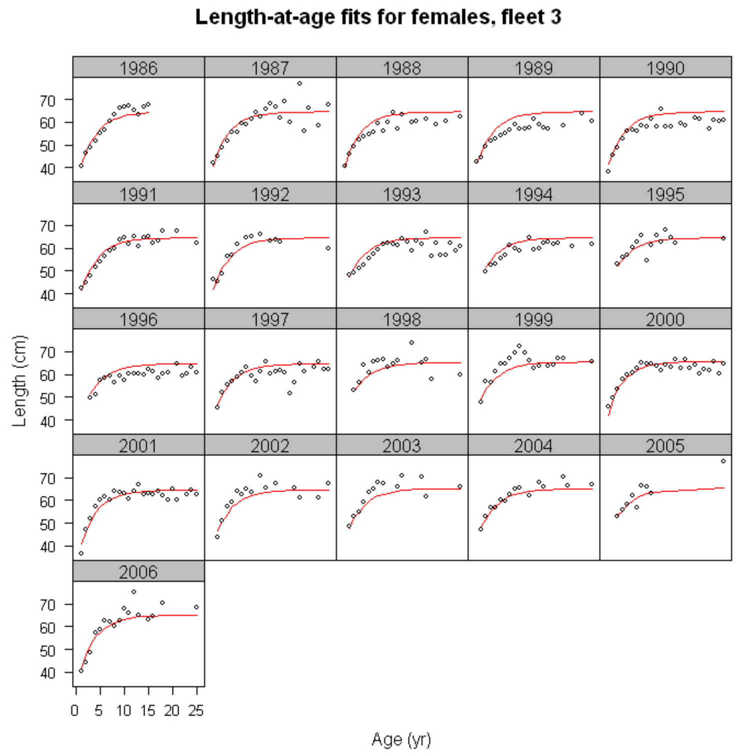


Figure 35. *Observed and expected female length-at-age and residuals for pot fishery for the post-STAR STAT model.*



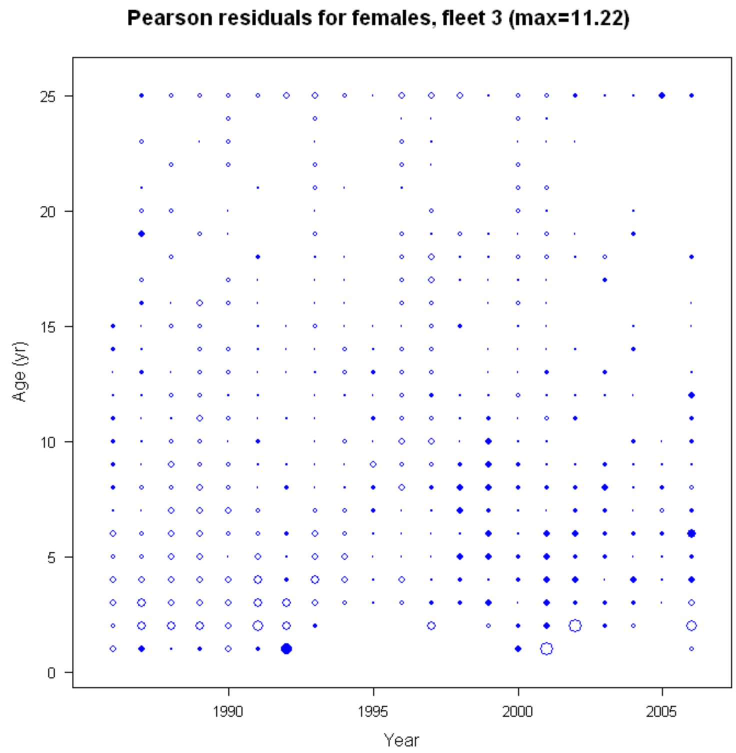
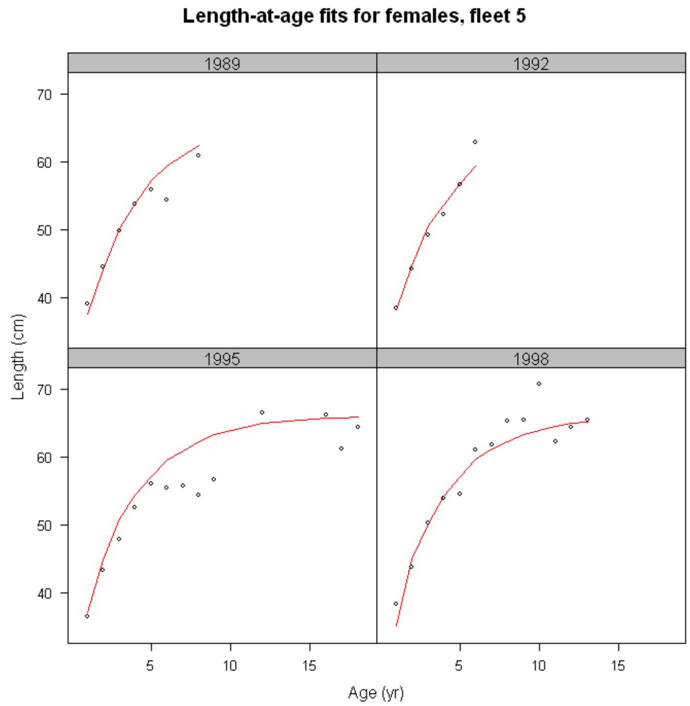


Figure 36. *Observed and expected female length-at-age and residuals for trawl fishery for the post-STAR STAT model.*



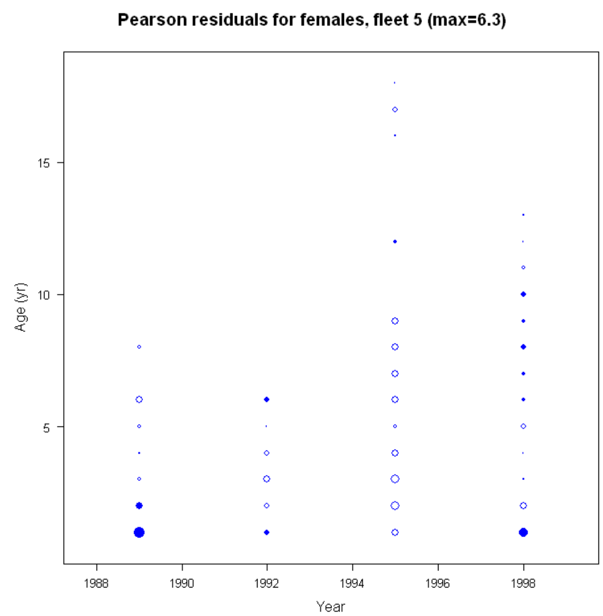
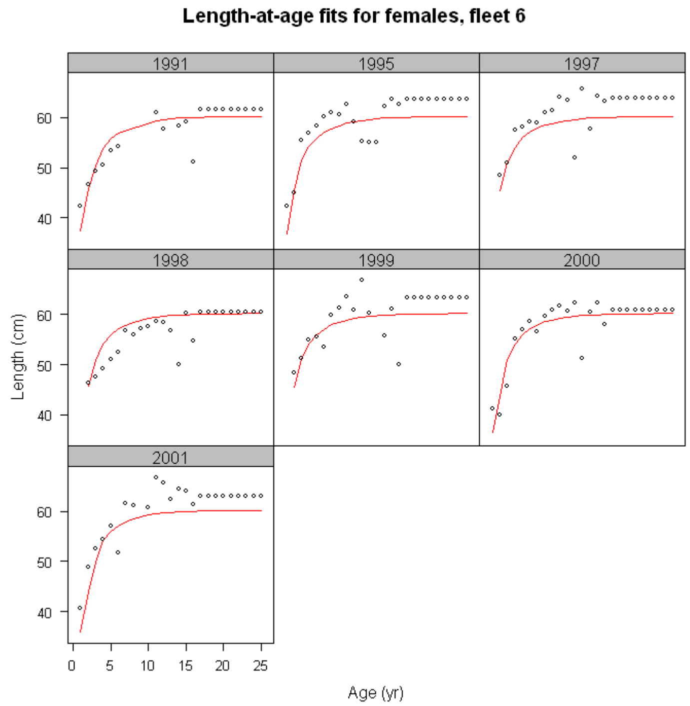


Figure 37. *Observed and expected female length-at-age and residuals for AFSC shelf survey for the post-STAR STAT model.*



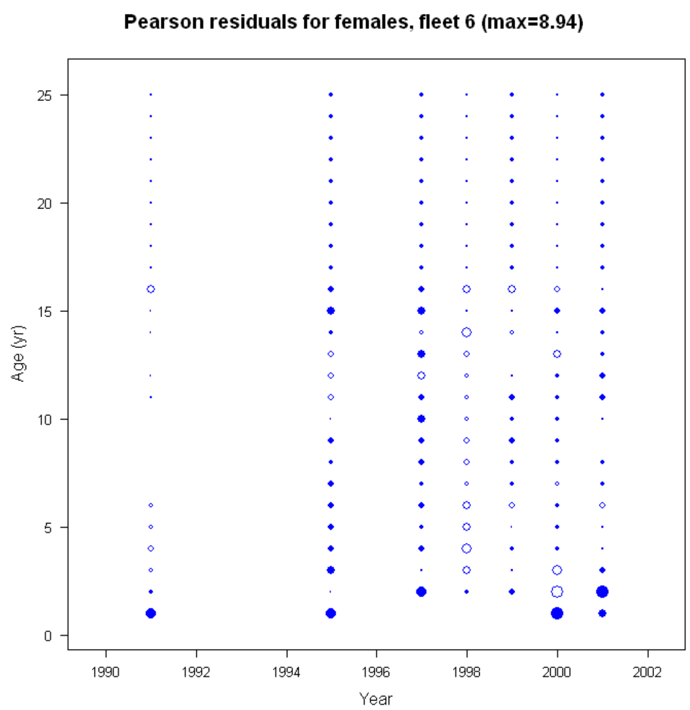
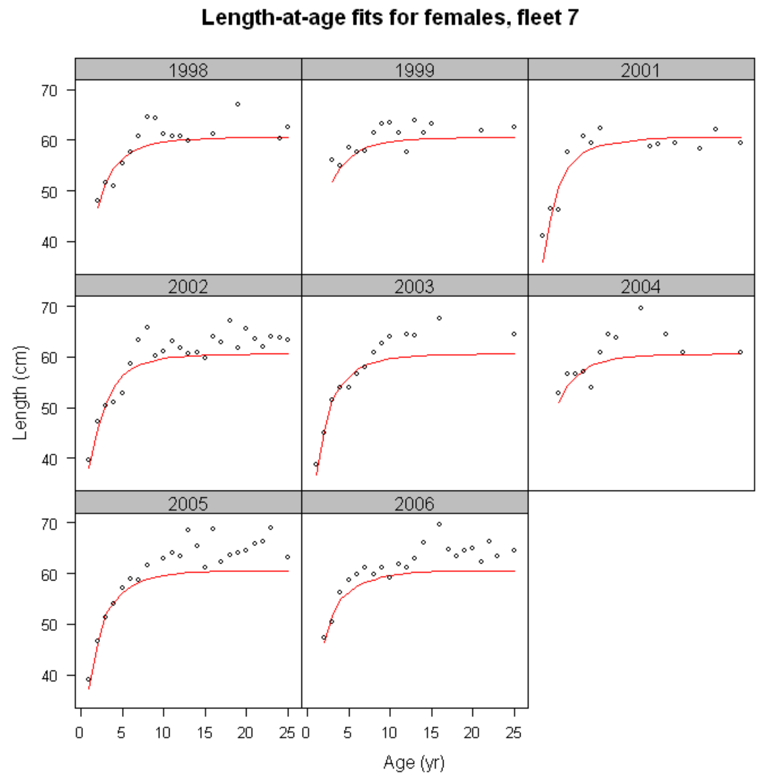


Figure 38. *Observed and expected female length-at-age and residuals for AFSC slope survey for the post-STAR STAT model.*



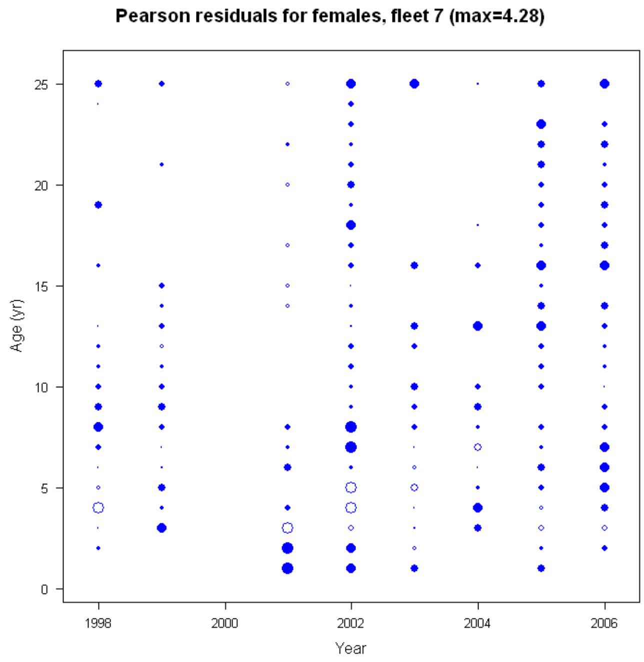
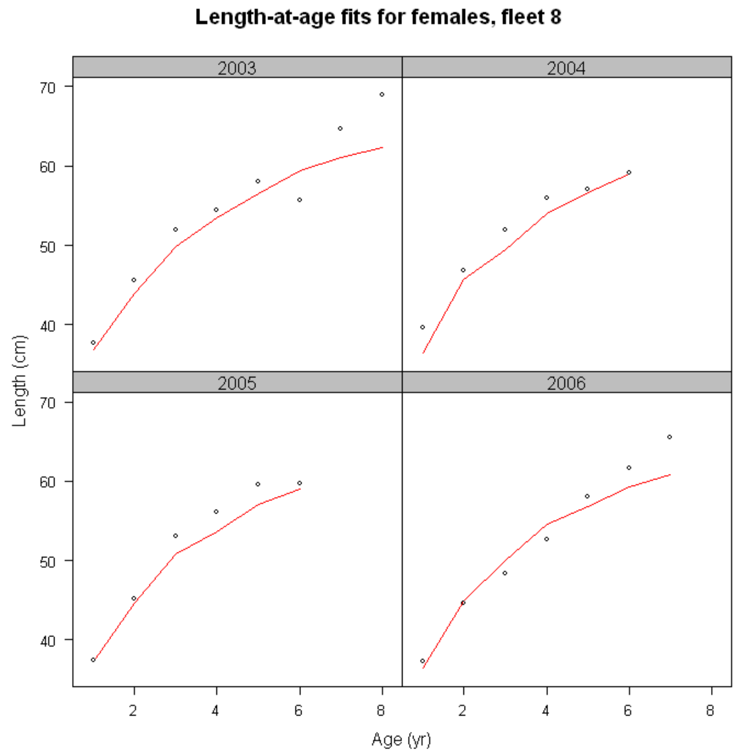


Figure 39. *Observed and expected female length-at-age and residuals for NWFSC combined/slope survey for the post-STAR STAT model.*



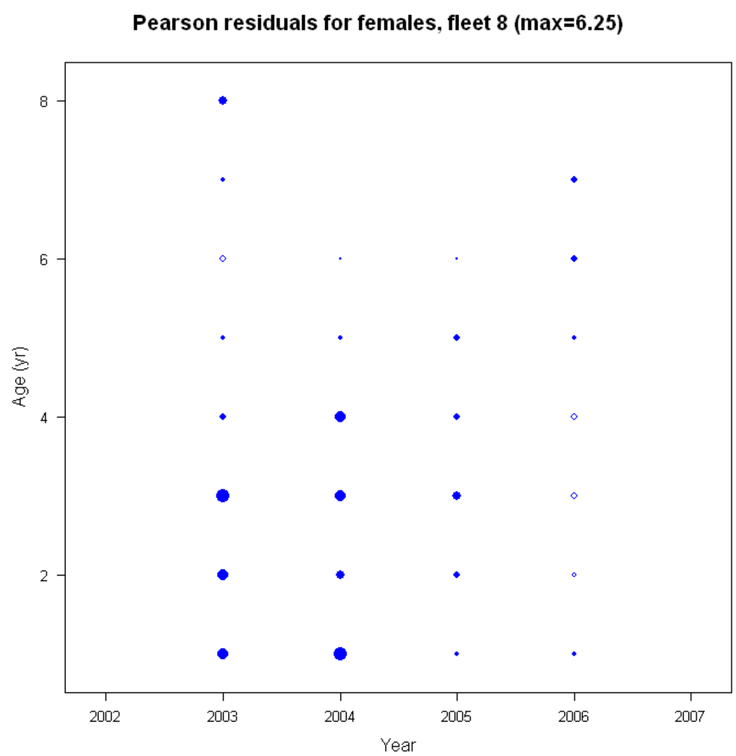
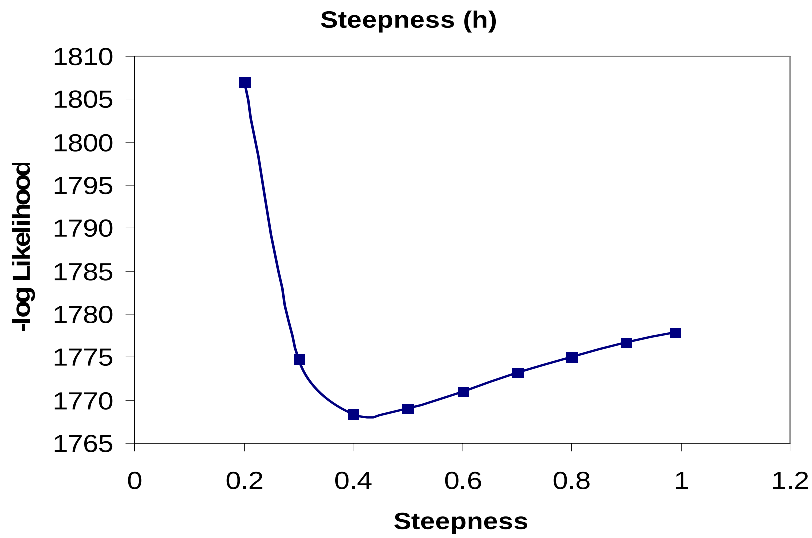


Figure 40. *Observed and expected female length-at-age and residuals for NWFSC combined/shelf survey for the post-STAR STAT model.*



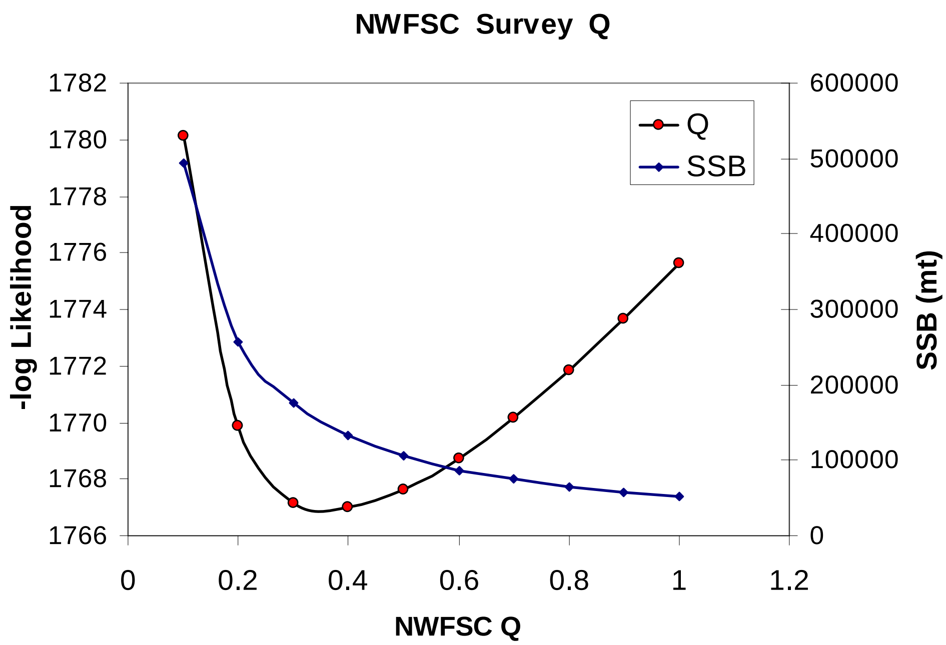


Figure 41. *Trend in total (top)and spawning stock biomass(bottom) with ~95% CI's for the post-STAR STAT model.*

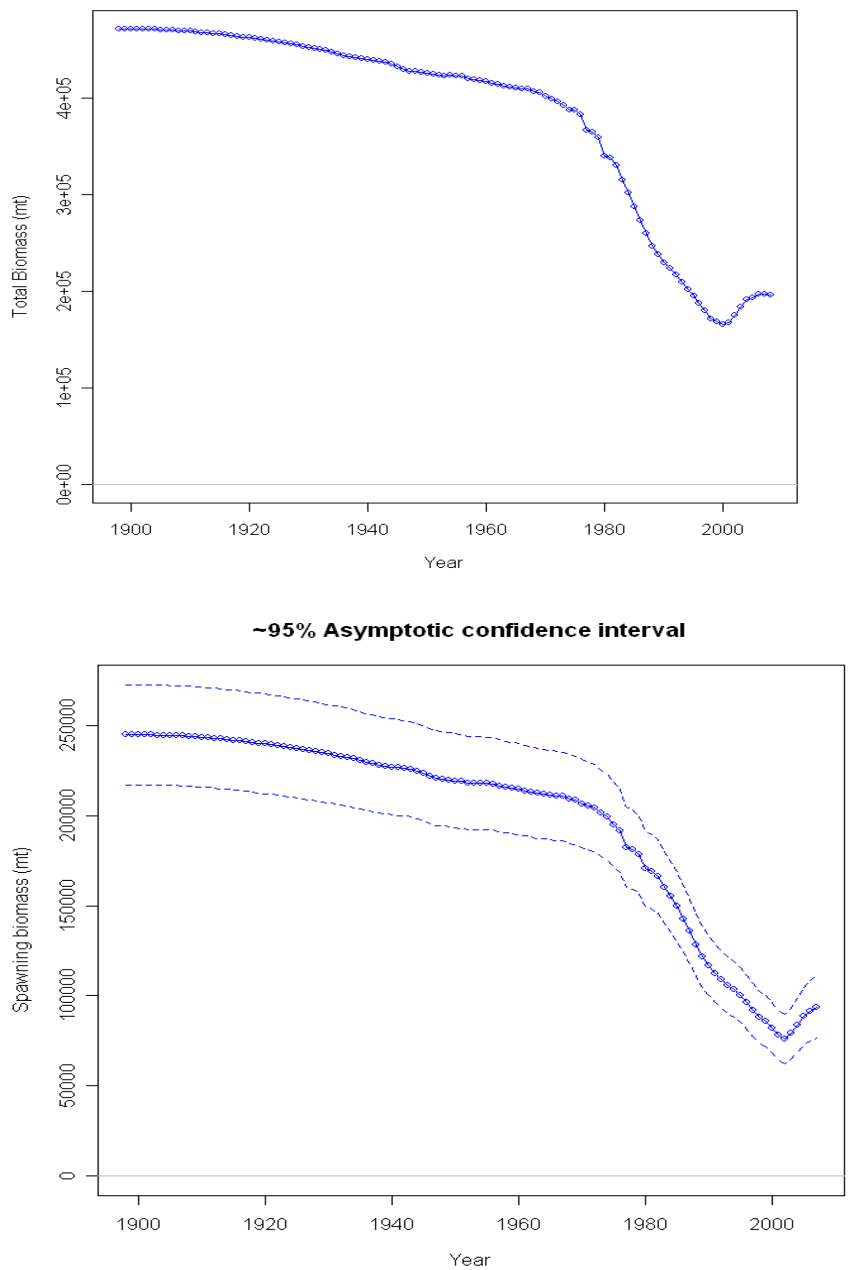
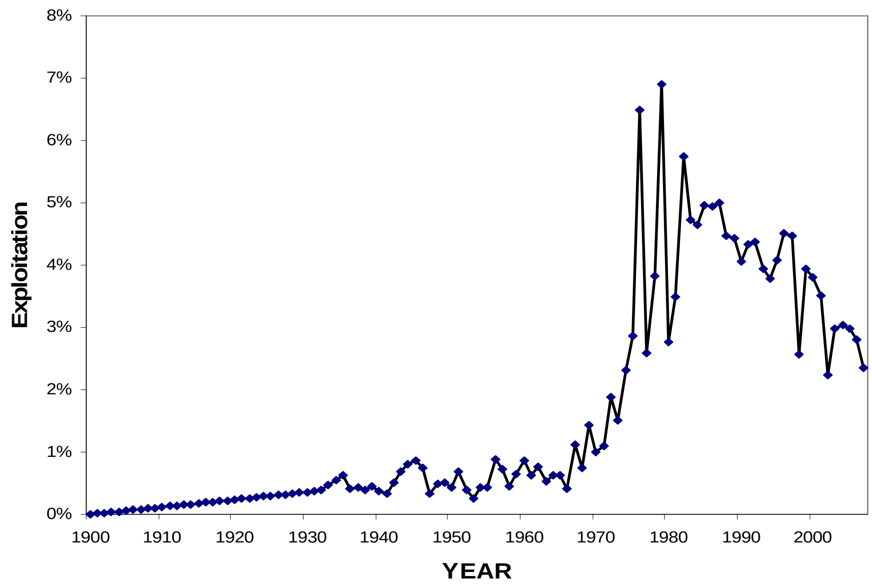


Figure 42. *Trend in total (top)and spawning stock biomass(bottom) with ~95% CI's for the post-STAR STAT model.*



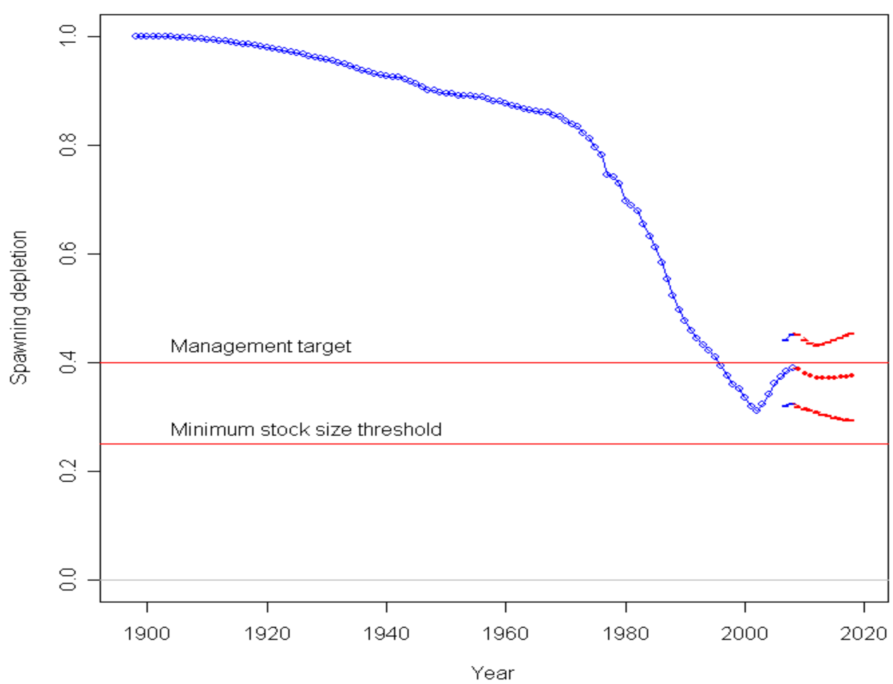
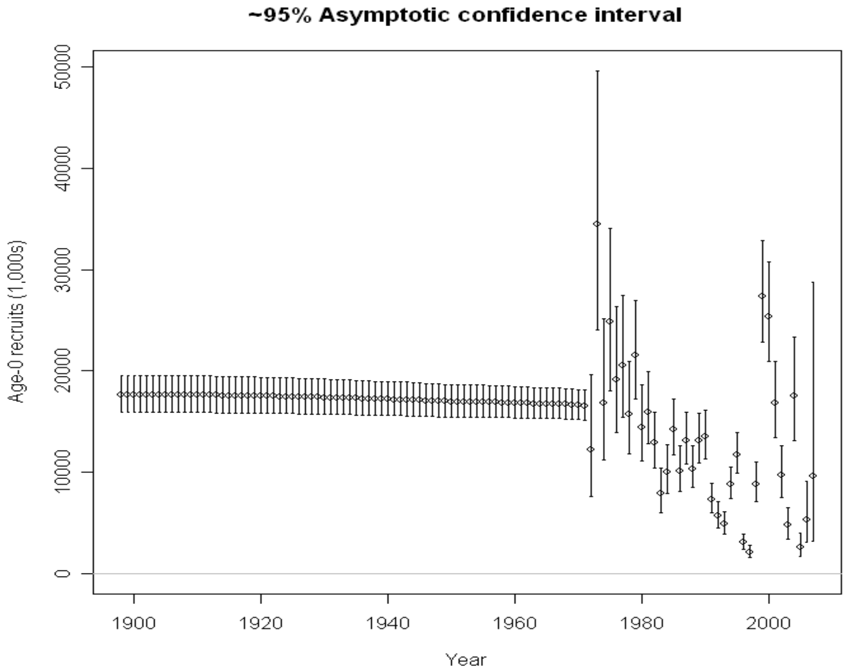


Figure 43. *Trend inexploitation (top)and spawning stock biomassdepletion (bottom) with ~95% CI's for the post-STAR STAT model.*



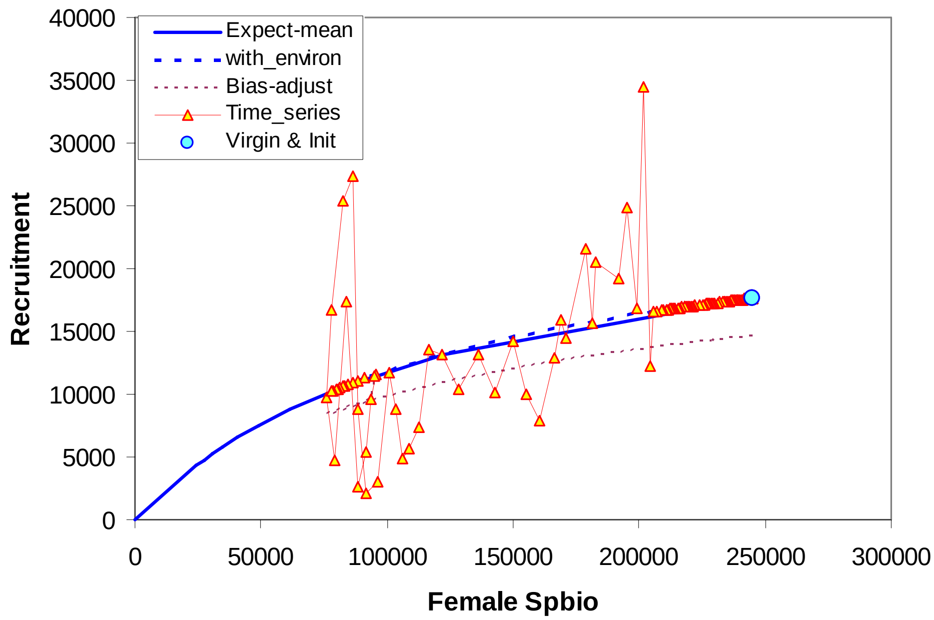
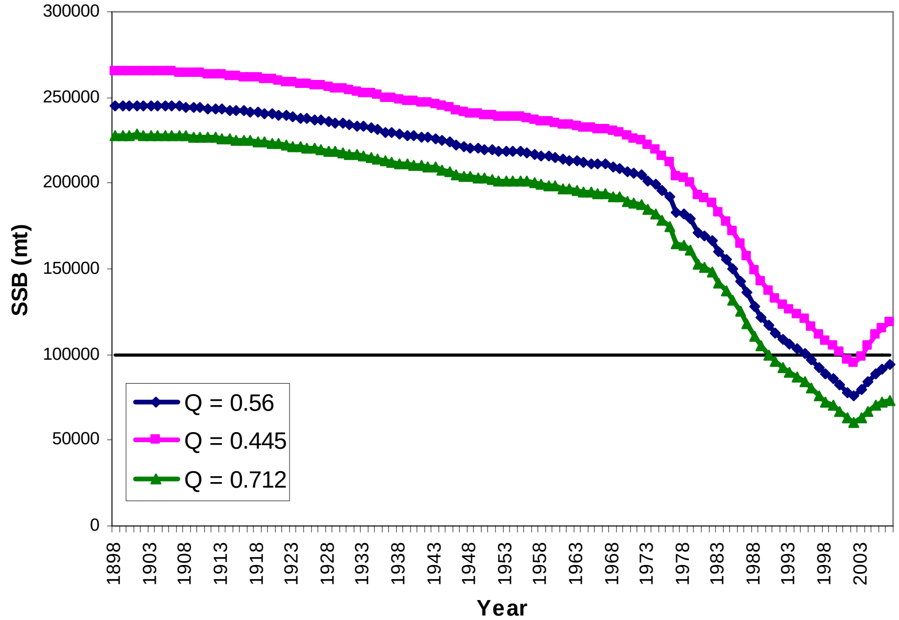


Figure 44. *Trend in recruitment with ~95% CI's (top) and stock-recruitment function (bottom) for the post-STAR STAT model.*



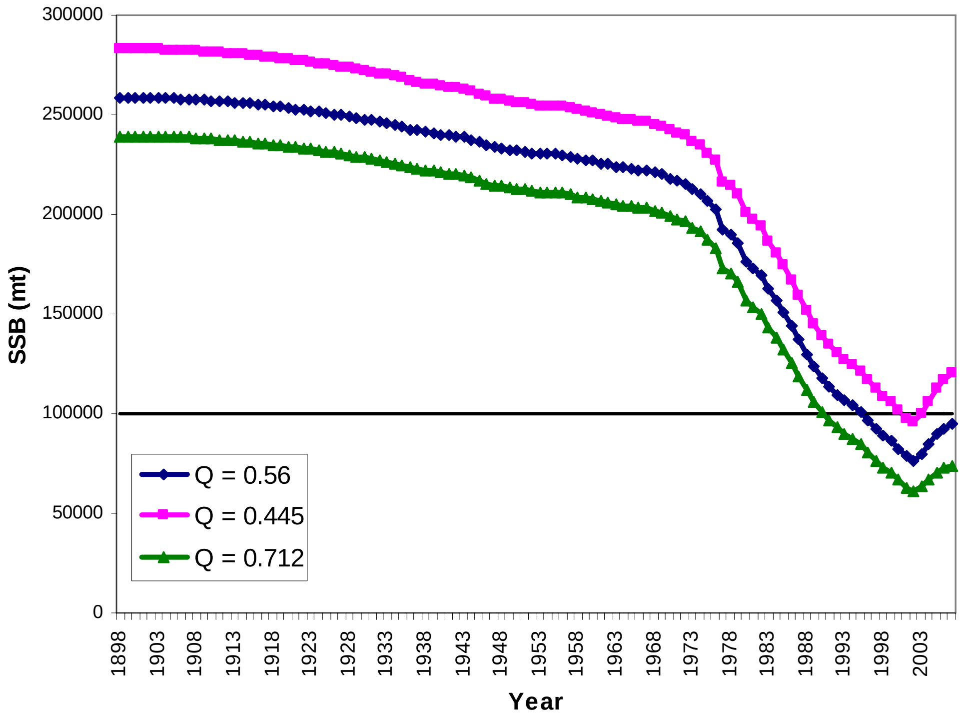
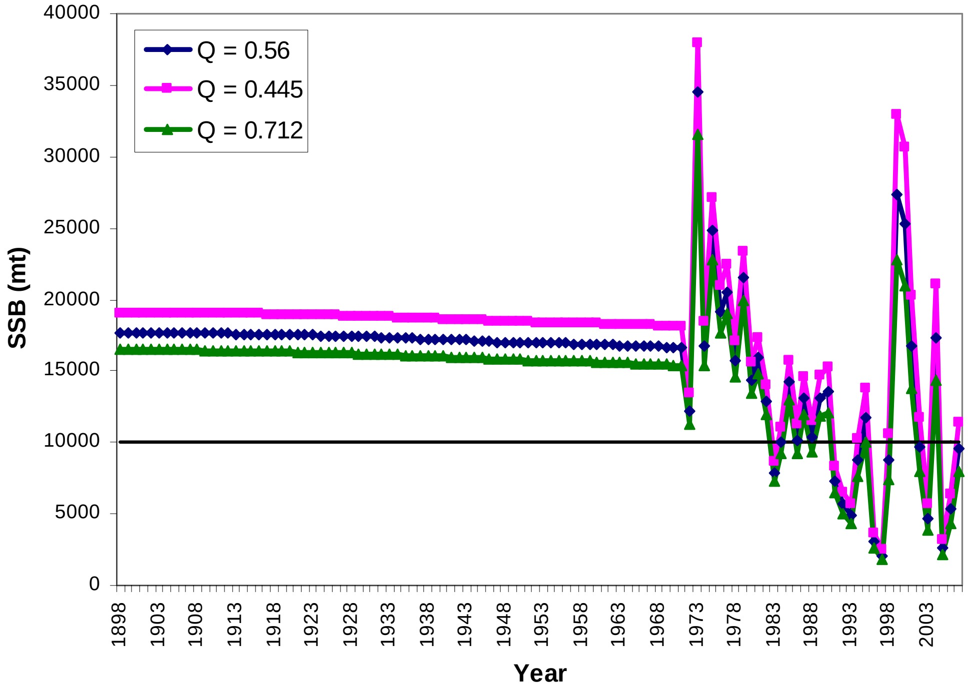


Figure45. *Trends in spawning stock biomass assuming the three states of nature based on varying q for the post-STAR STAT model with (top) and without (bottom) sea-surface height index included. Solid black line at 100,000 is for reference only.*



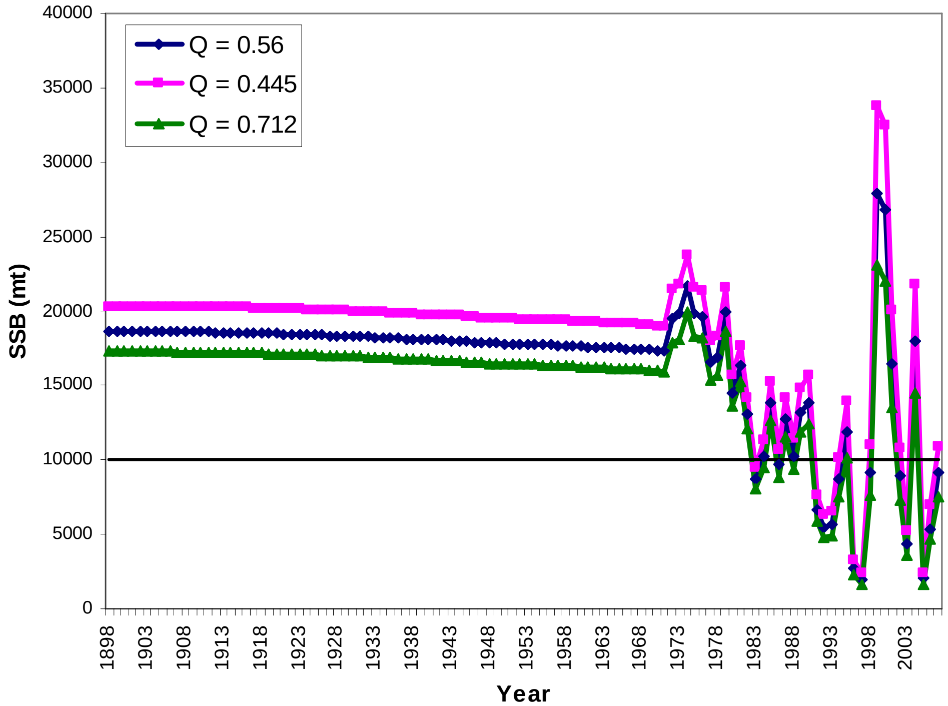
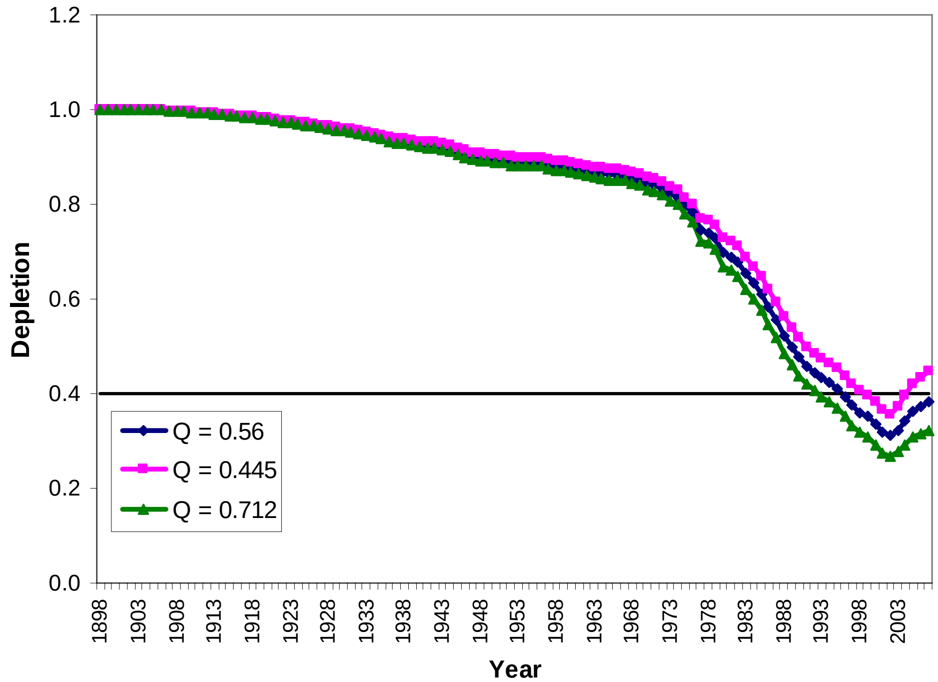


Figure 46. *Trends in recruitment assuming the three states of nature based on varying q for the post-STAR STAT model with (top) and without (bottom) sea-surface height index included. Solid black line at 10,000 is for reference only.*



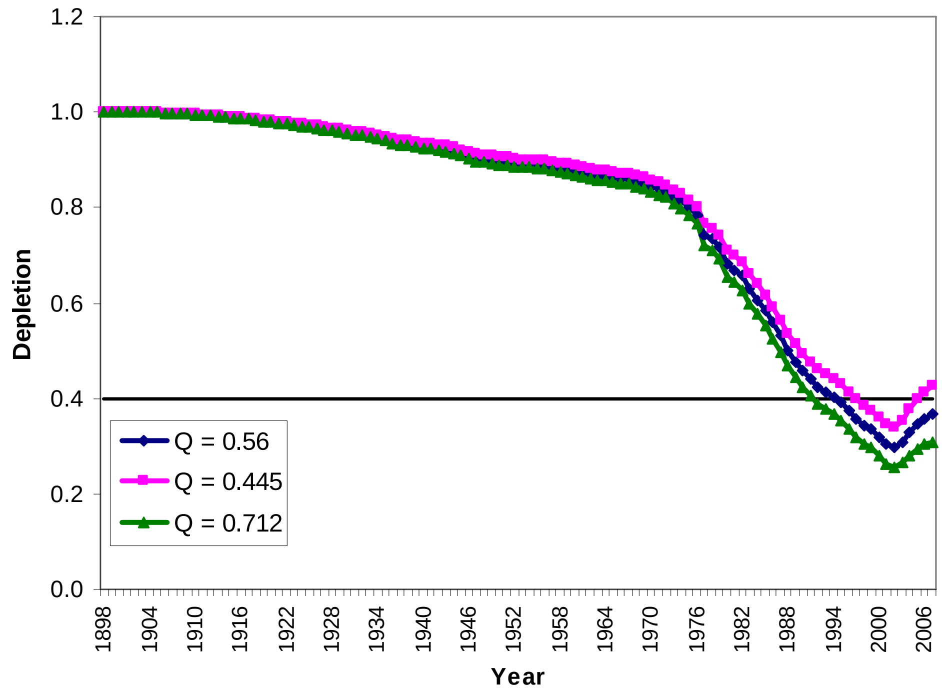


Figure 47. *Trends in depletion assuming the three states of nature based on varying q for the post-STAR STAT model with (top) and without (bottom) sea-surface height index included. Solid black line at 0.40 is for reference only.*

SPAWNING STOCK BIOMASS (mt)

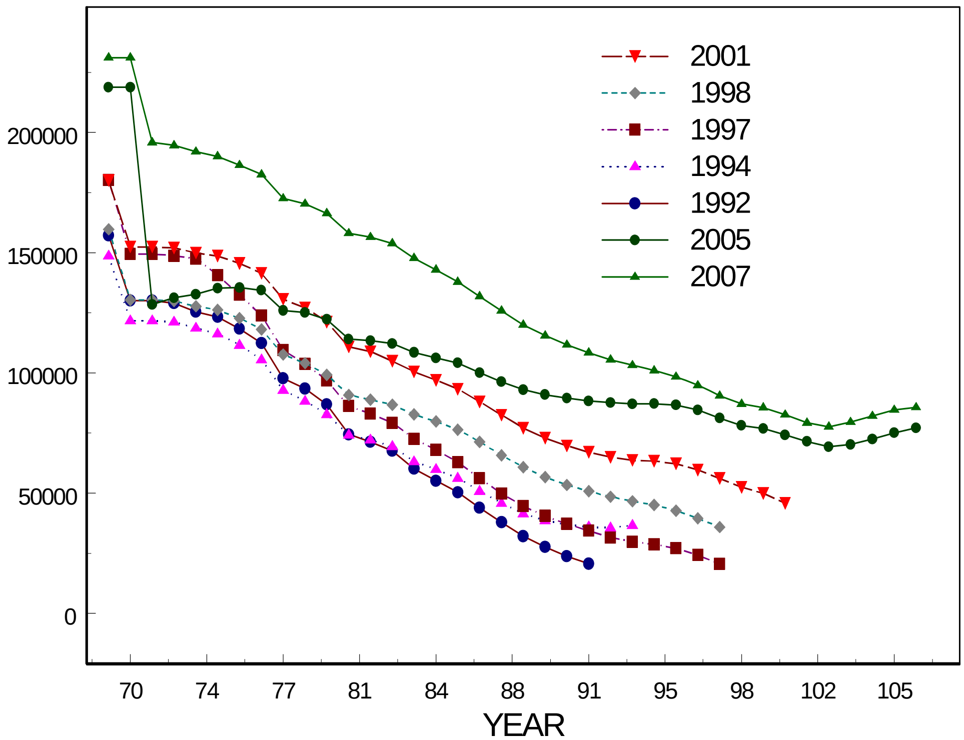


Figure 48. *Trends in spawning stock biomass from current and previous sablefish assessments conducted 1992-2007.*

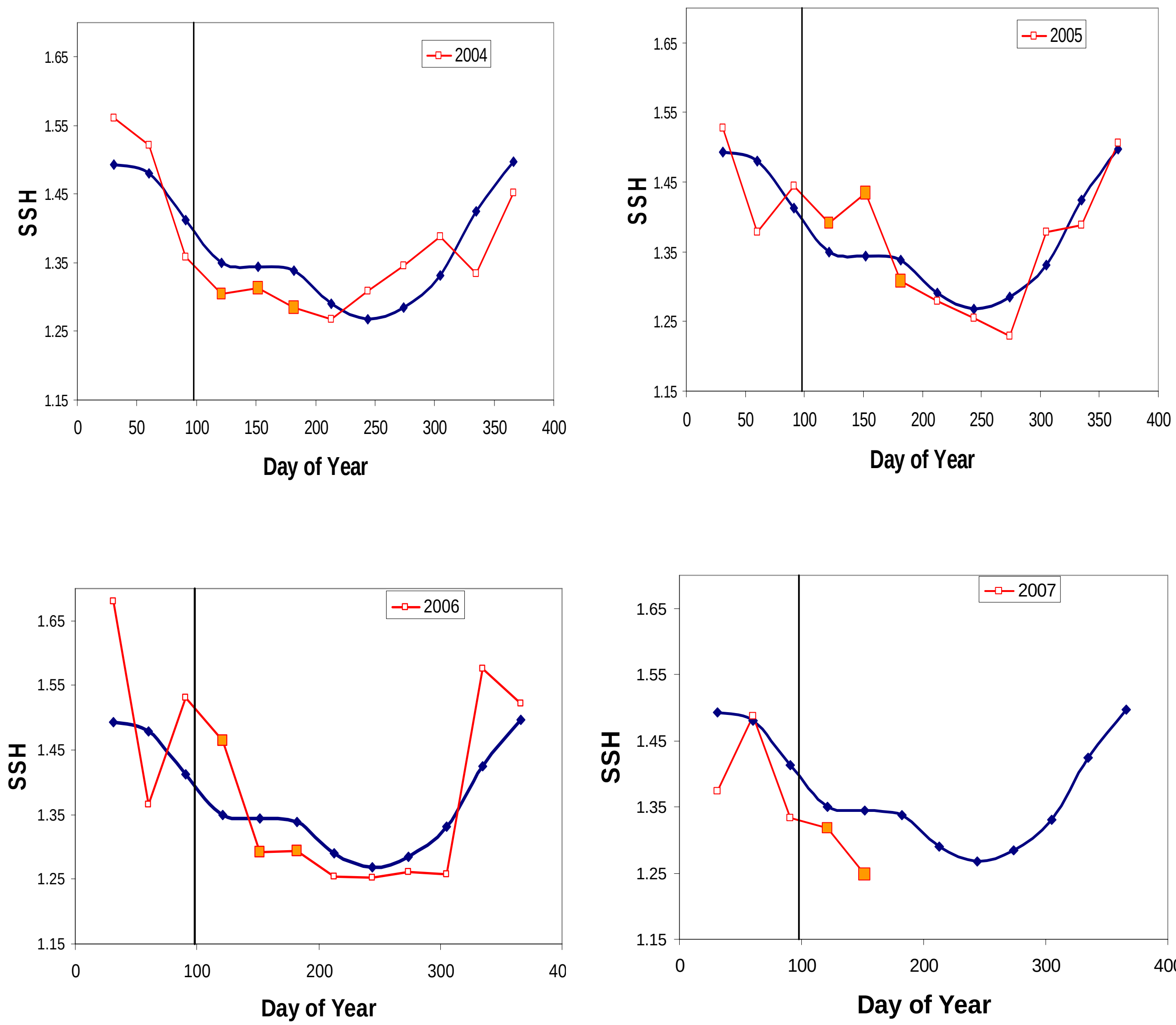


Figure 49. Monthly trends in SSH index by year overlaid on to the long-term average. Years 2004,, and 2007 depict average to above average year-class strength (sea level is below average for April, May, and June) while 2005 and 2006 depicts a relatively weak year-class (SSH is higher that aveaerage for April and/or May, and transition is late).

```
 #_data_and_control_files: sable07.dat // test.CTL
1                #_N_Growth_Patterns
1                #_N_submorphs
1                #_N_areas
1 1 1 1 1 1 1 1 1 #_area_assignments_for_each_fishery_and_survey
1                #_recruit_design_(G_Pattern_x_birthseas_x_area)_X_(0/1_flag)

0 #_recr_distr_interaction
0 #_Do_migration
 #_movement_pattern_(season_x_source_x_destination)_x_(0/1_flag)_minage_maxage
 0 0 0
 17 #_Nblock_Designs
 3 3 3   2  2  2 2 20 4 1 8 1 19 17 2 2 2 #_blocks_per_design
 1900 1986  1987 2005  2006 2007 #hkl lth
 1900 1986  1987 2005  2006 2007 #pot lth
 1900 1986  1987 2005  2006 2007 #twl lth

 1900 2001  2002 2006  #discards
 1900 1987  1988 2006
 1900 1987  1988 2006
 1900 1982  1983 2004
 1982 1982  1985 1985  1987 1987 1988 1988 1989 1989 1990 1990 1991 1991 1992 1992 1994 1994 1996 1996 1997 1997 1998
1998 1999 1999 2000 2000 2001 2001 2002 2002  2003 2003 2004 2004 2005 2005 2006 2006
 1985 1995  1996 2000  2001 2001  2002 2006
 1985 2006
 1900 1994  1995 1995  1996 1996  1997 1997 1998 1998 1999 1999 2000 2000 2001 2004
 1980 2004

 1900 1987 1988 1988 1989 1989 1990 1990 1991 1991 1992 1993 1994 1994 1995 1995 1996 1996 1997 1997 1998 1998 1999
1999 2000 2000 2001 2001 2002 2002 2003 2003 2004 2004 2005 2005 2006 2007
 1900 1987 1988 1988 1989 1989 1990 1990 1991 1991 1992 1993 1994 1994 1995 1995 1996 1996 1997 1997 1998 1998 1999
1999 2000 2000 2001 2001 2002 2002 2003 2003 2004 2007

 1900 1986  1987  2007 #hkl age
 1900 1986  1987  2007 #pot age
 1900 1986  1987  2007 #twl age


0.5  #_fracfemale
1    #_submorph_between/within
1    #vector_submorphdist_(-1_first_val_for_normal_approx)
4    #_natM_amin
15   #_natM_amax
1.66 #_Growth_Age-at-L1
25   #_Growth_Age-at-L2
0.00 #_SD_add_to_LAA
0    #_CV_Growth_Pattern
```

```
1    #_maturity_option
3    #_First_Mature_Age
3    #_parameter_offset_approach
2    #_env/block/dev_adjust_method    NEW_XXXX  (where 1=use previous method; 2=use new logistic method)
1    #_MGparm_Dev_Phase

#_growth_parms
#_LO    HI      INIT    PRIOR   PR_type    SD     PHASE   env-var use_dev dev_miny dev_maxy dev_stdd Blk_Des
Blk_Fxn(0,1,2)
  0.01    0.1     0.07    0.07      0      0.007  -3       0       0       0       0        0.5     0       0
#M1_natM_young
  -3      3       0       0         0      99     -3       0       0       0       0        0.5     0       0
#M1_natM_old_as_exponential_offset(rel_young)
  10      45      38.29   38.5      0      5       3       0       0       0       0        0.5     8       2
#M1_Lmin
  40      90      65.18   66.795    0      5       3       0       0       0       0        0.5     0       0
#M1_Lmax
  0.05    0.4     0.2495  0.21      0      0.5     4       0       0       0       0        0.5     0       0
#M1_VBK
  0.03    0.25    0.0456  0.05      0      0.5     4       0       0       0       0        0.5     0       0
#M1_CV-young
  -3      3       1.2500  0         0      99      6       0       0       0       0        0.5     0       0
#M1_CV-old_as_exponential_offset(rel_young)
#Male
  -3      3       0       0         0      99      -3      0       0       0       0        0.5     0       0
#M2_natM_young_as_exponential_offset(rel_morph_1)
  -3      3       0       0         0      99      -3      0       0       0       0        0.5     0       0
#M2_natM_old_as_exponential_offset(rel_young)
  -3      3       0       0         0      99      -3      0       0       0       0        0.5     0       0
#M2_Lmin_as_exponential_offset
  -3      3       -0.144  0         0      99      4       0       0       0       0        0.5     0       0
#M2_Lmax_as_exponential_offset
  -3      3       0.3091  0         0      99      4       0       0       0       0        0.5     0       0
#M2_VBK_as_exponential_offset
  -3      3       0       0         0      99      -3      0       0       0       0        0.5     0       0
#M2_CV-young_as_exponential_offset(rel_CV-young_for_morph_1)
  -3      3       0.9908  0         0      99      6       0       0       0       0        0.5     0       0
#M2_CV-old_as_exponential_offset(rel_CV-young)

    0       1 2.44E-06 2.44E-06     0     0.8     -2       0       0       0       0        0.5     0       0   #_wt-
len&maturity
    0       4 3.34694  3.34694      0     0.8     -2       0       0       0       0        0.5     0       0
    55     55      55       55      0     0.8     -2       0       0       0       0        0.5     0       0
   -3       3   -0.25    -0.25      0     0.8     -2       0       0       0       0        0.5     0       0
   -3       3       1        1      0     0.8     -2       0       0       0       0        0.5     0       0
   -3       3       0        0      0     0.8     -2       0       0       0       0        0.5     0       0
    0       1 2.44E-06 2.44E-06     0     0.8     -2       0       0       0       0        0.5     0       0
```

```
    0       4 3.34694  3.34694      0     0.8     -2       0       0       0       0       0.5     0       0

   -4       4       0       0      -1      99     -2       0       0       0       0       0.5     0       0
#_recrdistribution_by_growth_pattern
   -4       4       0       0      -1      99     -2       0       0       0       0       0.5     0       0   #_recrdi
1
   -4       5       4       0      -1      99     -2       0       0       0       0       0.5     0       0   #_recrdi
1
    1       2       1       1      -1      99     -2       0       0       0       0       0.5     0       0
#_cohort_growth_deviation

0 #_custom_MG-env_setup

1 #_custom_MG-block_setup
# Lo   Hi   Init        Pr      Prty     SD     Phase
 30    41   31.2521    38.5       0       .5       5    #_ 2  1982
 34    41   38.1853    38.5       0       .5       5    #_ 3  1985
 34    41   39.0863    38.5       0       .5       5    #_ 4  1987
 30    41   37.655     38.5       0       .5       5    #_ 5  1988
 34    41   39.9701    38.5       0       .5       5    #_ 6  1989
 34    41   39.0502    38.5       0       .5       5    #_ 7  1990
 34    42   38.5       38.5       0       .5       5    #_ 8  1991
 34    42   38.5       38.5       0       .5       5    #_ 9  1992
 34    42   38.5       38.5       0       .5       5    #_ 10 1994
 34    41   40.578     38.5       0       .5       5    #_ 11 1996
 34    41   39.9203    38.5       0       .5       5    #_ 12 1997
 34    41   36.7055    38.5       0       .5       5    #_ 13 1998
 34    41   39.4331    38.5       0       .5       5    #_ 14 1999
 34    41   39.614     38.5       0       .5       5    #_ 15 2000
 34    41   39.3364    38.5       0       .5       5    #_ 16 2001
 34    45   38.5       38.5       0       .5       5    #_ 17 2002
 34    41   39.6017    38.5       0       .5       5    #_ 18 2003
 34    41   39.1192    38.5       0       .5       5    #_ 19 2004
 34    41   39.6025    38.5       0       .5       5    #_ 20 2005
 34    45   41.0922    38.5       0       .5       5    #_ 21 2006


#_Spawner-Recruitment
1 #_SR_function
#_LO     HI   INIT     PRIOR   PR_type  SD   PHASE
  9      12    9.8      9.8      0      99     1  #R0
 0.2      1    0.4      0.4      0      99     2  #h (.2)
 0.2    1.5    0.6      0.6      0       1    -5  #sigma-r
  -5      5    0        0        0      99    -5  #ENV
  -5      5    0        0        0      99    -6  #R1
   0      2    0       -1        0       1    -3  #NEW_XXXX   This is a 6th SR_parm reserved for future use as
autocorrelation
```

```
2      #_SR_env_link
2 #_SR_env_target_1=devs;_2=R0;_3=steepness

1 #do_recr_dev:  0=none; 1=devvector; 2=simple deviations

  1972     2006   -5   4   2 #_recr_devs  ENV OFF
# 1925     2006   -5   4   2 #_recr_devs  ENV ON

#1965 #_first_yr_fullbias_adj_in_MPD
 1424 #_first_yr_fullbias_adj_in_MPD

#_initial_F_parms
#_LO HI  INIT  PRIOR  PR_type SD  PHASE
  0   1  0.00   0.01    0      1   -1
  0   1  0.00   0.00    0      1   -1
  0   1  0.00   0.01    0      1   -1

#_Q_setup
 # A=do power,
 # B=env-var,
 # C=extra SD,
 # D=devtype(<0=mirror, 0/1=none, 2=cons, 3=rand, 4=randwalk);
 # E=0=num/1=bio,
 # F=err_type

 #_A  B  C  D  E  F
   0  0  0  0  1  0  #HKL
   0  0  0  0  1  0  #POT
   0  0  0  0  1  0  #TWL
   1  1  0  2  0  0  #SSH
   0  0  0  2  1  0  #Shelf
   0  0  0  2  1  0  #Slope-AFSC
   0  0  0  2  1  0  #Slope-NWFSC
   0  0  0  2  1  0  #Combo-shallow
   0  0  0  2  0  0  #Bugs

#_Q_parms(if_any)
# LO    HI       INIT        PRIOR  PR_type  SD    PHASE
  -10    10     0.00000     0.00000    0     10     -1  #SSH Power
  -1     5      0.00000     0.00000    0     10     -1  #SSH extra SD
 -2.6   1.0     0.00000     0.00000    0     10      1  #SSH Q
 -2.6   1.0     0.00000     0.00000    0     10      1  #A-shelf Q
 -2.6   0.1     0.00000     0.00000    0     10      1  #A-slope Q
 -2.69  0.1    -0.57980     0.00000    0     10     -1  #N-slope Q (-0.8096=q(0.445); -0.5798=q(0.56), -
0.3396=q(0.712))
 -2.69  0.1     0.00000     0.00000    0     10      1  #Combo-shallow Q
```

```
 -1     5       0.00000     0.00000    0     10      1  #Bugs Q

#_size_selex_types
#_Pattern Discard Male Special
   24       2      0     0    # 1
   24       2      0     0    # 2
   24       2      0     0    # 3
   31       0      0     0    # 4
    0       0      0     0    # 5
   24       0      0     0    # 6
   24       0      0     0    # 7
    0       0      0     0    # 8
   31       0      0     0    # 9

#_age_selex_types
#_Pattern Discard Male Special
   20       0      0     0    # 1
   20       0      0     0    # 2
   20       0      0     0    # 3
    0       0      0     0    # 4
   20       0      0     0    # 5
   20       0      0     0    # 6
   20       0      0     0    # 7
   20       0      0     0    # 8
    0       0      0     0    # 9

#_selex_parms
 #_LO       HI   INIT      PRIOR   PR_type  SD    PHASE   env dev?  miny   maxy  dev_stdd BlkDes Block_Fxn
#_SIZE_SELEX 1_HKL NEW DOUBLE NORMAL
  32      80      68        68      0      99      -3      0   0     0       0     0.5     0    0   # PEAK
  -6      10    -4.5       2.3      0      99      -4      0   0     0       0     0.5     0    0   # TOP
  -5      15    3.9        4.6      0      99       6      0   1   1987    2005    0.25    1    1   # ASC-WIDTH
   4       9    7.2        7.2      0      99       5      0   0     0       0     0.5     0    0   # DSC-WIDTH
  -6       6    -5         -5       0      99      -3      0   0     0       0     0.5     0    0   # INIT
  -8      15    10         10       0      99      -6      0   0     0       0     0.5     0    0   # FINAL
# HKL discards
  18      70    43         30       0      99      -5      0   0     0       0     0.5     4    0   #
inflection_for_retention
  0.1      1     1          1       0      99      -5      0   0     0       0     0.5     4    0   #
slope_for_retention
  0.2     1.0   1           1       0      99      -5      0   0     0       0     0.5     4    0   #
asymptotic_retention
  -10     10    0           0       0      99      -5      0   0     0       0     0.5     0    0   #
male_offset_on_inflection
   18     70    18         18       0      99      -5      0   0     0       0     0.5     0    0   #
inflection_for_discard mortality
```

```
   0       0.1    1          1      0      99      -5      0   0     0       0     0.5     0    0   # slope_for_discard
mortality
  0.1      0.8   0.10    0.00       0      99      -5      0   0     0       0     0.5     0    0   # asymptotic
discard mortality (mortality rate)
  -10      10    0          0       0      99      -5      0   0     0       0     0.5     0    0   #
male_offset_discard mortality
##_SIZE_SELEX 2_POT NEW DOUBLE NORMAL (Option #24 Recommended option see SELEX24.XLS)
  32      80      54         54       0      99      -3     0   0     0       0     0.5     0    0   # PEAK
  -6      10    -4.5      -4.5       0      99      -4     0   0     0       0     0.5     0    0   # TOP
  -5      15     3.9        3.9       0      99       6     0   1   1987    2005    0.25    3    1   # ASC-WIDTH
   4       9     7.2        7.2       0      99       5     0   0     0       0     0.5     0    0   # DSC-WIDTH
  -6       6      -5         -5       0      99      -3     0   0     0       0     0.5     0    0   # INIT
  -8      15      10         10       0      99      -6     0   0     0       0     0.5     0    0   # FINAL
##POT discards
  18      70      43         30       0      99      -5     0   0     0       0     0.5     4    0   #
inflection_for_retention
  0.1     1.0      1          1       0      99      -5     0   0     0       0     0.5     4    0   #
slope_for_retention
  0.2     1.0      1          1       0      99      -5     0   0     0       0     0.5     4    0   #
asymptotic_retention
  -10     10       0          0       0      99      -5     0   0     0       0     0.5     0    0   #
male_offset_on_inflection
  18      70      18         18       0      99      -5     0   0     0       0     0.5     0    0   #
inflection_for_discard mortality
  0.1     0.1      1          1       0      99      -5     0   0     0       0     0.5     0    0   # slope_for_discard
mortality
  0.2     0.8     0.10     0.02       0      99      -5     0   0     0       0     0.5     0    0   # asymptotic
discard mortality (mortality rate)
  -10     10       0          0       0      99      -5     0   0     0       0     0.5     0    0   #
male_offset_discard mortality
##_SIZE_SELEX 3_TWL NEW DOUBLE NORMAL (Option #24 Recommended option see SELEX24.XLS)
   20     85      54         54       0      99      -3    0    0     0       0     0.5     0    0   # PEAK
  -10     0.5     -5         -5       0      99      -4    0    0     0       0     0.5     0    0   # TOP
  -15     20      5.2        5.2      0      99       6    0    1   1987    2005    0.25    3    1   # ASC-WIDTH
   0.0001 10       5          5       0      99       5    0    0     0       0     0.5     0    0   # DSC-WIDTH
   -10.   10      -5         -5       0      99      -5    0    0     0       0     0.5     0    0   # INIT
   -5.    4.      0.3        0.3      0      99      -5    0    0     0       0     0.5     0    0   # FINAL
#TWL discards
  18      70      43        32        0      99      -5    0    0     0       0     0.5     4    0   #
inflection_for_retention
  0.1      1       1         1        0      99      -5    0    0     0       0     0.5     4    0   #
slope_for_retention
  0.2      1       1         1        0      99      -5    0    0     0       0     0.5     4    0   #
asymptotic_retention
  -10     10       0         0        0      99      -5    0    0     0       0     0.5     0    0   #
male_offset_on_inflection
```

```
  18       70      18      18        0      99      -5    0    0     0       0     0.5     0    0   #
inflection_for_discard mortality
  0.1      0.1     1        1        0      99      -5    0    0     0       0     0.5     0    0   # slope_for_discard
mortality
  0.1      0.8     0.50    0.05      0      99      -5    0    0     0       0     0.5     0    0   # asymptotic
discard mortality (mortality rate)
  -10      10      0       0         0      99      -5    0    0     0       0     0.5     0    0   #
male_offset_discard mortality
#===========================================================================================================
===========================
#_SIZE_SELEX 6  AFSC-slope
   30      70        55         55   0      99     -2     0    0     0       0     0.5     0    0   #  PEAK
  -15       3        -6       -2.3   0      99     -2     0    0     0       0     0.5     0    0   #  TOP
  -5       15   2.26264        6.3   0      99      2     0    0     0       0     0.5     0    0   #  ASC-WIDTH
  -1       15   3.82942       -4.1   0      99      2     0    0     0       0     0.5     0    0   #  DSC-WIDTH
  -10      10   -5          -5       0      99      2     0    0     0       0     0.5     0    0   #  INIT
  -15      10   -0.722349     10     0      99      2     0    0     0       0     0.5     0    0   #  FINAL
#_SIZE_SELEX 7  NWFSC-slope
   30      70        53         53   0      99     -2     0    0     0       0     0.5     0    0   #  PEAK
  -15       3        -6       -2.3   0      99     -2     0    0     0       0     0.5     0    0   #  TOP
  -5       15   2.26264        6.3   0      99      2     0    0     0       0     0.5     0    0   #  ASC-WIDTH
  -1       15   3.82942       -4.1   0      99      2     0    0     0       0     0.5     0    0   #  DSC-WIDTH
  -10      10   -5          -5       0      99      2     0    0     0       0     0.5     0    0   #  INIT
  -15      10   -0.722349     10     0      99      2     0    0     0       0     0.5     0    0   #  FINAL
###########################################################################################################
#######
#_AGE_SELEX 1
    0       5      2           3     0      99     -3     0    0     0       0     0.5     0    0   #  PEAK
  -15      -1     -3.5         1     0      99     -3     0    0     0       0     0.5     0    0   #  TOP
   -5      10      6.7        -1     0      99      3     0    0     0       0     0.5     0    0   #  ASC-WIDTH
   -1      10      4.1       0.2     0      99      5     0    0     0       0     0.5     0    0   #  DSC-WIDTH
   -5       9      5           5     0      99     -3     0    0     0       0     0.5     0    0   #  INIT
  -10      10     -5           1     0      99      6     0    1  1987    2003     0.25     15   1   #  FINAL
#_AGE_SELEX 2
    0       5      2           3     0      99     -3     0    0     0       0     0.5     0    0   #  PEAK
  -15      -1     -3.5         1     0      99     -3     0    0     0       0     0.5     0    0   #  TOP
   -5      10      6.7        -1     0      99      3     0    0     0       0     0.5     0    0   #  ASC-WIDTH
   -1      10      4.1       0.2     0      99      5     0    0     0       0     0.5     0    0   #  DSC-WIDTH
   -5       9      5           5     0      99     -3     0    0     0       0     0.5     0    0   #  INIT
  -10      10     -5           1     0      99      6     0    1  1987    2003     0.25    16    1   #  FINAL
#_AGE_SELEX 3
   0       5      2            3     0      99     -3     0    0     0       0     0.5     0    0   #  PEAK
 -15      -1     -3.5          1     0      99     -3     0    0     0       0     0.5     0    0   #  TOP
  -5      10     6.7          -1     0      99      3     0    0     0       0     0.5     0    0   #  ASC-WIDTH
  -1      10     4.1         0.2     0      99      5     0    0     0       0     0.5     0    0   #  DSC-WIDTH
  -5       9     5             5     0      99     -3     0    0     0       0     0.5     0    0   #  INIT
 -10      10    -5             1     0      99      6     0    1  1987    2005     0.25     17   1   #  FINAL
```

```
#_AGE_SELEX 5 (Double Normal)
   0.1      2       0.6       1      0      99     -2     0    0     0       0     0.5     0    0   #  PEAK
   -30      0      -5.2     0.3      0      99      2     0    0     0       0     0.5     0    0   #  TOP
   -5       5      -5.2       5      0      99     -2     0    0     0       0     0.5     0    0   #  ASC-WIDTH
   -5       5      -0.3       1      0      99      2     0    0     0       0     0.5     0    0   #  DSC-WIDTH
   -30      9       -30      -5      0      99     -2     0    0     0       0     0.5     0    0   #  INIT
   -5       5        -5      -5      0      99     -2     0    0     0       0     0.5     0    0   #  FINAL
#_AGE_SELEX 5 (Double Normal)
  -5       4     2.2          3      0      99     -2     0    0     0       0     0.5     0    0   #  PEAK
 -15       6    -7.1          2      0      99     -2     0    0     0       0     0.5     0    0   #  TOP
  -5      15     2.5         -1      0      99      2     0    0     0       0     0.5     0    0   #  ASC-WIDTH
  -5      25     4.6        0.2      0      99     -2     0    0     0       0     0.5     0    0   #  DSC-WIDTH
 -10      10      -5        0.1      0      99     -2     0    0     0       0     0.5     0    0   #  INIT
  -5      20     10           1      0      99     -2     0    0     0       0     0.5     0    0   #  FINAL
#_AGE_SELEX 7 (Double Normal)
  -5       4     2.2          3      0      99     -2     0    0     0       0     0.5     0    0   #  PEAK
 -15       6    -7.1          2      0      99     -2     0    0     0       0     0.5     0    0   #  TOP
  -5      15     2.5         -1      0      99      2     0    0     0       0     0.5     0    0   #  ASC-WIDTH
  -5      25     4.6        0.2      0      99     -2     0    0     0       0     0.5     0    0   #  DSC-WIDTH
 -10      10      -5        0.1      0      99     -2     0    0     0       0     0.5     0    0   #  INIT
  -5      20     10           1      0      99     -2     0    0     0       0     0.5     0    0   #  FINAL
#_AGE_SELEX 8 (Double Normal)
 0.1       2    0.3           1      0      99     -2     0    0     0       0     0.5     0    0   #  PEAK
 -20      40     -4         0.3      0      99      2     0    0     0       0     0.5     0    0   #  TOP
 -10       7    3.4           5      0      99      2     0    0     0       0     0.5     0    0   #  ASC-WIDTH
 -2        4    2.4           1      0      99      2     0    0     0       0     0.5     0    0   #  DSC-WIDTH
  4        9    -5           -5      0      99     -2     0    0     0       0     0.5     0    0   #  INIT
 -5        5    -5           -5      0      99     -2     0    0     0       0     0.5     0    0   #  FINAL

1 #_env/block/dev_adjust_method    NEW_XXXX  (where 1=use previous method; 2=use new logistic method)
0 #_custom_sel-env_setup
1 #_custom_sel-block_setup

 #LO     HI   INIT   PRIOR  PR_Type  SD    PHASE

-10     10      0       0     0      99       6     # Block-1-1
-10     10      0       0     0      99       6     # Block-1-2
-10     10      0       0     0      99       6     # Block-1-3
-10     10      0       0     0       3      -4     # Block-4-1
-10     10      0       0     0       3      -4     # Block-4-2
-10     10      0       0     0       3      -4     # Block-4-1
-10     10      0       0     0       3      -4     # Block-4-2
-10     10      0       0     0       3      -4     # Block-4-1
-10     10      0       0     0       3      -4     # Block-4-2
###############################################################################################
-10     10      0       0     0      99       6     # Block-2-1
-10     10      0       0     0      99       6     # Block-2-2
```

```
-10     10      0       0     0      99       6     # Block-2-3
-10     10      0       0     0       3      -4     # Block-4-1
-10     10      0       0     0       3      -4     # Block-4-2
-10     10      0       0     0       3      -4     # Block-4-1
-10     10      0       0     0       3      -4     # Block-4-2
-10     10      0       0     0       3      -4     # Block-4-1
-10     10      0       0     0       3      -4     # Block-4-2
###########################################################################################
-10     10      0       0     0      99       6     # Block-3-1
-10     10      0       0     0      99       6     # Block-3-2
-10     10      0       0     0      99       6     # Block-3-3
-10     10      0       0     0       3      -4     # Block-4-1
-10     10      0       0     0       3      -4     # Block-4-2
-10     10      0       0     0       3      -4     # Block-4-1
-10     10      0       0     0       3      -4     # Block-4-2
-10     10      0       0     0       3      -4     # Block-4-1
-10     10      0       0     0       3      -4     # Block-4-2
#### AGE SELEX ##############################################################################
-10     10      0       0     0      99       6     # Block-15-1
-10     10      0       0     0      99       6     # Block-15-2
#######
-10     10      0       0     0      99       6     # Block-16-1
-10     10      0       0     0      99       6     # Block-16-2
#######
-10     10      0       0     0      99       6     # Block-17-1
-10     10      0       0     0      99       6     # Block-17-2

4 #_selparmdev-phase

#_Variance_adjustments_to_input_values
#_1  2  3  4  5   6  7    8   9
 0   0  0  0  0   0  0    0   0  #_add_to_survey_CV
 0   0  0  0  0   0  0    0   0  #_add_to_discard_CV
 0   0  0  0  0   0  0    0   0  #_add_to_bodywt_CV

# 1 1 1 1 1 1 1 1 1 #_mult_by_lencomp_N
# 1.85   2.16    1.43         0 0.65         0.82         1.01         0.75    0.00
#  1.41        2.02    1.24         0 0.51         0.81         0.82         0.65      0.00
   1.70   2.16     1.358   0 0.53      0.82      0.91      0.682  0.000


# 1 1 1 1 1 1 1 1 1 #_mult_by_agecomp_N
#0.897    1.252      0.804     0 0.417      1.0      0.752      0.424     0.000
# 0.882         1.244      0.681     0 0.402      1.10           0.631      0.372      0.000
# 1.32      1.69   1.27    0 0.37      0.95      0.69      0.48   0.00
  1.1      1.5     1.05    0 0.385     1         0.65      0.42   0
```

```
 1 1 1 1 1 1 1 1 1 #_mult_by_size-at-age_N


300 #_DF_for_discard_like
300 #_DF_for_meanbodywt_like

1 #_maxlambdaphase
1 #_sd_offset
#_survey_lambdas
#HKL  POT  TWL  4/ENV 5/SHELF   6/AK-SLOPE  7/NW-SLOPE  8/Combo-shallow   9/Bugs
 1     1    1    1      1           1         1          1                0
 #_discard_lambdas
0.1   0.1   0.1  0      0           0          0           0                0
#_meanwtlambda(one_for_all_sources)
  1
#_lenfreq_lambdas
  .1    .1    .1    0      1           1          1           1                0
#_age_freq_lambda
  .1    .1   .1     0      1           1          1           1                0
#_size@age_lambdas
 .1    .1    .1     0     .1          .1         .1          .1                0
#_initial_equil_catch
1
#_recruitment_lambda
1
#_parm_prior_lambda
1
#_parm_dev_timeseries_lambda
1
# crashpen lambda
1000
#max F
0.90

999     #_end-of-file
```