9 Gulf of Alaska Shortraker/Rougheye and Other Slope Rockfish

by
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9.0 Executive Summary

The North Pacific Fishery Management Council (NPFMC) recently adopted a policy that allows assessments to be made on a biennial basis for certain species or species groups whose assessments rely heavily on results of biennial trawl surveys. The shortraker/rougheye and "other slope rockfish" management groups in the Gulf of Alaska fall into this category. Thus, because no trawl survey was conducted in the Gulf of Alaska in 2004, a detailed assessment of these two groups was not done. Last year's full assessment is available in Clausen et al. (2003) or on the web at: <http://www.afsc.noaa.gov/refm/docs/2003/GOAsrre.pdf>. This Executive Summary will present commercial catches for 2003 and 2004 and a brief summary of last year's assessment, along with a discussion of alternative ABCs for shortraker/rougheye rockfish.

Final commercial catches (mt) for 2003, and catches for 2004 as of October 9, 2004, by Gulf of Alaska management area, are as follows:

	Management Area			Gulfwide	Gulfwide	Gulfwide
Year	Western	Central	Eastern	total	ABC	TAC
		Shortraker/Rougheye Rockfish				
2003	225	856	321	1,402	1,620	1,620
2004	266	326	365	957	1,318	1,318
		Other Slope Rockfish				
2003	130	700	248	1,078	5,050	990
2004	240	523	102	865	3,900	670

As in the past, exploitable biomass for shortraker and rougheye rockfish and "other slope rockfish" was estimated by the unweighted average biomass of the most recent three trawl surveys (1999, 2001, and 2003), excluding the estimated biomass in the 1-100 m depth stratum. The 1-100 m depth stratum was removed from the estimate because most rockfish in this stratum are small juvenile fish younger than the age of recruitment, and thus are not considered exploitable. This results in an exploitable biomass of 32,723 mt for shortraker rockfish, 40,281 mt for rougheye rockfish and 89,455 mt for "other slope rockfish". Applying an F_{ABC}=0.75M rate to the exploitable biomass of shortraker rockfish and an F_{ABC}=M rate to that of rougheye rockfish results in ABCs of 753 mt and 1,007 mt, respectively, or a combined total of 1,760 mt for the shortraker/rougheye management group. For "other slope rockfish", applying an F_{ABC}=M rate to the exploitable biomass of sharpchin rockfish and an F_{ABC}=0.75M rate to that of the other species results in ABCs of 1,035 mt and 2,866 mt, respectively, or a combined total of 3,901 mt for the "other slope rockfish" management group. Details of these ABC computations are listed in the following table, together with corresponding levels of overfishing:

Table 9-1. Summary of computations of ABCs and overfishing levels for shortraker/rougheye and "other slope rockfish" for 2004 and 2005. Because ABCs and overfishing levels are based on each management group, individual species are shown for illustrative purposes only.

Species	Exploitable Biomass (mt)	ABC F	ABC Yield (mt)	Overfishing F	Overfishing Yield (mt)
Shortraker rockfish	32,723	F=0.75M=0.023	753	F=M=0.030	982
Rougheye rockfish	40,281	F=M=0.025	1,007	F35%=0.038	1,531
Total, shortraker/rougheye	73,004		1,760		2,512
Sharpchin rockfish	20,698	F=M=0.050	1,035	F35%=0.064	1,325
Redstripe rockfish	11,259	F=0.75M=0.075	844	F=M=0.100	1,126
Harlequin rockfish	8,961	F=0.75M=0.045	403	F=M=0.060	538
Silvergrey rockfish	37,746	F=0.75M=0.030	1,132	F=M=0.040	1,510
Redbanded rockfish	6,897	F=0.75M=0.045	310	F=M=0.060	414
Minor species	3,893	F=0.75M=0.045	175	F=M=0.060	234
Total, other slope rockfish	89,455		3,901		5,146

Geographic Apportionments

Geographic apportionment of these ABCs amongst management areas of the Gulf of Alaska is based on a weighted average of the percent exploitable biomass distribution for each area in the three most recent trawl surveys. In these computations, each successive survey is given a progressively heavier weighting using factors of 4, 6, and 9, respectively. The apportionment values for shortraker/rougheye rockfish are: Western area, 19.01%; Central area, 49.74%; and Eastern area, 31.24%. Apportionment values for "other slope rockfish" are: Western area, 1.04%; Central area, 7.77%; and Eastern area, 91.19%. The Eastern area for "other slope rockfish" is further divided into the West Yakutat area and the East Yakutat/Southeast Outside area. Based on a procedure identical to the other apportionment calculations (a 4:6:9 weighted average biomass of the three most recent trawl surveys), the Eastern area apportionment is subdivided as follows: West Yakutat, 3.58%; and East Yakutat/Southeast Outside, 96.42%.

"Other Slope Rockfish" ABC

For "other slope rockfish" in 2005, we recommend the same ABCs and apportionment values as we did for 2004. **Thus, the 2005 "other slope rockfish" ABC would be 3,900 mt, apportioned to the management areas as follows: Western, 40 mt; Central, 300 mt; West Yakutat, 130 mt, and East Yakutat/Southeast Outside, 3,430 mt.**

Shortraker/Rougheye ABC

In contrast to "other slope rockfish", the 2005 recommended ABC for shortraker/rougheye rockfish in the Gulf of Alaska is problematic. **In Appendix 9A, we present four alternative shortraker/rougheye ABC values for review by the Plan Team, and we have chosen to not recommend a preferred option.**

Rougheye Rockfish Model

A detailed age-structured model for rougheye rockfish was completed this year for the first time and is presented in Appendix 9B. Although some modeling for rougheye rockfish had been done previously, it was experimental and based on a very small age sample. The new model was able to effectively incorporate longline survey data, but additional age data are needed to ensure model stability. **The model's estimated ABC for rougheye rockfish in the Gulf of Alaska is 1,162 mt, which is similar to the ABC of 1,007 mt estimated by the old method based on trawl survey exploitable biomass.**

Reference

Clausen, D. M., J. T. Fujioka, and J. Heifetz. 2003. Shortraker/rougheye and other slope rockfish. In Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p. 531 – 572. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage AK 99501.

Appendix 9A – Alternative ABCs for Shortraker/Rougheye Rockfish in the Gulf of Alaska

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Introduction

Past computations of ABC for the shortraker/rougheye rockfish management group in the Gulf of Alaska have been based on survey biomass estimates for these species. Because rougheye rockfish have almost always had a much larger biomass in the surveys than shortraker rockfish, rougheye have therefore comprised a larger proportion of the ABC. However, data from the NMFS Alaska Groundfish Observer Program (Clausen et al. 2003; see also Tables 9A-4 - 9A-8) have indicated that a majority of the shortraker/rougheye catch appears to be shortraker rockfish. This means that shortraker rockfish may be disproportionately harvested within the shortraker/rougheye group, and it raises the possibility that shortraker may be overexploited under the current ABC methodology. To remedy this situation, the North Pacific Fisheries Management Council's (NPFMC) Scientific and Statistical Committee (SSC) in December 2002 suggested that the combined shortraker/rougheye ABC could be set at a level such that the individual ABC for shortraker would not be exceeded. An easy and straightforward way to do this is to divide the ABC for shortraker rockfish by the estimated proportion of shortraker in the shortraker/rougheye catch to yield an alternative value of the combined ABC. In last year's SAFE report, we gave an example of an alternative ABC value (1,035 mt) for shortraker/rougheye based on this method, although we noted in the text that our estimate of the shortraker catch from the NMFS Groundfish Observer Program may have been biased because we did not account for catch differences by gear type when making the estimate. In this appendix, we present four possible ABC alternatives for shortraker/rougheye rockfish in 2005, two of which are based on the SSC's suggested procedure.

Shortraker/Rougheye ABC Alternative 1

This alternative is the same ABC for shortraker/rockfish as presented in this year's Executive Summary and was our recommendation in last year's SAFE report. However, it was later rejected by the SSC at their December 2003 meeting and replaced by ABC Alternative 2. Alternative 1 represents a continuation of what has been the standard way to compute ABC for shortraker/rougheye in the Gulf of Alaska since 1994, i.e., computing exploitable biomass from the average of the three most recent trawl surveys and then multiplying these by appropriate values of F. **For Alternative 1, ABC for shortraker/rougheye in 2004 and 2005 would be 1,760 mt, divided into these area apportionments: Western, 335 mt; Central, 875 mt; and Eastern, 200 mt.**

Shortraker/Rougheye ABC Alternative 2

At its December 2003 meeting, the SSC decided that to protect shortraker rockfish from disproportionate harvest within the shortraker/rougheye group, the old method of determining ABC (i.e., Alternative 1) should be replaced by the new method described above in the Introduction. An important requirement of the computations in the new method is an accurate estimate of the proportion of the shortraker catch within the shortraker/rougheye group. Because the estimated proportion of the shortraker catch presented in our November 2003 SAFE report may have been biased, the SSC requested that new estimates be computed. The new estimates took into account catch differences by gear type and were based on the NMFS Alaska Regional Office catch accounting system rather than data from the Observer Program (Ianelli 2003). Details of the methods and data used to determine the new estimates are shown in the section below entitled "Catch Composition Data Used to Calculate ABC Alternatives 2 and 3 for Shortraker/Rougheye Rockfish" and in Tables 9A-1 – 9A-3. The results indicated the proportion of the shortraker catch within the shortraker/rougheye group was 56%, 54%, and 61% for the years 2000, 2001, and 2002, respectively (Table 9A-3). The SSC recommended using the average of these values, 57%, in computing ABC for shortraker/rougheye. **Thus, in this method that we call Alternative 2, the ABC for shortraker rockfish of 753 mt is divided by 0.57 (the proportion of shortraker in the shortraker/rougheye catch) to yield an ABC of 1,318 mt for the shortraker/rougheye group. This ABC is apportioned amongst the management areas as follows: Western, 254 mt; Central, 656 mt; and Eastern, 408 mt.** The NPFMC accepted these ABC values for the shortraker/rougheye group in the Gulf of Alaska in 2004.

Shortraker/Rougheye ABC Alternative 3

Alternative 3 is a new alternative that we present here for the first time. Its methods are similar to those used for determining the example alternative ABC presented in the November 2003 SAFE report, as both are based on data from the Observer Program. This is in contrast to Alternative 2, which used the NMFS Alaska Regional Office catch accounting system to make its catch estimates. In comparison to the example alternative ABC in the November 2003 SAFE report, Alternative 3 is considered an improvement that reduces the risk of possible bias in the estimation of shortraker and rougheye rockfish catches. Possible bias is reduced because Alternative 3 takes into account catch differences by gear type, whereas the example 2003 alternative did not.

We are presenting Alternative 3 because it may provide a more accurate estimate of the true proportion of the shortraker catch than does Alternative 2. Alternative 2 bases its catch estimates on the NMFS catch accounting system, which is derived from a combination of data turned in by fishermen, processors, and observers. In the case of fishermen and processors, prior to 2004 there was no requirement to report catches of shortraker/rougheye rockfish by species, and fishermen and processors were free to report their catch as either shortraker, rougheye, or shortraker/rougheye combined. Shortraker and rougheye rockfish are often difficult for an untrained person to separate taxonomically, and fishermen and processors had no particular incentive to accurately identify the fish to species. In some instances, it is possible that economic marketing may have influenced fishermen and processors to report one species rather than the other, which would result in inaccurate species catch reports[1]. In contrast, all observers in the NMFS Observer Program are trained in identification of Alaska groundfish, and they are instructed as to the importance of accurate identifications. Consequently, because Alternative 3 is based only on catch data from observers, its catch estimates for shortraker and rougheye rockfish may be more reliable than those in the NMFS catch accounting system. Details of the methods and data used to determine the catch estimates for Alternative 3 are shown in the section below entitled "Catch Composition Data Used to Calculate ABC Alternatives 2 and 3 for Shortraker/Rougheye Rockfish" and in Tables 9A-4 – 9A-8.

[1] T. Pearson, Kodiak Fisheries Research Center, National Marine Fisheries Service, Sustainable Fisheries, 302 Trident Way, Room 212, Kodiak, AK 99615. Pers. commun. Jan. 2004.

The catch estimates for Alternative 3 show that shortraker rockfish comprise a much larger proportion of the shortraker/rougheye catch than they do for Alternative 2 (see Table 9A-8 vs. Table 9A-3). The Alternative 3 estimates (based on observer data) indicate that shortraker rockfish comprise about 2/3rd of the shortraker/rougheye catch, whereas the Alternative 2 estimates (based on the NMFS catch accounting system) show that shortraker usually comprise slightly more than ½ of the catch. Further examination of these catch estimates by gear type reveals that the two methods of estimating catch generally agree on the species composition of the trawl catch, but find very different results for the longline catch (see Table 9A-7 vs. Table 9A-2). The estimates of longline catch from the NMFS catch accounting system show approximately equal catches of shortraker and rougheye for most years, whereas those based on observer data indicate that shortraker predominate by a factor of about 3 to 1.

As previously discussed, the species catch data from the Observer Program may be more accurate than those from the NMFS catch accounting system because of the better identification of shortraker and rougheye rockfish by observers. Further evidence lending credence to the observer estimates is the consistent predominance of shortraker rockfish in the species composition of the longline catches. Even though the rate of observer coverage of shortraker/rougheye longline catches is relatively low in the Gulf of Alaska compared to that of trawls (Table 9A-6), the observed catch of shortraker rockfish on longlines is much greater than that of rougheye rockfish in virtually every area and year (Appendix 9A, Table 9A-4). This remarkable consistency in the observer data strongly suggests that shortraker rockfish do indeed comprise the majority of the longline catch of shortraker/rougheye.

Finally, one other factor favoring the observer data and Alternative 3 is that starting in 2003, the NMFS catch accounting system was modified in such a way that it can no longer provide catch estimates by species. New algorithms were written that estimated catch, but catches from these algorithms are only available for specified management species or species groups. The new system cannot account for non-specified species or individual species within management groups, such as shortraker and rougheye rockfish in the Gulf of Alaska. Although there are plans to eventually modify the algorithms to allow catch estimates by species, at present the only way to estimate the species catch of shortraker and rougheye is to use data from the Observer Program.

Therefore, **Alternative 3** estimates the 2005 ABC for shortraker/rougheye rockfish in the Gulf of Alaska as follows: The estimated proportion of shortraker rockfish in the shortraker/rougheye catch for the three most recent years is 0.701 in 2001, 0.794 in 2002, and 0.719 in 2003, with an average proportion of 0.738 (Table 9A-8). **The ABC for shortraker rockfish, 753 mt, divided by 0.738, yields a Gulfwide ABC of 1,020 mt for the shortraker/rougheye management group. This ABC can then be apportioned to the geographic areas based on the apportionment values listed above: Western, 194 mt; Central, 507 mt; and Eastern, 319 mt.**

Shortraker/Rougheye ABC Alternative 4

This alternative, which was briefly mentioned in last year's SAFE report, would dispense with the shortraker/rougheye group entirely and establish separate ABCs for each species. **Hence, Alternative 4 ABCs for 2005 in the Gulf of Alaska would be 753 mt for shortraker rockfish and 1,007 mt for rougheye rockfish.** Establishing separate ABCs for shortraker and rougheye rockfish would solve the problem that presently exists regarding possible overexploitation of shortraker rockfish within the shortraker/rougheye group. If this alternative was adopted, management of these two species in Gulf of Alaska would also be consistent with that in the Bering Sea and Aleutian Islands, where separate ABCs for shortraker and rougheye were initiated in 2004. Although separating shortraker and rougheye rockfish in the Gulf of Alaska appears to be a logical management step and will probably occur sometime in the future, at present it may not be a feasible option. This is because of the current difficulty obtaining accurate species catch identification for shortraker and rougheye rockfish, especially from the longline fishery. Species identification is not so much of a problem in the Bering Sea and Aleutian Islands, where observer coverage rates are relatively high for both trawl and longline vessels. In the Gulf of Alaska, however, observer coverage is low or non-existent on the small vessels that comprise most of the longline fleet. Therefore, to successfully manage shortraker and rougheye rockfish in the Gulf of Alaska separately under their own individual ABCs and TACS, we would be dependent on fishermen and processors to make accurate species identifications. An aggressive training program to educate fishermen and processors on the identification of shortraker and rougheye rockfish would likely be required before Alternative 4 could be adopted.

Comments on Shortraker/Rougheye ABC Alternatives

Although we are definitely concerned about possible overexploitation of shortraker rockfish in the Gulf of Alaska, we are also concerned about the methodology used in Alternatives 2 and 3 to obtain new ABC estimates for shortraker/rougheye rockfish. To compute ABC, Alternatives 2 and 3 both rely on estimates of the proportion of shortraker in the catch; as we have discussed, however, these estimates are uncertain. Alternative 3 is probably preferable to Alternative 2 because the former is based exclusively on observer identifications, and these observer data were highly consistent in showing a predominance of shortraker rockfish in the longline catches over many areas and years. Even so, the amount of observed shortraker/rougheye catch in the longline fishery was relatively low, which suggests caution in the use of these estimates for determining ABC. Also, Alternative 3's relatively low ABC of 1,020 mt represents a significant decrease compared to previous ABCs for shortraker/rougheye rockfish in the Gulf of Alaska. This ABC is low enough that it could impose a hardship to commercial fishermen if it were to result in closures of other fisheries because of shortraker/rougheye bycatch constraints

One option would be to revert back to the old method of determining ABC (Alternative 1) until additional catch information is available and/or fishermen and processors are better trained in identification of the two species. A cooperative research project involving the Alaska Longline Fishermen's Association and NMFS is planned for 2005 to obtain information on the shortraker/rougheye species catch composition from un-observed longline vessels in the Gulf of Alaska. The project will also train processing crews at shoreside plants to correctly identify the two species and later will investigate how successful the training was. After this project is completed, we could then re-examine the possible change of our ABC determinations to one of the new alternatives.

References

Clausen, D. M., J. T. Fujioka, and J. Heifetz. 2003. Shortraker/rougheye and other slope rockfish. In Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p. 531 – 572. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage AK 99501.

Ianelli, J. 2003. An examination of GOA SR/RE species composition available from the NMFS catch-accounting system. Unpubl. manu. 3 p. (Available from National Marine Fisheries Service, Alaska Fisheries Science Science, REFM Division, 7600 Sand Point Way NE, Seattle WA 98115-0070).

Sources of Catch Composition Data Used to Calculate ABC Alternatives 2 and 3 for Shortraker/Rougheye Rockfish

The data in Tables 9A-1 through 9A-3 were originally listed in Ianelli (2003) and are from the NMFS Alaska Regional Office catch accounting system. These three tables were used to estimate the proportion of shortraker rockfish in the Gulf of Alaska shortraker/rougheye catch (see column 4 in Table 9A-3). This proportion in turn was used to calculate shortraker/rougheye ABC for Alternative 2 in this appendix. For the years 1993-2002, catches were available in the catch accounting system by gear type for two categories of shortraker/rougheye: those catches specifically identified as rougheye or shortraker, and those identified only as shortraker/rougheye combined. The species proportions computed from the identified catch (Table 9A-2) were applied to the shortraker/rougheye combined catches in Table 9A-1 to estimate the species composition of the combined catches. These estimated catches were then added to the identified catch to yield estimates of total catch for each species (Table 9A-3). Because of technical changes in the catch accounting system, only data for an overall catch of shortraker/rougheye combined are available for 2003.

The data in Tables 9A-4 through 9A-8 were newly compiled for this appendix and are from the NMFS Alaska Groundfish Observer Program database and from the NMFS Alaska Regional Office website. These tables were used to estimate the proportion of shortraker rockfish in the Gulf of Alaska shortraker/rougheye catch (see column 4 in Table 9A-8). This proportion in turn was used to calculate shortraker/rougheye ABC for Alternative 3 in this appendix. Tables 9A-4 and 9A-5 contain the basic data, from which the remaining tables are derived. Catches for 1993-2003 were available from the observer database by area, gear, and species for those hauls sampled by observers (Table 9A-4). These data were then used to compute the proportions of the shortraker and rougheye catch by gear type (Table 9A-7). Finally, these proportions were applied to the combined shortraker/rougheye catches from the Regional Office website (Table 9A-5) to yield estimates of the total catch for each species (Table 9A-8).

Table 9A-1. Catch (mt) of shortraker and rougheye rockfish in the Gulf of Alaska, by gear type, 1993-2003, based on data from the NMFS Alaska Regional Office catch accounting system. (SR/RE = shortraker and rougheye rockfish combined; RE = rougheye rockfish; SR = shortraker rockfish; n.a. = not available).

Year	SR/RE Trawl	RE Trawl	SR Trawl	SR/RE Longline	RE Longline	SR Longline	SR/RE Total
1993	1,391	15	30	486	116	58	2,095
1994	891	38	20	703	110	57	1,819
1995	1,398	60	92	406	168	125	2,249
1996	927	107	81	268	169	102	1,654
1997	717	144	208	195	180	159	1,604
1998	494	283	139	387	220	194	1,717
1999	524	71	133	207	201	174	1,310
2000	780	84	131	290	229	229	1,743
2001	510	117	165	544	309	331	1,976
2002	516	75	165	233	161	158	1,309
2003	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1,405

Table 9A-2. Composition (proportion) of the shortraker and rougheye rockfish identified catch in the Gulf of Alaska, by gear type, 1993-2003, based on the data in Table 9A-1 from the NMFS Alaska Regional Office catch accounting system. (RE = rougheye rockfish; SR = shortraker rockfish; n.a. = not available).

	Composition of Identified SR-RE Catch			
	Trawl		Longline	
Year	RE	SR	RE	SR
1993	0.33	0.67	0.67	0.33
1994	0.66	0.34	0.66	0.34
1995	0.39	0.61	0.57	0.43
1996	0.57	0.43	0.62	0.38
1997	0.41	0.59	0.53	0.47
1998	0.67	0.33	0.53	0.47
1999	0.35	0.65	0.54	0.46
2000	0.39	0.61	0.50	0.50
2001	0.41	0.59	0.48	0.52
2002	0.31	0.69	0.50	0.50
2003	n.a.	n.a.	n.a.	n.a.

Table 9A-3. Total estimated catch (mt) of shortraker and rougheye rockfish in the Gulf of Alaska, by gear type, 1993-2003, based on the data in Tables 9A-1 and 9A-2 from the NMFS Alaska Regional Office catch accounting system. Also shown is the estimated percentage of shortraker rockfish in the shortraker/rougheye catch. (RE = rougheye rockfish; SR = shortraker rockfish; n.a. = not available).

Year	RE	SR	% SR
1993	919	1,177	56.2
1994	1,195	624	34.3
1995	1,013	1,236	55.0
1996	971	683	41.3
1997	721	882	55.0
1998	1,040	677	39.4
1999	565	745	56.8
2000	763	980	56.2
2001	900	1,076	54.4
2002	515	793	60.6
2003	n.a.	n.a.	n.a.
Average % SR 2000-2002 =			57.1

Table 9A-4. Observed catch (kg) of shortraker and rougheye rockfish in the Gulf of Alaska, by gear type, 1993-2003. (From NMFS Alaska Observer Program database; RE = rougheye and SR = shortraker; E. Yak/SE = East Yakutat/Southeastern area).

		Non-pelagic trawl			Pelagic trawl			Longline			Grand
Year	Area	RE	SR	Total	RE	SR	Total	RE	SR	Total	total
1993	Shumagin	9,436	7,392	16,828	0	0	0	6,968	37,644	44,612	61,440
	Chirikof	54,121	52,704	106,825	9	513	523	6,964	12,910	19,874	127,221
	Kodiak	117,037	223,635	340,673	17	1	19	16,927	38,176	55,104	395,795
	W. Yakutat	10,903	78,675	89,577	889	233	1,122	7,821	56,950	64,771	155,470
	E. Yak/SE	1,086	4,786	5,872	0	0	0	2,920	2,701	5,621	11,493
	Total	192,583	367,192	559,775	915	748	1,663	41,600	148,381	189,981	751,419
1994	Shumagin	23,097	27,010	50,106	3	0	3	1,500	7,355	8,855	58,964
	Chirikof	16,578	21,405	37,982	5	11	16	6,033	1,814	7,847	45,845
	Kodiak	115,776	194,108	309,884	1,637	451	2,088	5,197	5,975	11,171	323,143
	W. Yakutat	10,255	115,792	126,047	6,965	667	7,632	1,992	17,304	19,296	152,975
	E. Yak/SE	9,915	7,343	17,259	0	0	0	337	3,484	3,821	21,080
	Total	175,620	365,658	541,278	8,610	1,129	9,739	15,058	35,932	50,991	602,008
1995	Shumagin	60,729	14,696	75,425	8	0	8	11,040	42,466	53,506	128,939
	Chirikof	54,467	100,412	154,879	264	0	264	313	761	1,074	156,217
	Kodiak	134,594	261,509	396,104	258	0	258	2,559	8,006	10,565	406,926
	W. Yakutat	22,892	123,139	146,031	2,091	4,109	6,199	4,119	15,983	20,102	172,333
	E. Yak/SE	4	20,554	20,559	0	0	0	9,869	19,148	29,017	49,576
	Total	272,687	520,311	792,998	2,620	4,109	6,729	27,899	86,364	114,263	913,990

Table 9A-4. (continued.)

		Non-pelagic trawl			Pelagic trawl			Longline			Grand
Year	Area	RE	SR	Total	RE	SR	Total	RE	SR	Total	total
1996	Shumagin	11,397	2,404	13,800	17	0	17	17,320	37,155	54,475	68,292
	Chirikof	27,488	39,688	67,176	6,284	0	6,284	642	4,306	4,948	78,409
	Kodiak	140,865	170,994	311,859	39	0	39	5,296	12,842	18,138	330,036
	W. Yakutat	23,966	110,453	134,419	845	533	1,378	4,049	15,856	19,905	155,702
	E. Yak/SE	7,095	30,365	37,461	0	0	0	5,832	31,577	37,410	74,871
	Total	210,811	353,904	564,716	7,185	533	7,718	33,141	101,735	134,876	707,309
1997	Shumagin	3,856	21,964	25,821	39	361	400	8,921	37,962	46,883	73,104
	Chirikof	30,734	21,221	51,955	97	107	204	281	3,221	3,501	55,660
	Kodiak	140,971	161,021	301,993	198	0	198	1,474	8,493	9,967	312,157
	W. Yakutat	4,812	73,520	78,332	2,692	29,493	32,186	1,276	12,431	13,707	124,225
	E. Yak/SE	16,026	10,001	26,027	0	0	0	13,800	16,278	30,078	56,105
	Total	196,400	287,728	484,128	3,026	29,961	32,987	25,751	78,386	104,137	621,251
1998	Shumagin	17,887	16,703	34,590	0	0	0	6,885	22,702	29,587	64,177
	Chirikof	11,099	4,612	15,711	407	0	407	1,857	3,546	5,402	21,520
	Kodiak	324,116	129,629	453,745	0	0	0	3,896	14,019	17,915	471,660
	W. Yakutat	3,646	135,845	139,492	0	35,220	35,220	1,237	14,635	15,871	190,583
	E. Yak/SE	0	0	0	0	0	0	7,663	19,813	27,475	27,475
	Total	356,748	286,790	643,538	407	35,220	35,627	21,537	74,714	96,251	775,415

Table 9A-4. (continued.)

Year	Area	Non-pelagic trawl RE	Non-pelagic trawl SR	Non-pelagic trawl Total	Pelagic trawl RE	Pelagic trawl SR	Pelagic trawl Total	Longline RE	Longline SR	Longline Total	Grand total
1999	Shumagin	12,790	50,072	62,863	0	0	0	3,072	12,305	15,377	78,240
	Chirikof	39,088	40,342	79,430	0	0	0	440	950	1,390	80,820
	Kodiak	50,305	104,372	154,677	57	310	367	1,887	7,231	9,117	164,161
	W. Yakutat	17,905	103,723	121,628	0	8,035	8,035	2,111	7,293	9,404	139,066
	E. Yak/SE	0	0	0	0	0	0	3,292	16,422	19,714	19,714
	Total	120,089	298,509	418,597	57	8,345	8,401	10,801	44,201	55,002	482,001
2000	Shumagin	25,471	17,716	43,187	0	2	2	4,126	7,937	12,063	55,252
	Chirikof	20,874	4,007	24,881	0	0	0	629	3,752	4,381	29,262
	Kodiak	146,057	327,961	474,018	917	147	1,064	5,423	11,567	16,991	492,073
	W. Yakutat	11,134	96,207	107,341	8	4,367	4,375	2,943	5,955	8,898	120,613
	E. Yak/SE	0	0	0	0	0	0	7,367	20,286	27,653	27,653
	Total	203,536	445,890	649,427	924	4,516	5,440	20,488	49,498	69,985	724,852
2001	Shumagin	16,964	10,745	27,708	68	0	68	2,218	5,540	7,758	35,534
	Chirikof	4,915	3,486	8,401	2,422	1,548	3,969	889	1,466	2,355	14,726
	Kodiak	66,964	129,759	196,723	26	22	49	1,674	11,392	13,066	209,837
	W. Yakutat	9,748	39,694	49,441	0	10,060	10,060	2,018	6,555	8,573	68,075
	E. Yak/SE	0	0	0	0	0	0	6,880	11,914	18,793	18,793
	Total	98,591	183,683	282,274	2,516	11,630	14,146	13,678	36,867	50,545	346,965

Table 9A-4. (continued.)

		Non-pelagic trawl			Pelagic trawl			Longline			Grand
Year	Area	RE	SR	Total	RE	SR	Total	RE	SR	Total	total
2002	Shumagin	17,068	128,295	145,363	0	0	0	4,670	14,053	18,724	164,086
	Chirikof	28,654	69,976	98,631	2,466	1,803	4,269	86	1,337	1,423	104,322
	Kodiak	29,844	145,616	175,461	259	1,674	1,933	2,111	6,096	8,207	185,601
	W. Yakutat	3,448	42,932	46,380	396	23,296	23,692	2,789	6,161	8,950	79,021
	E. Yak/SE	0	0	0	0	0	0	2,305	6,538	8,842	8,842
	Total	79,014	386,819	465,833	3,122	26,773	29,894	11,961	34,184	46,145	541,873
2003	Shumagin	22,553	42,371	64,924	0	0	0	6,199	22,462	28,661	93,585
	Chirikof	34,024	68,255	102,278	14,873	9,985	24,858	843	2,233	3,076	130,212
	Kodiak	57,300	147,484	204,784	198	87	285	2,123	6,528	8,651	213,720
	W. Yakutat	15,759	61,609	77,368	455	6,499	6,954	1,745	6,140	7,885	92,207
	E. Yak/SE	0	0	0	0	0	0	4,416	9,844	14,259	14,259
	Total	129,636	319,719	449,354	15,526	16,571	32,097	15,326	47,207	62,533	543,984
Grand Total		2,035,715	3,816,203	5,851,918	44,907	139,535	184,442	237,240	737,469	974,709	7,011,068

Table 9A-5. Total catch (mt) of the shortraker/rougheye management category in the Gulf of Alaska, by gear type, 1993-2003, based on data on the NMFS Alaska Regional Office website.

Year	Trawl	Longline	Total
1993	1,277	655	1,932
1994	951	881	1,832
1995	1,550	700	2,250
1996	1,116	545	1,661
1997	1,068	543	1,611
1998	915	818	1,733
1999	728	583	1,311
2000	996	747	1,743
2001	791	1,184	1,975
2002	756	567	1,323
2003	900	505	1,405

Table 9A-6. Percent of the total shortraker/rougheye catch in the Gulf of Alaska that was observed, by gear type, 1993-2003. Percents were computed from data in Table 9A-4 and Table 9A-5.

	Percent observed	
Year	Trawl	Longline
1993	44.0	29.0
1994	57.9	5.8
1995	51.6	16.3
1996	51.3	24.7
1997	48.4	19.2
1998	74.2	11.8
1999	58.7	9.4
2000	65.8	9.4
2001	37.5	4.3
2002	65.6	8.1
2003	53.5	12.4

Table 9A-7. Species composition (proportion) of the observed shortraker and rougheye catch by gear type, 1993-2003, based on the observer data in Table 9A-4.

	Composition of Observed SR-RE Catch			
	Trawl		Longline	
Year	RE	SR	RE	SR
1993	0.34	0.66	0.22	0.78
1994	0.33	0.67	0.30	0.70
1995	0.34	0.66	0.24	0.76
1996	0.38	0.62	0.25	0.75
1997	0.39	0.61	0.25	0.75
1998	0.53	0.47	0.22	0.78
1999	0.28	0.72	0.20	0.80
2000	0.31	0.69	0.29	0.71
2001	0.34	0.66	0.27	0.73
2002	0.17	0.83	0.26	0.74
2003	0.30	0.70	0.25	0.75

Table 9A-8. Estimated catch (mt) of shortraker and rougheye rockfish in the Gulf of Alaska, 1993-2003, from observer data, based on applying the proportions in Table 9A-7 to the catches in Table 9A-5. Also shown is the estimated percentage of shortraker rockfish in the shortraker/rougheye catch.

Year	RE	SR	% SR
1993	584	1,348	69.8
1994	578	1,254	68.4
1995	705	1,545	68.7
1996	559	1,102	66.4
1997	546	1,065	66.1
1998	664	1,069	61.7
1999	319	992	75.6
2000	529	1,214	69.6
2001	590	1,385	70.1
2002	272	1,051	79.4
2003	395	1,010	71.9
Average % SR 2001-2003 =			73.8

Appendix 9B: Rougheye Rockfish Age-Structured Model

by
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9B.0 Overview

Rougheye rockfish (*Sebastes aleutianus*) have traditionally been assessed with a running average of trawl survey biomass estimates and combined with shortraker rockfish (*Sebastes borealis*) for management purposes. Recently, two years of survey age composition data have become available. In this appendix, we explore the use of a generic rockfish model developed in a modeling workshop held at the Auke Bay Laboratory in February 2001[1]. The model was constructed with AD Model Builder software (Otter Research Ltd 2000). The model is a separable age-structured model with allowance for size composition data that is adaptable to several rockfish species. The primary difference for rougheye rockfish is the incorporation of data from the sablefish longline survey. We present two models which incorporate all of the available rougheye rockfish data and provide reasonable fits to the data for consideration by the Plan Team.

9B.1 Data

9B.1.1 Fishery Data

Catch

Catches range from 130 mt to 2418 mt from 1977 to 2004. The catches from 1977-1996 were taken from Soh (1998). Catches from 1997-2002 were extracted from a document presented to the NPFMC last year with the remainder from the NMFS Regional Office "blend estimates" multiplied by the proportion of SR/RE from the same document (Ianelli 2003). These catches can be seen in Figure 9B-1 and Table 9B-1.

Size composition

Observers aboard fishing vessels and at onshore processing facilities have provided data on size composition of the commercial catch of rougheye rockfish. Table 9B-2 summarizes the available length compositions from 1988-2004. There was no data available for 1989, 1994-1999. Figure 9B-7 shows the length distributions graphically along with the recommended model predictions. Lengths were binned into 2 cm categories to obtain better sample sizes per bin from 20-60+ with the (+) group containing all the fish 60 cm and larger. Approximately 72% of the lengths are from the trawl fishery and 28% are from the longline survey. The selectivity curve for the fishery should be somewhere between the longline survey and the trawl survey.

[1]Rockfish Modeling Workshop, NMFS Auke Bay Laboratory, 11305 Glacier Hwy., Juneau, AK. February, 2001.

9B.1.2 Survey Data

9B.1.2.1 Bottom trawl survey

Biomass Estimates from Trawl Surveys

Bottom trawl surveys were conducted on a triennial basis in the Gulf of Alaska in 1984, 1987, 1990, 1993, 1996. These surveys became biennial for the 2001 and 2003 surveys. The surveys provide much information on rougheye rockfish, including an abundance index, age composition, and growth characteristics. The surveys are theoretically an estimate of absolute biomass, but we treat them as an index in the stock assessment model. The triennial surveys covered all areas of the Gulf of Alaska out to a depth of 500 m (in some surveys to 1,000 m), but the 2001 survey did not sample the eastern Gulf of Alaska. Summaries of biomass estimates from the 1984-2003 surveys are provided in Table 9B-3. Trawl survey biomass estimates with sampling error and model predictions are shown in Figure 9B-2. Since the 2001 survey did not sample the Eastern Gulf and we had an index for that year from the longline survey, we did not use it in this model.

Age Compositions

Ages were determined from the break-and-burn method (Chilton and Beamish 1982). Only two survey age compositions have been completed from the 1984-2003 trawl surveys, 1990 and 1999. Although rougheye rockfish have been reported to be greater than 200 years old (Munk 2001), the highest age collected in these two years was 129. The average was 15.4 and 18.9 years in 1990 and 1999, respectively (Table 9B-4). A large proportion of 9-10 year old fish in the 1990 survey appeared to have survived as indicated from the presence of a higher proportion of 18-19 year old fish in the 1999 age composition. Ages used in the model were from 3-25+ with older ages pooled into the (+) group. Age compositions and model fits are shown in Figure 9B-8.

Survey Size Compositions

Gulfwide population size compositions for rougheye rockfish are in Table 9B-5 and the compositions used in the model with model fits are in Figure 9B-9. The size compositions were somewhat variable, with what appeared to be a tendency toward more small fish in the last two surveys. This could indicate good recruitment events or the diminishing of larger fish in the population. The 1990 and 1999 size compositions were not used in the model, because they were used in construction of the size-at-age matrix.

9B.1.2.2 Sablefish longline survey

Biomass Estimates from Longline Surveys

Catch, effort, and length data were collected during sablefish longline surveys for rougheye rockfish. Rougheye data were collected outside of the SR/RE complex since 1990. These longline surveys likely provide an accurate index of sablefish abundance (Sigler 2000) and may also provide a reasonable index for rougheye rockfish in addition to the trawl surveys. These data were expressed as a relative population weight and used as a second biomass index in the model. The standard deviation of the time series was used as the standard error of the individual estimates and equaled approximately 20%. The index along with the recommended model predictions are shown in Table 9B-6 and Figure 9B-3.

Survey Size Compositions

Large samples of length compositions were collected Gulf-wide for a subsample of rougheye rockfish. These compositions show that small fish were rarely caught in the longline survey and that the length distribution was fairly stable through time (Table 9B-7, Figure 9B-10).

9B.2 Analytic Approach

9B.2.1 Model Structure

We present model results for rougheye rockfish based on an age-structured model using AD Model Builder software (Otter Research Ltd 2000). Previously, the rougheye rockfish stock assessment was based solely on trawl survey biomass estimates. The assessment model is now based on a generic rockfish model developed in a workshop held in February 2001[1] and follows closely the GOA Pacific ocean perch model (Hanselman et al. 2003). The main difference between the rougheye model and the Pacific ocean perch model is the addition of data from the sablefish longline survey. Unlike the Pacific ocean perch model, the starting point for the rougheye model was 1977, so the population at the starting point has already sustained significant fishing pressure. The parameters, population dynamics and equations of the model are described in Box 1.

9B.2.2 Parameters Estimated Independently

Size at 50% maturity has been determined for 430 specimens of rougheye rockfish (McDermott 1994). This was converted to 50% maturity-at-age using the size-at-age matrix from this stock assessment. These data are summarized below (size is in cm fork length and age is in years).

Sample size	Size at 50% maturity (cm)	Age at 50% maturity
430	43.9	19

A von Bertalanffy growth curve was fitted to survey size-at-age data from 1990 and 1999. Sexes were combined. A size-at-age transition matrix was then constructed by adding normal error with a standard deviation equal to the standard deviation of survey ages for each size class. The estimated parameters for the growth curve are shown below:

L_∞=51.2 cm κ=0.08 t_0=-1.15 n=866

Weight-at-age was constructed with weight-at-age data from the same data set as the length-at-age. The estimated growth parameters are shown below. A correction of $(W_\infty-W_a)/2$ was used for the weight of the pooled ages (Schnute et al. 2001).

W_∞=2311 g κ=0.05 t_0=1.68 β=1.712 n=735

Aging error matrices were constructed by assuming that the break-and-burn ages were unbiased but had a given amount of normal error around each age. We used the error structure of the Pacific ocean perch model because we used approximately the same age bins for the rougheye assessment. Future assessments will examine this assumption as aging error may be higher for rougheye rockfish.

9B.2.3 Parameters estimated conditionally

Parameters estimated conditionally include but are not limited to: catchability, selectivity (up to full selectivity) for surveys and fishery, recruitment deviations, mean recruitment, fishing mortality, natural mortality, and spawners per recruit levels. Other parameters are described in Box 1.

BOX 1. AD Model Builder POP Model Description

Parameter definitions	
y	Year
a	Age classes
l	Length classes
w_a	Vector of estimated weight at age, $a_0 \rightarrow a_+$
m_a	Vector of estimated maturity at age, $a_0 \rightarrow a_+$
a_0	Age it first recruitment
a_+	Age when age classes are pooled
μ_r	Average annual recruitment, log-scale estimation
μ_f	Average fishing mortality
ϕ_y	Annual fishing mortality deviation
τ_y	Annual recruitment deviation
σ_r	Recruitment standard deviation
fs_a	Vector of selectivities at age for fishery, $a_0 \rightarrow a_+$
ss_a	Vector of selectivities at age for survey, $a_0 \rightarrow a_+$
M	Natural mortality, log-scale estimation
$F_{y,a}$	Fishing mortality for year y and age class a ($fs_a \mu_f e^{\varepsilon}$)
$Z_{y,a}$	Total mortality for year y and age class a ($=F_{y,a}+M$)
$\varepsilon_{y,a}$	Residuals from year to year mortality fluctuations
$T_{a,a'}$	Aging error matrix
$T_{a,l}$	Age to length transition matrix
q_1	Trawl survey catchability coefficient
q_2	Longline survey catchability coefficient
SB_y	Spawning biomass in year y, ($=m_a\, w_a\, N_{y,a}$)
M_{prior}	Prior mean for natural mortality
q_{prior}	Prior mean for catchability coefficient
$\sigma_{r(prior)}$	Prior mean for recruitment variance
σ_M^2	Prior CV for natural mortality
σ_q^2	Prior CV for catchability coefficient
$\sigma_{\sigma_r}^2$	Prior CV for recruitment deviations

BOX 1 (Continued)

Equations describing the observed data

Equation	Description
$\hat{C}_y = \sum_a \frac{N_{y,a} * F_{y,a} * \left(1 - e^{-Z_{y,a}}\right)}{Z_{y,a}} * w_a$	Catch equation
$\hat{I}_{1y} = q_1 * \sum_a N_{y,a} * \frac{s_a}{\max(s_a)} * w_a$	Trawl survey biomass index (mt)
$\hat{I}_{2y} = q_2 * \sum_a N_{y,a} * \frac{s_a}{\max(s_a)} * w_a$	Longline survey biomass index (mt)
$\hat{P}_{y,a'} = \sum_a \left(\frac{N_{y,a} * s_a}{\sum_a N_{y,a} * s_a} \right) * T_{a,a'}$	Survey age distribution Proportion at age
$\hat{P}_{y,l} = \sum_a \left(\frac{N_{y,a} * s_a}{\sum_a N_{y,a} * s_a} \right) * T_{a,l}$	Survey length distribution Proportion at length
$\hat{P}_{y,a'} = \sum_a \left(\frac{\hat{C}_{y,a}}{\sum_a \hat{C}_{y,a}} \right) * T_{a,a'}$	Fishery age composition Proportion at age
$\hat{P}_{y,l} = \sum_a \left(\frac{\hat{C}_{y,a}}{\sum_a \hat{C}_{y,a}} \right) * T_{a,l}$	Fishery length composition Proportion at length

Equations describing population dynamics

Start year

$$N_a = \begin{cases} e^{\left(\mu_r + \tau_{styr-a_o-a-1}\right)}, & a = a_0 \\ e^{\left(\mu_r + \tau_{styr-a_o-a-1}\right)} e^{-(a-a_0)M}, & a_0 < a < a_+ \\ \frac{e^{(\mu_r)} e^{-(a-a_0)M}}{\left(1 - e^{-M}\right)}, & a = a_+ \end{cases}$$

Number at age of recruitment

Number at ages between recruitment and pooled age class

Number in pooled age class

Subsequent years

$$N_{y,a} = \begin{cases} e^{\left(\mu_r + \tau_y\right)}, & a = a_0 \\ N_{y-1,a-1} * e^{-Z_{y-1,a-1}}, & a_0 < a < a_+ \\ N_{y-1,a-1} * e^{-Z_{y-1,a-1}} + N_{y-1,a} * e^{-Z_{y-1,a}}, & a = a_+ \end{cases}$$

Number at age of recruitment
Number at ages between recruitment and pooled age class
Number in pooled age class

Formulae for likelihood components	**BOX 1 (Continued)**
$L_1 = \lambda_1 \sum_y \left(\ln \left[\frac{C_y + 0.01}{\hat{C}_y + 0.01} \right] \right)^2$	Catch likelihood
$L_2 = \lambda_2 \sum_y \frac{\left(I_{1y} - \hat{I}_{1y} \right)^2}{2 * \hat{\sigma}^2 \left(I_{1y} \right)}$	Trawl survey biomass index likelihood
$L_3 = \lambda_3 \sum_y \frac{\left(I_{2y} - \hat{I}_{2y} \right)^2}{2 * \hat{\sigma}^2 \left(I_{2y} \right)}$	Longline survey biomass index likelihood
$L_4 = \lambda_4 \sum_{styr}^{endyr} -n^*{}_y \sum_{l}^{l+} \left(P_{y,l} + 0.001 \right) * \ln \left(\hat{P}_{y,l} + 0.001 \right)$	Fishery length composition likelihood
$L_5 = \lambda_5 \sum_{styr}^{endyr} -n^*{}_y \sum_{a}^{a+} \left(P_{y,a} + 0.001 \right) * \ln \left(\hat{P}_{y,a} + 0.001 \right)$	Trawl survey age composition likelihood
$L_6 = \lambda_6 \sum_{styr}^{endyr} -n^*{}_y \sum_{l}^{l+} \left(P_{y,l} + 0.001 \right) * \ln \left(\hat{P}_{y,l} + 0.001 \right)$	Trawl survey size composition likelihood
$L_7 = \lambda_7 \sum_{styr}^{endyr} -n^*{}_y \sum_{l}^{l+} \left(P_{y,l} + 0.001 \right) * \ln \left(\hat{P}_{y,l} + 0.001 \right)$	Longline survey size composition likelihood
$L_8 = \frac{1}{2\sigma_M^2} \left(\ln M / M_{prior} \right)^2$	Penalty on deviation from prior distribution of natural mortality
$L_9 = \frac{1}{2\sigma_{q_1}^2} \left(\ln q_1 / q_{1prior} \right)^2$	Penalty on deviation from prior distribution of catchability coefficient for trawl survey
$L_{10} = \frac{1}{2\sigma_{q_2}^2} \left(\ln q_2 / q_{2prior} \right)^2$	Penalty on deviation from prior distribution of catchability coefficient for longline survey
$L_{11} = \frac{1}{2\sigma_{\sigma_r}^2} \left(\ln \sigma_r / \sigma_{r(prior)} \right)^2$	Penalty on deviation from prior distribution of recruitment deviations
$L_{12} = \lambda_{12} \left[\frac{1}{2 * \sigma_r^2} \sum_y \tau_y^2 + n_y * \ln \left(\sigma_r \right) \right]$	Penalty on recruitment deviations
$L_{13} = \lambda_{13} \sum_y \varepsilon_y^2$	Fishing mortality regularity penalty
$L_{14} = \lambda_{14} \bar{s}^2$	Average selectivity penalty (attempts to keep average selectivity near 1)
$L_{15} = \lambda_{15} \sum_{a_0}^{a_+} \left(s_i - s_{i+1} \right)^2$	Selectivity dome-shapedness penalty – only penalizes when the next age's selectivity is lower than the previous (penalizes a downward selectivity curve at older ages)
$L_{16} = \lambda_{16} \sum_{a_0}^{a_+} \left(FD(FD(s_i - s_{i+1}) \right)^2$	Selectivity regularity penalty (penalizes large deviations from adjacent selectivities by adding the square of second differences
$L_{total} = \sum_{i=1}^{16} L_i$	Total objective function value

9B.2.4 Uncertainty

Evaluation of model uncertainty has recently become an integral part of the "precautionary approach" in fisheries management. In complex stock assessment models such as this model, evaluating the level of uncertainty is difficult. One way is to examine the standard errors of parameter estimates from the Maximum Likelihood (ML) approach derived from the Hessian matrix. While these standard errors give some measure of variability of individual parameters, they often underestimate their variance and assume that the joint distribution is multivariate normal. An alternative approach is to examine parameter distributions through Markov Chain Monte Carlo (MCMC) methods (Gelman et al. 1995). When treated this way, our stock assessment is a large Bayesian model, which includes informative (e.g., lognormal natural mortality with a small CV) and noninformative (or nearly so, such as a parameter bounded between 0 and 10) prior distributions. In the models presented in this SAFE report, the number of parameters estimated is 125. In a low-dimensional model, an analytical solution might be possible, but in one with this many parameters, an analytical solution is intractable. Therefore, we use MCMC methods to estimate the Bayesian posterior distribution for these parameters. The basic premise is to use a Markov chain to simulate a random walk through the parameter space which will eventually converge to a stationary distribution which approximates the posterior distribution. Determining whether a particular chain has converged to this stationary distribution can be complicated, but generally if allowed to run long enough, the chain will converge (Jones and Hobert 2001). The "burn-in" is a set of iterations removed at the beginning of the chain. This method is not strictly necessary but we use it as a precautionary measure. In our simulations we removed the first 50,000 iterations out of 5,000,000 and "thinned" the chain to one value out of every thousand, leaving a sample distribution of 4,950. We compared running means of the chain, examined autocorrelation, and examined traces of the chains after removing the "burn-in" and "thinning". We believe that convergence to the posterior distribution was likely if a long chain was used and obvious problems in diagnostic plots were note encountered. We used these MCMC methods to provide further evaluation of uncertainty in the results below.

9B.3 Model Evaluation

9B.3.1 Alternative Models

9B.3.1.1 Model 1: Constrained natural mortality

This model was the base model that was used in the GOA Pacific ocean perch assessment. In addition to the parameters of the POP model, we estimated catchability and selectivity for the longline survey. All data components were given a likelihood weighting of one. Each year of data components was weighted within a likelihood component by scaling the age sample size to a maximum of 100. We used informative priors on trawl survey catchability, natural mortality, and recruitment variation. We used a noninformative prior for the longline survey catchability, since we did not know a realistic range of values.

9B.3.1.2 Model 2: Loose natural mortality and catchability

Model 2 is identical to Model 1, but we placed relatively noninformative priors on trawl catchability and natural mortality.

9B.4 Model Results

9B.4.1 Model Comparison

Table 9B-8 summarizes the results from the two alternative models. Models 1 and 2 have similar fits to the data. The fits to the survey biomasses were reasonable for both models and indices (Figures 9B-2, 3, 15, 16) as were fits to age and size compositions (Figures 9B-7, 8, 9, 10, 19, 20, 21, 22). However, trawl survey biomass estimates from both models did not capture the observed increased biomass in 1993. The large catches between 1988 and 1990 (Figure 9B-1) and the associated high estimates of fishing mortality (Figures 9B-12, 23) may have driven down future population estimates for a time. Also, the 1993 predicted trawl survey length compositions for both models disagreed to some extent with the observed values (Figures 9B-9, 21). In contrast, the longline survey biomass estimates do increase slightly between the observed increases in 1997 and 2000. This reaction of the model was likely due to the consecutive longline surveys and the better agreement between predicted and observed length compositions for those years. Average observed biomass years surrounded the spikes of 1997 and 2000, which would restrict the model from large increases predictions of longline survey biomass estimates.

The main difference in the models was the estimates of natural mortality and catchability. When natural mortality was estimated to be higher in Model 2, it caused the harvest rate and biomass to go up by lowering catchability. Thus, while the fits to the data were similar, the two models resulted in strikingly different ABC values. Biomass estimates, while different in magnitude in each model, suggested that the time series was stable or increasing. (Figures 9B-4, 5, 17, 18). Fishing mortality had a larger range, higher mean and was more variable under the Model 1 scenario than Model 2 (Figures 9B-11, 23). Under either model scenario, recruitment was highly variable and apparently unrelated to spawning stock biomass (Figures 9B-13, 25).

In Model 2, the parameter values for natural mortality and catchability converged at reasonable values when allowed to vary together, whereas the POP model could not give reasonable values when both were estimated simultaneously. This was an interesting result, considering that there was much more age data for Pacific ocean perch, and a longer time series of length and catch. This may indicate that the addition of the longline survey data provides sufficient data contrast to estimate natural mortality and catchability at the same time.

Results of MCMC simulation show fairly wide confidence bands for biomass estimates (Figures 9B-4, 5, 17, 18) with the most uncertainty when natural mortality and catchability were allowed more variability (Model 2). MCMC confidence bands for recruitment nearly contain zero for most recruitment estimates, indicating these estimates were a source of considerable uncertainty in the model (Figures 9B-12, 24). Due to the higher estimates of natural mortality in Model 2, the recruitments were higher but also more uncertain (Figure 9B-24).

The management paths from both models suggest that management is on track and has kept the stock in the ‘optimum’ quadrant where $B_{now}/B_{40\%}$ exceeds one and $F_{now}/F_{40\%}$ continues to stay below one (Figures 9B-14, 26). The Model 1 scenario suggested that we briefly exceeded $F_{40\%}$ several times since 1977, while we have always been below $F_{40\%}$ in the Model 2 scenario.

9B.5 Summary

These two rougheye models are good tools for examining the biological data on the species. The fact that we were able to estimate catchability and natural mortality simultaneously is encouraging, but the results of both models rely on only two years of survey age composition data. The use of longline survey data in addition to trawl survey integrated easily into the model. Neither model fits significantly better than the other. We suggest that until more age data is obtained and in the face of uncertainty, it is preferable to be more conservative and use a natural mortality closer to what we have traditionally used. We would recommend the use of Model 1 until more age data is obtained which would yield an ABC of 1,162 mt. In the future we may begin collecting ages from the longline survey and examine splitting the fishery data into trawl and longline fisheries.

9B.6 Literature Cited

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Table 9B-1. Estimated catch history for rougheye rockfish from Soh (1998), NPFMC, and NMFS regional office "blend estimates."

Year	Catch
1977	1443
1978	568
1979	645
1980	1353
1981	719
1982	569
1983	628
1984	760
1985	130
1986	438
1987	525
1988	1621
1989	2185
1990	2418
1991	350
1992	1127
1993	922
1994	1191
1995	1014
1996	971
1997	722
1998	1040
1999	565
2000	763
2001	901
2002	514
2003	603
2004	416

Table 9B-2. Fishery size compositions and sample size by year and pooled pairs of adjacent lengths. No data are available for 1989, and 1994-1999.

Length (cm)	1988	1990	1991	1992	1993	2000	2001	2002	2003	2004
21	0.013	0.004	0.001	0.000	0.000	0.003	0.002	0.002	0.000	0.000
23	0.014	0.000	0.004	0.004	0.000	0.007	0.009	0.004	0.000	0.000
25	0.017	0.002	0.004	0.008	0.000	0.003	0.004	0.004	0.001	0.000
27	0.018	0.002	0.006	0.018	0.008	0.013	0.004	0.004	0.001	0.001
29	0.016	0.015	0.016	0.014	0.008	0.003	0.029	0.002	0.003	0.003
31	0.018	0.011	0.032	0.039	0.000	0.020	0.029	0.005	0.003	0.007
33	0.018	0.025	0.037	0.041	0.008	0.013	0.033	0.004	0.008	0.011
35	0.026	0.031	0.059	0.047	0.015	0.029	0.027	0.022	0.017	0.016
37	0.034	0.034	0.071	0.059	0.008	0.042	0.047	0.035	0.023	0.022
39	0.052	0.054	0.088	0.084	0.045	0.072	0.058	0.059	0.056	0.030
41	0.085	0.075	0.115	0.082	0.091	0.114	0.107	0.071	0.076	0.045
43	0.118	0.122	0.120	0.124	0.129	0.167	0.172	0.159	0.115	0.074
45	0.119	0.143	0.122	0.120	0.182	0.180	0.179	0.163	0.137	0.111
47	0.116	0.132	0.102	0.120	0.144	0.141	0.112	0.190	0.148	0.153
49	0.095	0.134	0.062	0.071	0.129	0.082	0.056	0.115	0.127	0.152
51	0.053	0.076	0.042	0.055	0.106	0.072	0.027	0.082	0.099	0.132
53	0.034	0.033	0.030	0.033	0.061	0.016	0.022	0.040	0.065	0.096
55	0.026	0.021	0.021	0.018	0.000	0.013	0.009	0.009	0.043	0.057
57	0.020	0.019	0.013	0.012	0.015	0.007	0.009	0.013	0.032	0.035
59	0.018	0.011	0.012	0.006	0.008	0.003	0.009	0.007	0.017	0.022
60+	0.089	0.055	0.043	0.043	0.045	0.000	0.056	0.011	0.029	0.034
Sample size	301	5798	523	1398	490	306	448	547	2901	2033

Table 9B-3. Rougheye rockfish biomass estimates from NMFS triennial/biennial trawl surveys in the Gulf of Alaska. S.E. = Standard error. We exclude the 2001 survey because no sampling was performed in the Eastern Gulf.

Year	1984	1987	1990	1993	1996	1999	2003
Biomass	46,999	43,929	46,142	64,077	45,806	39,655	43,202
S.E.	7,111	6,647	6,982	9,695	6,931	6,000	6,724

Table 9B-4. Rougheye rockfish trawl survey age compositions extrapolated to population. Pooled age 25+ includes all fish 25 and older.

Age (yr)	1990	1999
3	0.00042	0
4	0.001011	0.026732
5	0.004531	0.053204
6	0.008129	0.025101
7	0.034653	0.032525
8	0.036532	0.058478
9	0.087412	0.137057
10	0.136329	0.050357
11	0.079349	0.043176
12	0.033942	0.018551
13	0.063935	0.043079
14	0.057863	0.044015
15	0.029222	0.044846
16	0.020881	0.054321
17	0.011679	0.046156
18	0.005273	0.056225
19	0.028775	0.029652
20	0.010546	0.036034
21	0.013787	0.018725
22	0.008729	0.019102
23	0.014869	0.0174
24	0.021323	0.012945
25+	0.290809	0.132318
Sample size	216	650

Table 9B-5. NMFS trawl survey length compositions for rougheye rockfish. 1990 and 1999 are excluded because they are used in the size-age transition matrix. 2001 is excluded because the Eastern Gulf was not sampled. Is length 21 a pooled length class?

Length (cm)	1984	1987	1993	1996	2003
21	0.020	0.047	0.048	0.079	0.127
23	0.016	0.032	0.015	0.049	0.052
25	0.026	0.030	0.015	0.052	0.039
27	0.023	0.028	0.017	0.046	0.038
29	0.019	0.028	0.078	0.037	0.043
31	0.033	0.039	0.017	0.049	0.051
33	0.036	0.050	0.022	0.049	0.052
35	0.044	0.055	0.027	0.044	0.042
37	0.055	0.070	0.032	0.060	0.038
39	0.057	0.070	0.044	0.061	0.047
41	0.083	0.079	0.049	0.082	0.061
43	0.143	0.083	0.065	0.111	0.090
45	0.164	0.111	0.072	0.107	0.103
47	0.118	0.108	0.100	0.078	0.086
49	0.076	0.084	0.116	0.044	0.054
51	0.039	0.040	0.125	0.023	0.023
53	0.019	0.022	0.118	0.014	0.009
55	0.009	0.008	0.072	0.005	0.006
57	0.006	0.005	0.030	0.006	0.003
59	0.004	0.003	0.011	0.002	0.002
60+	0.009	0.007	0.006	0.002	0.004
Sample size	1,470	1,458	2,138	2,260	1,754

Table 9B-6. Rougheye rockfish relative population weights estimated from annual Gulf of Alaska longline survey.

Year	RPW	S.E.
1990	26,202	5,240
1991	33,341	6,668
1992	25,534	5,107
1993	28,782	5,756
1994	28,622	5,724
1995	33,663	6,733
1996	32,002	6,400
1997	46,456	9,291
1998	32,247	6,449
1999	35,299	7,060
2000	49,935	9,987
2001	35,267	7,053
2002	33,582	6,716
2003	33,611	6,722
2004	31,270	6,254

Table 9B-7. Size compositions for rougheye rockfish in the Gulf of Alaska from the annual longline survey. Ages are binned in adjacent pairs and pooled at 60 and greater cm.

Length (cm)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
21	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
23	0.002	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
25	0.003	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.001	0.000	0.000
27	0.003	0.001	0.001	0.002	0.001	0.002	0.001	0.001	0.001	0.003	0.001	0.003	0.002	0.001	0.004
29	0.005	0.004	0.004	0.005	0.004	0.004	0.003	0.003	0.002	0.005	0.003	0.004	0.005	0.003	0.013
31	0.012	0.010	0.010	0.015	0.010	0.007	0.008	0.006	0.005	0.009	0.006	0.013	0.009	0.007	0.024
33	0.019	0.017	0.017	0.029	0.019	0.015	0.014	0.012	0.010	0.013	0.015	0.017	0.018	0.012	0.020
35	0.026	0.032	0.031	0.042	0.033	0.019	0.025	0.018	0.024	0.023	0.024	0.029	0.031	0.016	0.035
37	0.045	0.047	0.044	0.058	0.050	0.027	0.041	0.026	0.039	0.035	0.045	0.044	0.046	0.032	0.059
39	0.067	0.071	0.069	0.081	0.068	0.047	0.061	0.038	0.059	0.047	0.061	0.064	0.073	0.058	0.082
41	0.088	0.097	0.100	0.108	0.086	0.073	0.085	0.050	0.090	0.068	0.083	0.086	0.095	0.096	0.093
43	0.118	0.122	0.125	0.135	0.100	0.104	0.113	0.083	0.118	0.101	0.109	0.103	0.130	0.111	0.112
45	0.138	0.135	0.150	0.145	0.126	0.135	0.135	0.130	0.145	0.152	0.142	0.131	0.137	0.141	0.142
47	0.140	0.157	0.147	0.140	0.139	0.165	0.166	0.180	0.163	0.188	0.159	0.150	0.141	0.171	0.148
49	0.123	0.134	0.133	0.105	0.140	0.150	0.169	0.185	0.147	0.170	0.154	0.149	0.128	0.161	0.116
51	0.082	0.085	0.085	0.064	0.105	0.116	0.100	0.132	0.098	0.108	0.096	0.103	0.089	0.099	0.074
53	0.043	0.041	0.040	0.033	0.061	0.058	0.043	0.071	0.048	0.050	0.054	0.053	0.051	0.048	0.039
55	0.020	0.021	0.017	0.018	0.030	0.035	0.019	0.030	0.021	0.016	0.023	0.024	0.019	0.019	0.015
57	0.013	0.008	0.009	0.008	0.013	0.017	0.008	0.014	0.013	0.005	0.013	0.011	0.011	0.010	0.012
59	0.007	0.005	0.005	0.004	0.006	0.013	0.004	0.008	0.007	0.003	0.005	0.004	0.007	0.005	0.008
60	0.046	0.012	0.010	0.007	0.011	0.015	0.006	0.015	0.012	0.006	0.010	0.011	0.008	0.010	0.006
Sample size	9,822	11,243	9,702	8,821	11,459	6,360	7,221	11,651	6,014	6,396	8,923	5,218	6,334	5,083	6,408

Table 9B-8. Likelihoods and MLE estimates of key parameters with estimates of standard error (σ) derived from Hessian matrix.

	Model 1			***Model 2***		
Likelihoods	Value	Weight		Value	Weight	
Catch	0.389	1		0.189	1	
Trawl Biomass	2.920	1		2.707	1	
Longline Biomass	5.481	1		5.681	1	
Trawl Survey Ages	25.969	1		24.763	1	
Trawl Fishery Sizes	24.585	1		24.990	1	
Trawl Survey Sizes	36.940	1		36.071	1	
Longline Survey Sizes	31.769	1		31.229	1	
Data-Likelihood	***128.052***			**125.631**		
Penalties/Priors						
Recruitment Deviations	2.141	1		6.099	1	
Fishery Selectivity	1.051	1		1.139	1	
Trawl Selectivity	0.497	1		0.598	1	
Longline Selectivity	0.818	1		0.979	1	
Fish-Sel Domeshape	0.000	1		0.000	1	
Survey-Sel Domeshape	0.019	1		0.020	1	
LL-Sel Domeshape	0.000	1		0.000	1	
Average Selectivity	0.000	1		0.000	1	
F Regularity	0.842	0.1		0.789	0.1	
σ_r prior	3.016			0.883		
q-trawl	0.168			0.074		
q-longline	0.411			0.091		
M	0.003			0.148		
Total	8.966			10.819		
Objective Fun. Total (unweighted)	***137.814***			**136.860**		
Parameter Estimates	Value	σ	Priors~LN(μ,σ)	Value	σ	Priors
q-trawl	1.296	0.410	(1,0.2)	0.681	0.400	(1,1)
q-longline	1.073	0.378	(1,1)	0.653	0.343	(1,1)
M	0.034	0.003	(0.03,0.01)	0.052	0.009	(0.03,1)
σ_r	0.942	0.061	(1.1,0.001)	1.055	0.034	(1.1,0.001)
Log-mean-rec	0.171	0.323		1.193	0.664	
$F_{40\%}$	0.039	0.008		0.055	0.013	
Total Biomass (mt)	44,304	15,066		78,949	42,484	
B_{2005} (mt)	12,496	4,665		20,069	10,733	
$B_{0\%}$ (mt)	27,280			29,085		
$B_{40\%}$ (mt)	10,912			11,634		
$ABC_{F40\%}$ (mt)	**1,162**			2,588		
$F_{50\%}$	0.027	0.005		0.038	0.009	
$ABC_{F50\%}$ (mt)	806			1804		

Figure 9B-1. Estimated commercial catches for Gulf of Alaska rougheye rockfish.

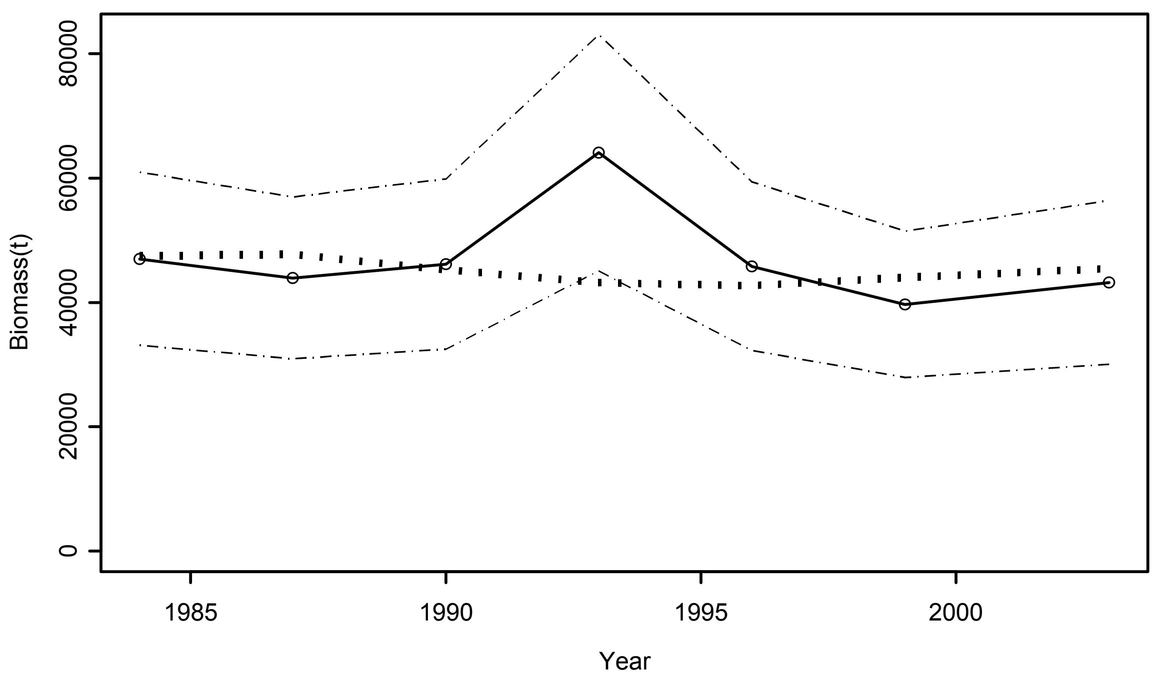

Figure 9B-2. Observed and predicted GOA rougheye rockfish trawl survey biomass. Observed biomass=solid line and Model 1 predicted biomass=dotted line. Outer dashed lines represent 95% CIs of sampling error for observed biomass. Should you use error bars instead of lines for CIs. Have x –axis be the years you have surveys for.

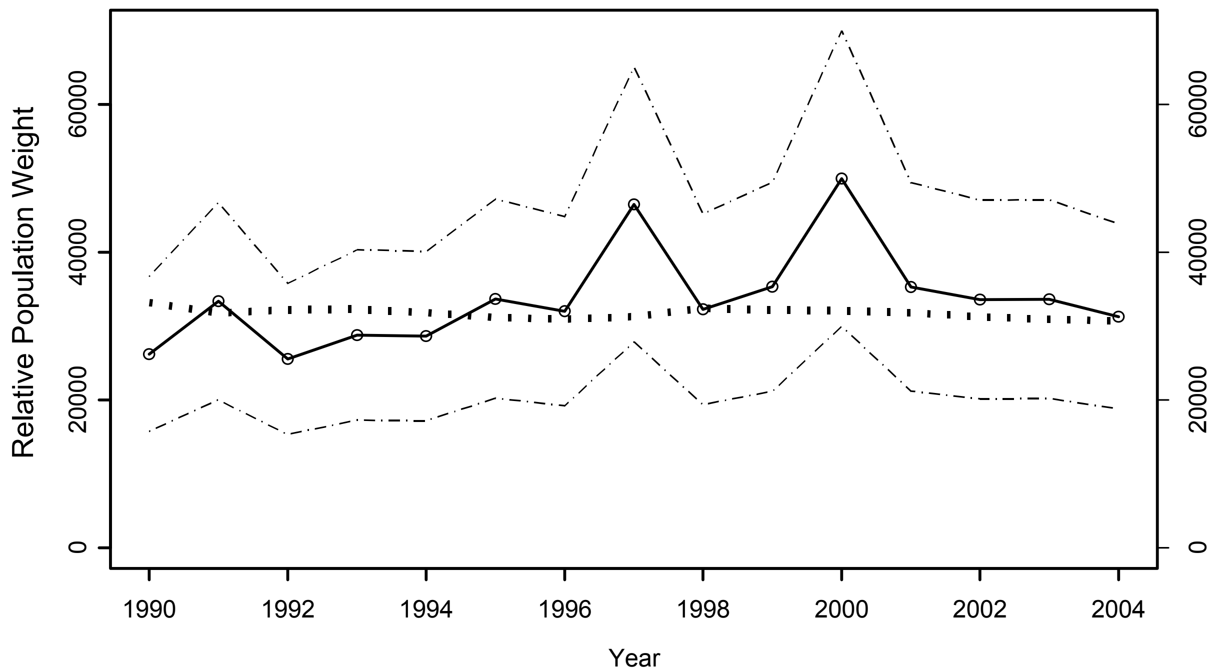

Figure 9B-3. Observed and predicted GOA rougheye rockfish longline survey relative population weight. Observed biomass=solid line and Model 1 predicted biomass=dotted line. Outer dashed lines represent 95% CIs of sampling error for observed biomass.

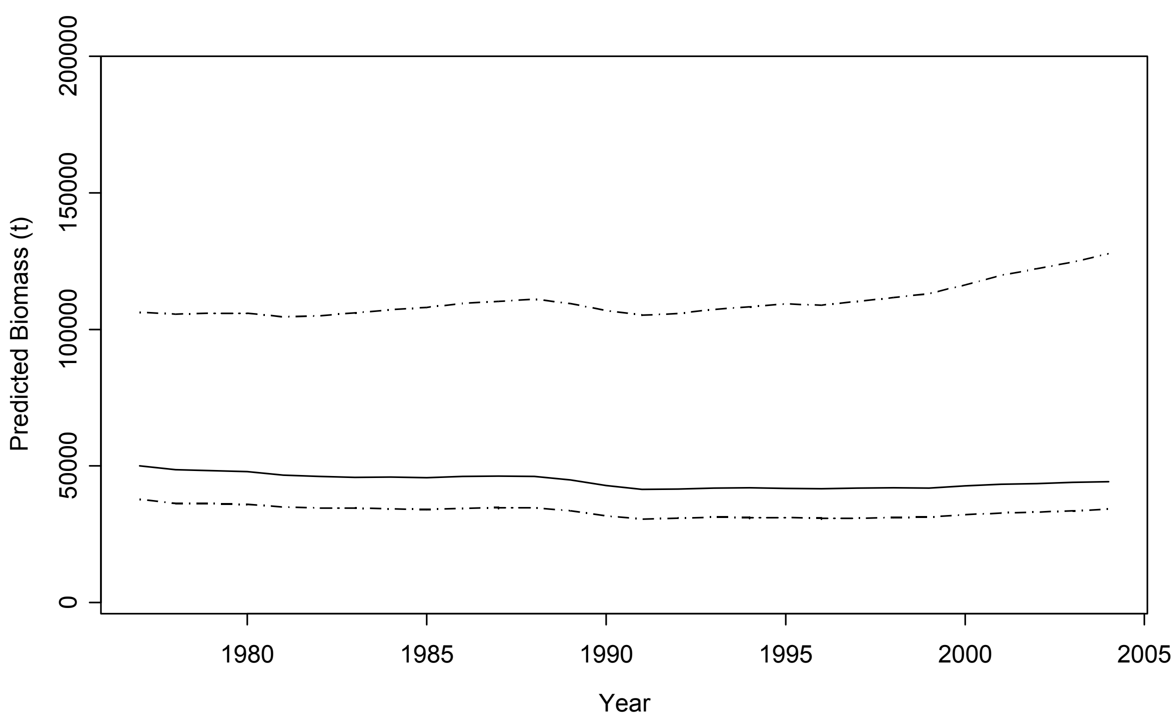

Figure 9B-4. Time series of predicted total biomass for Model 1. Dashed lines represent 95% confidence intervals from 5 million MCMC runs.

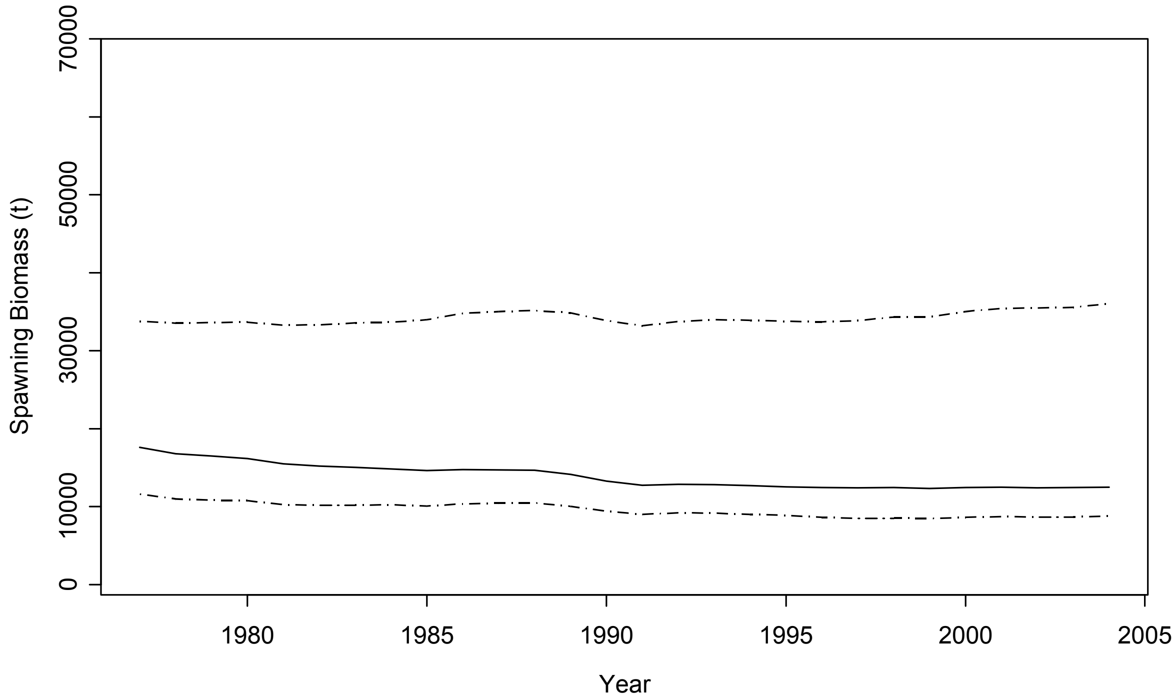

Figure 9B-5. Time series of predicted spawning biomass of GOA rougheye rockfish for Model 1. Dashed lines represent 95% confidence intervals from 5 million MCMC runs.

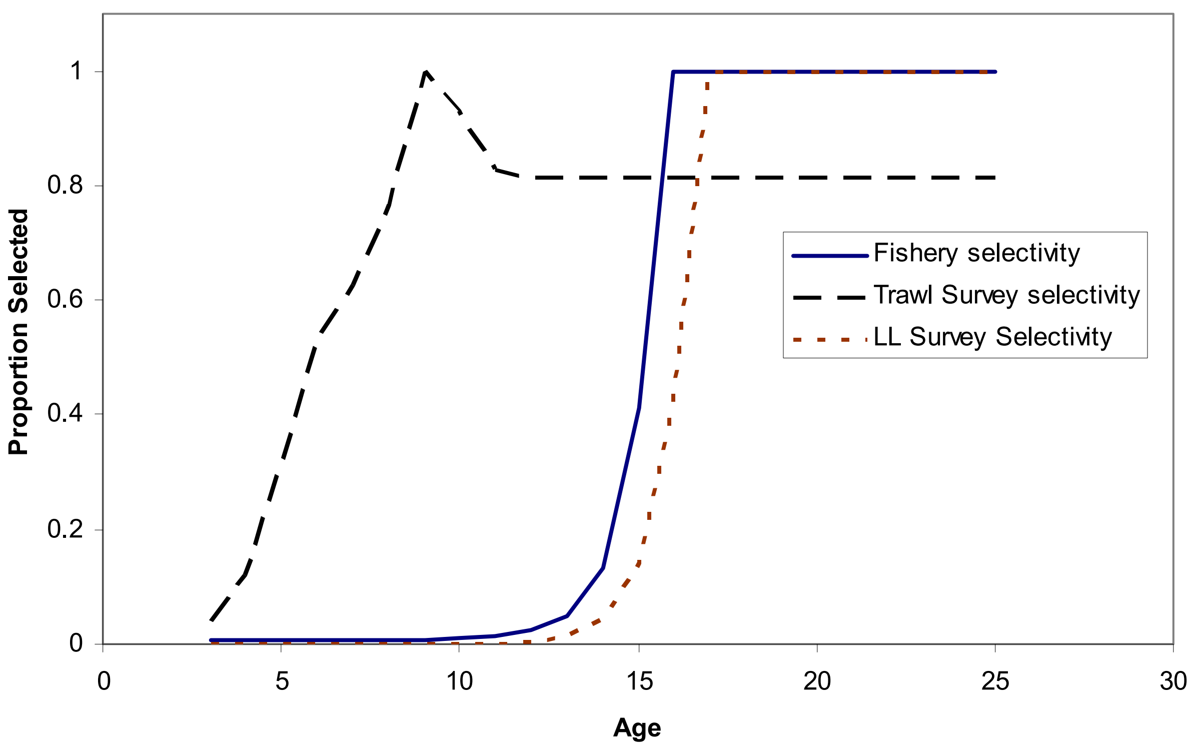

Figure 9B-6. Estimated selectivity curves for Model 1 of GOA rougheye rockfish. Dashed line=Trawl survey selectivity, dotted line=Longline survey selectivity, Solid line=Combined fishery selectivity.

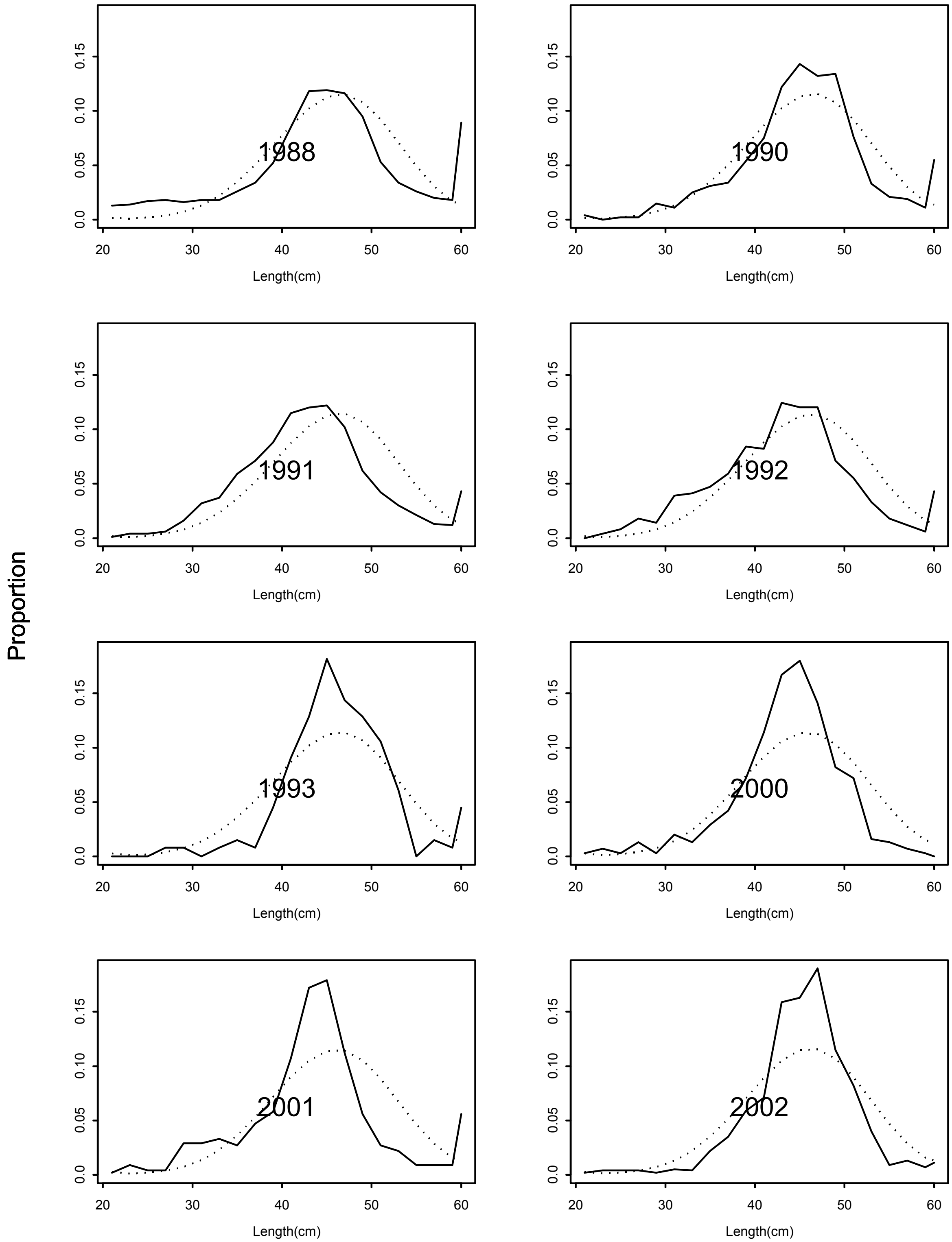

Figure 9B-7. Trawl fishery length compositions for GOA rougheye rockfish for base model. Observed=solid line, predicted for Model 1=dotted line.

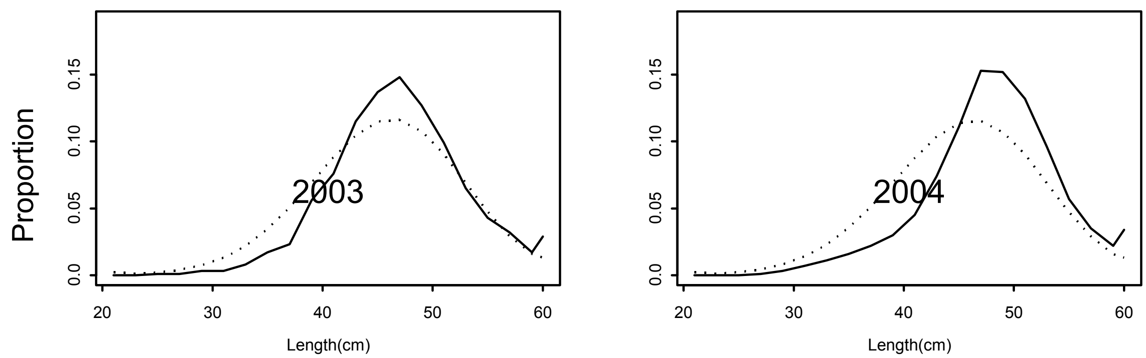

Figure 9B-7(continued). Fishery length compositions for GOA rougheye rockfish. Observed=solid line, predicted for Model 1=dotted line.

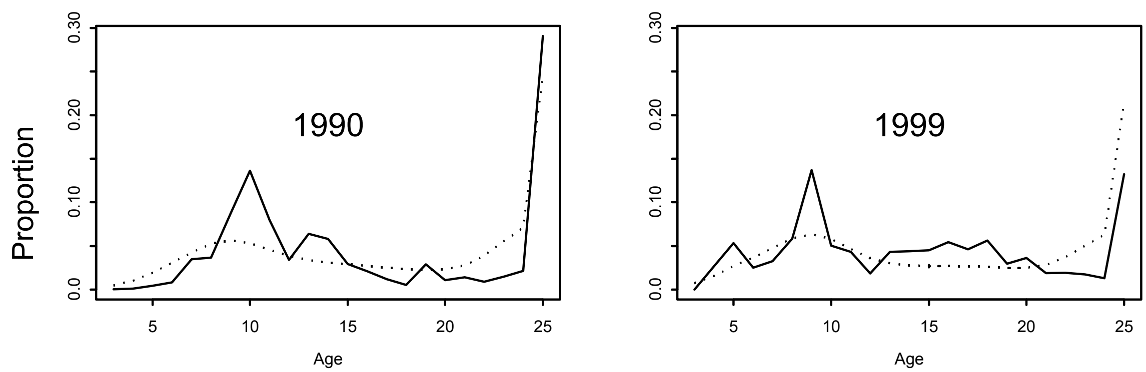

Figure 9B-8. Trawl survey age composition by year for GOA rougheye rockfish. Observed=solid line, predicted for Model 1=dotted line.

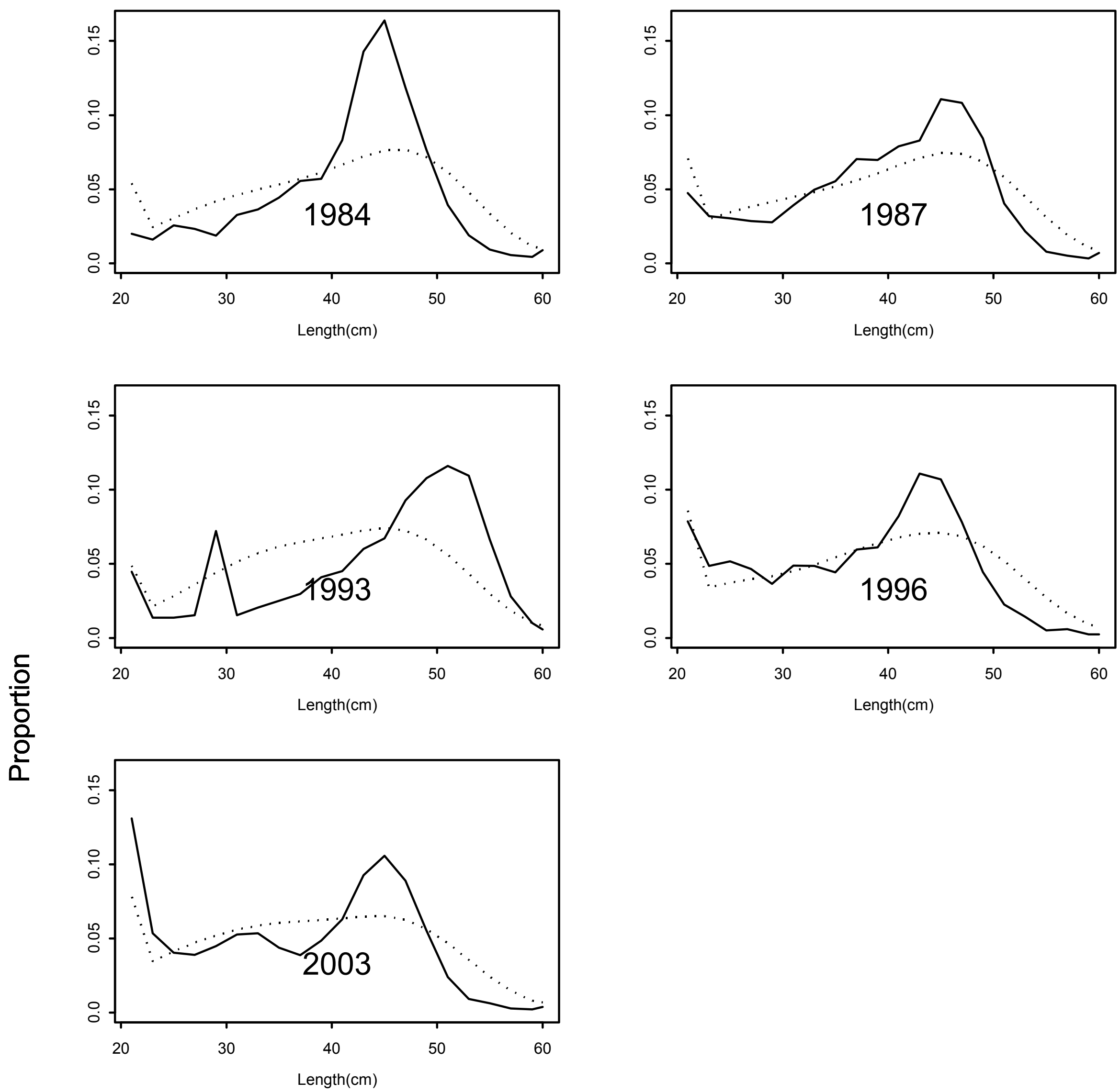

Figure 9B-9. Trawl survey length composition by year for GOA rougheye rockfish. Observed=solid line, predicted for Model 1=dotted line. Sizes distributions for 1990 and 1999 are not used in the model because they are used in calculating the size-age transition matrix.

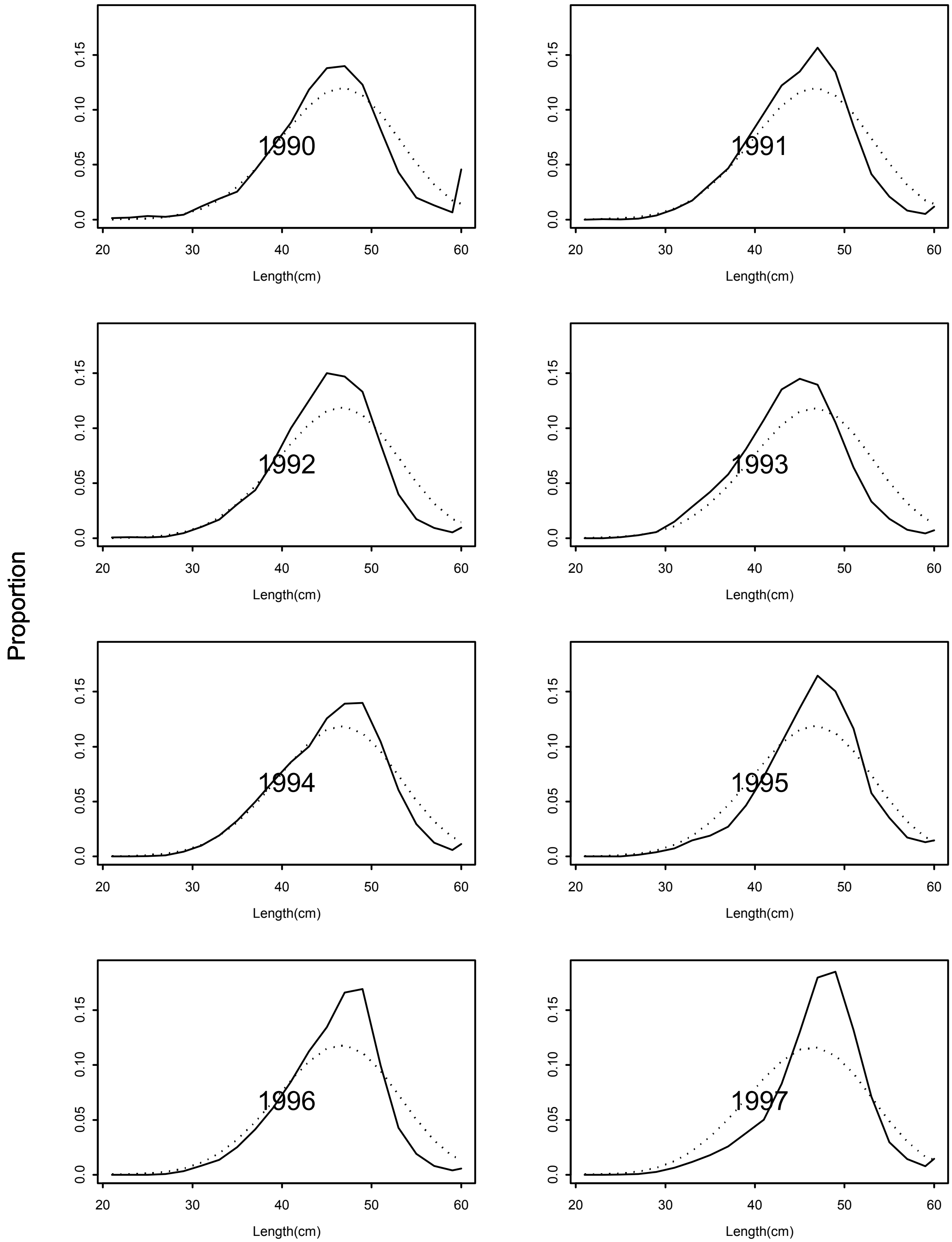

Figure 9B-10. Longline survey length composition by year for GOA rougheye rockfish. Observed=solid line, predicted for Model 1=dotted line.

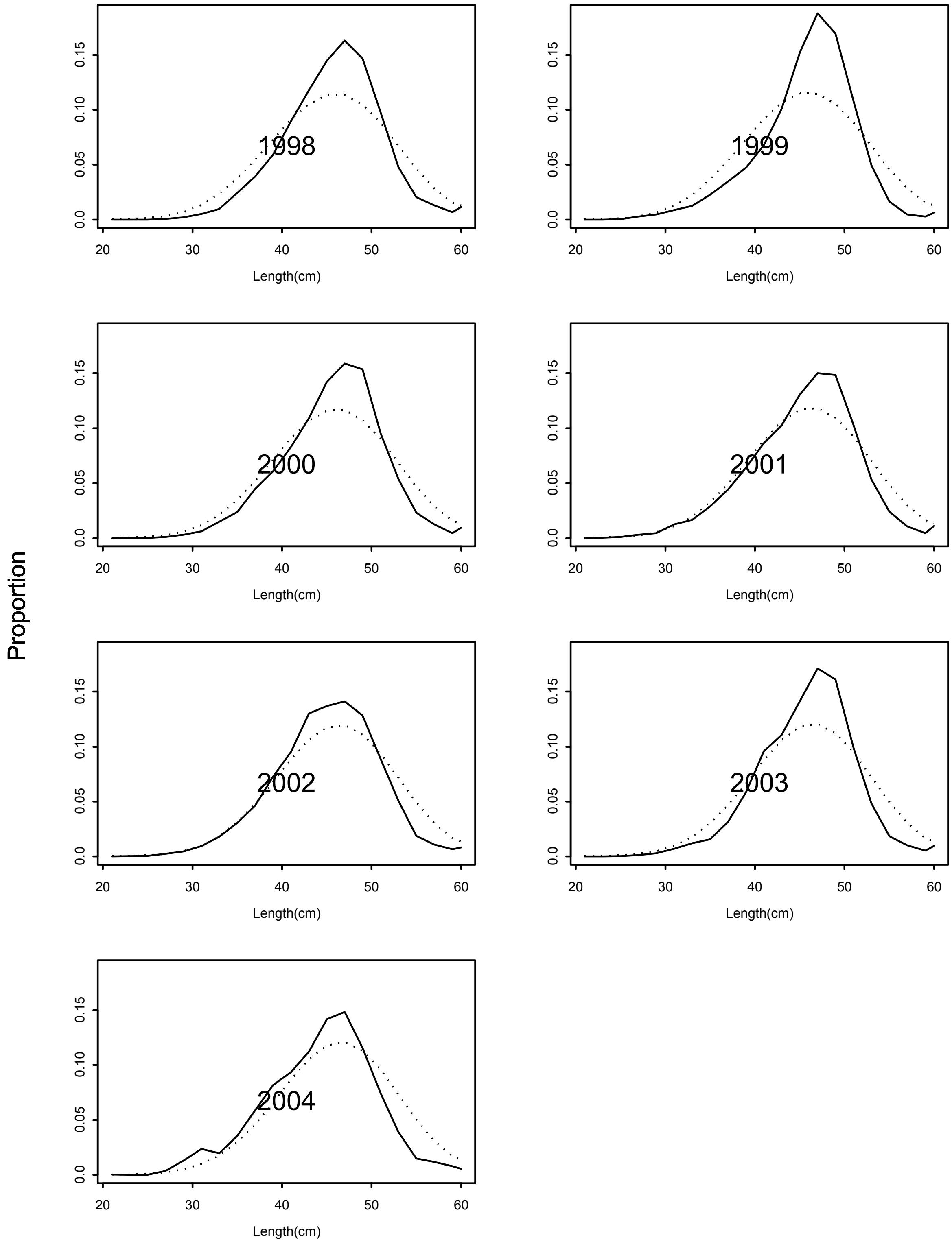

Figure 9B-10 (continued). Longline survey length composition for GOA rougheye rockfish. Observed=solid line, predicted for Model 1=dotted line.

Figure 9B-11. Time series of estimated fully selected fishing mortality for GOA rougheye rockfish from Model 1.

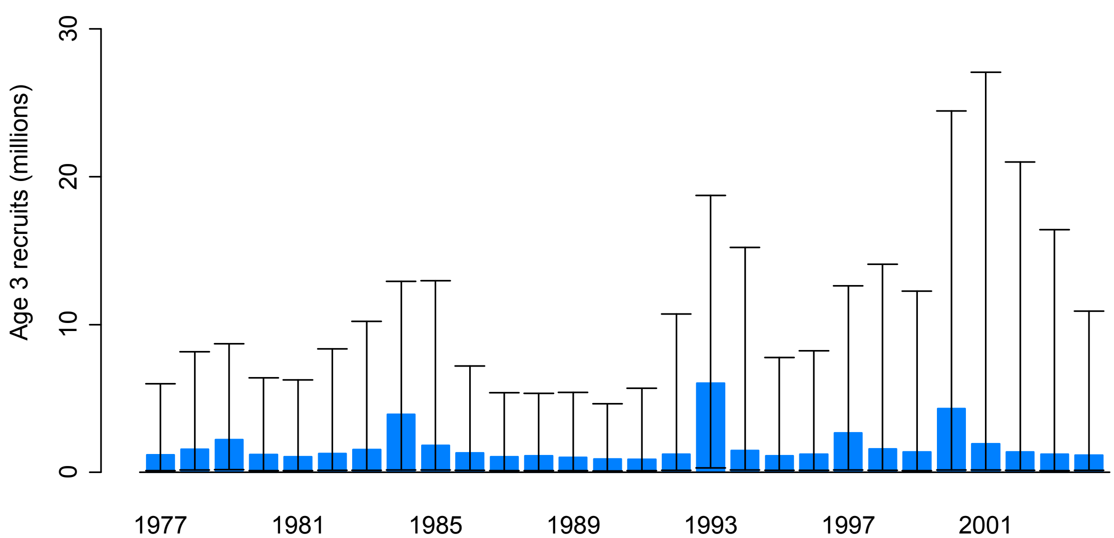

Figure 9B-12. Estimated recruitments (age 3) for GOA rougheye rockfish from Model 1.

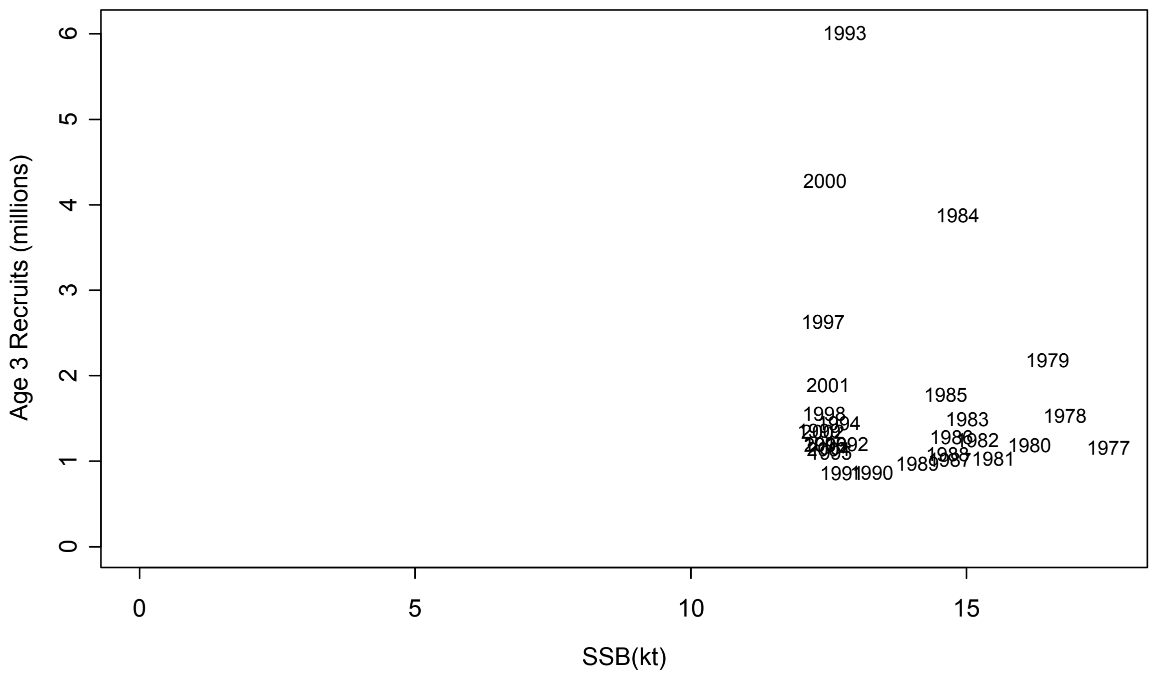

Figure 9B-13. Scatterplot of spawner-recruit data for GOA rougheye rockfish estimated from Model 1. Label is year class of age 3 recruits. SSB = Spawning stock biomass.

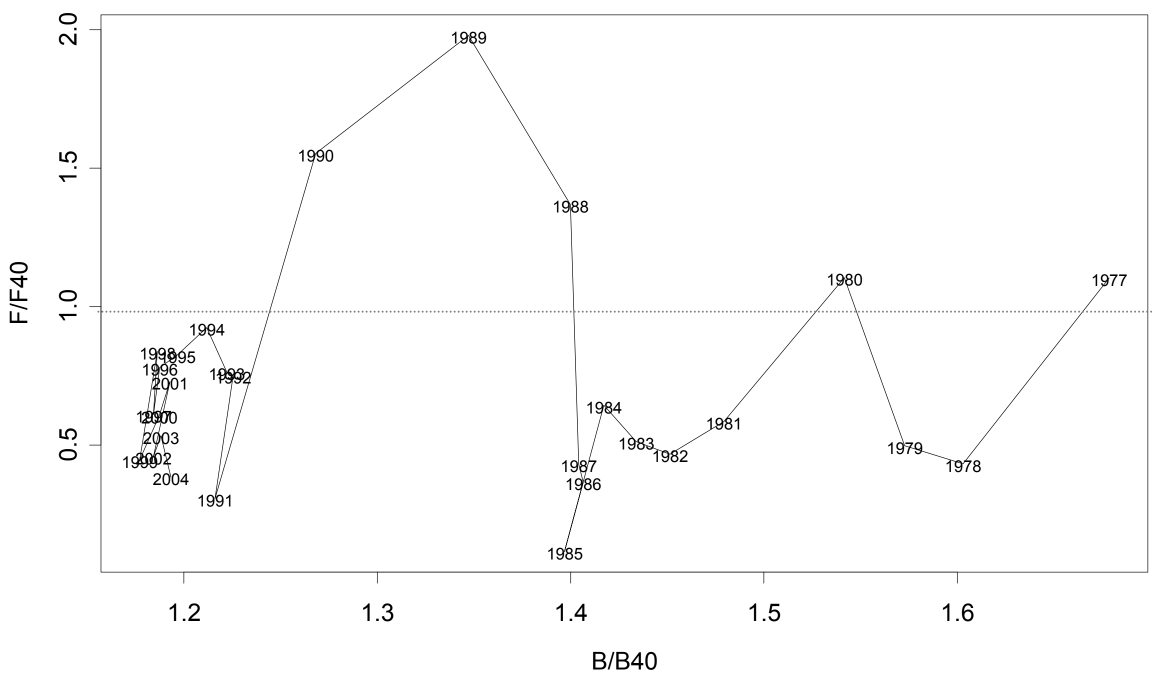

Figure 9B-14. Time series of estimated fishing mortality over $F_{40\%}$ versus estimated spawning biomass over $B_{40\%}$ for Model 1.

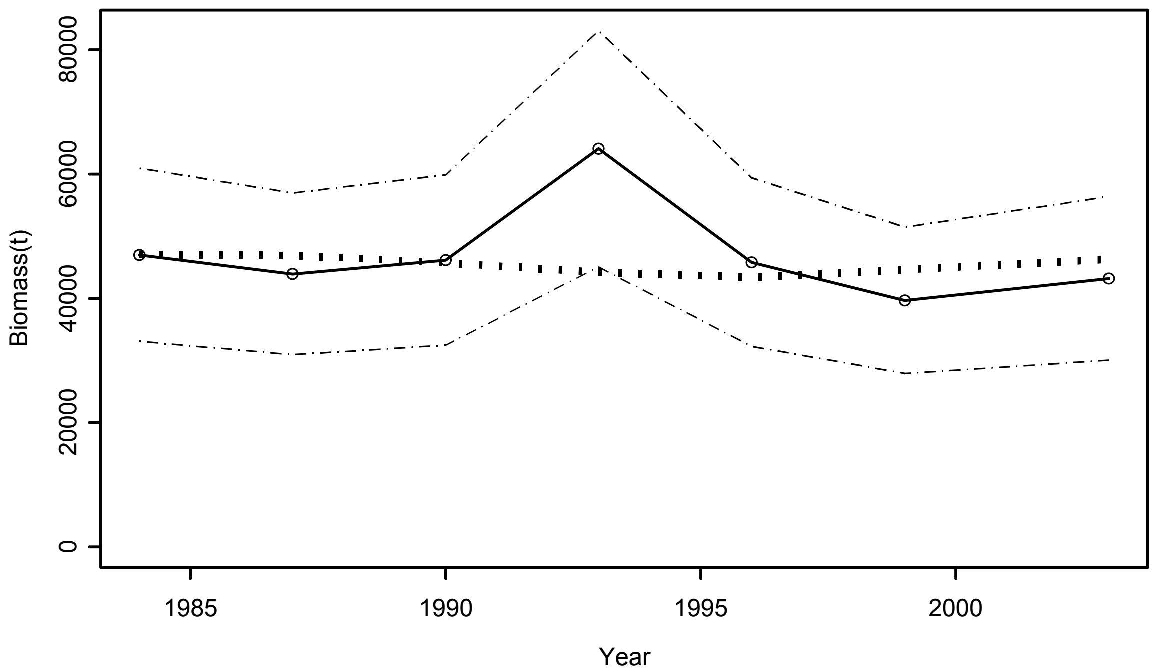

Figure 9B-15. Observed and predicted GOA rougheye rockfish trawl survey biomass. Observed biomass=solid line and Model 2 predicted biomass=dotted line. Outer dashed lines represent 95% CIs of sampling error for observed biomass.

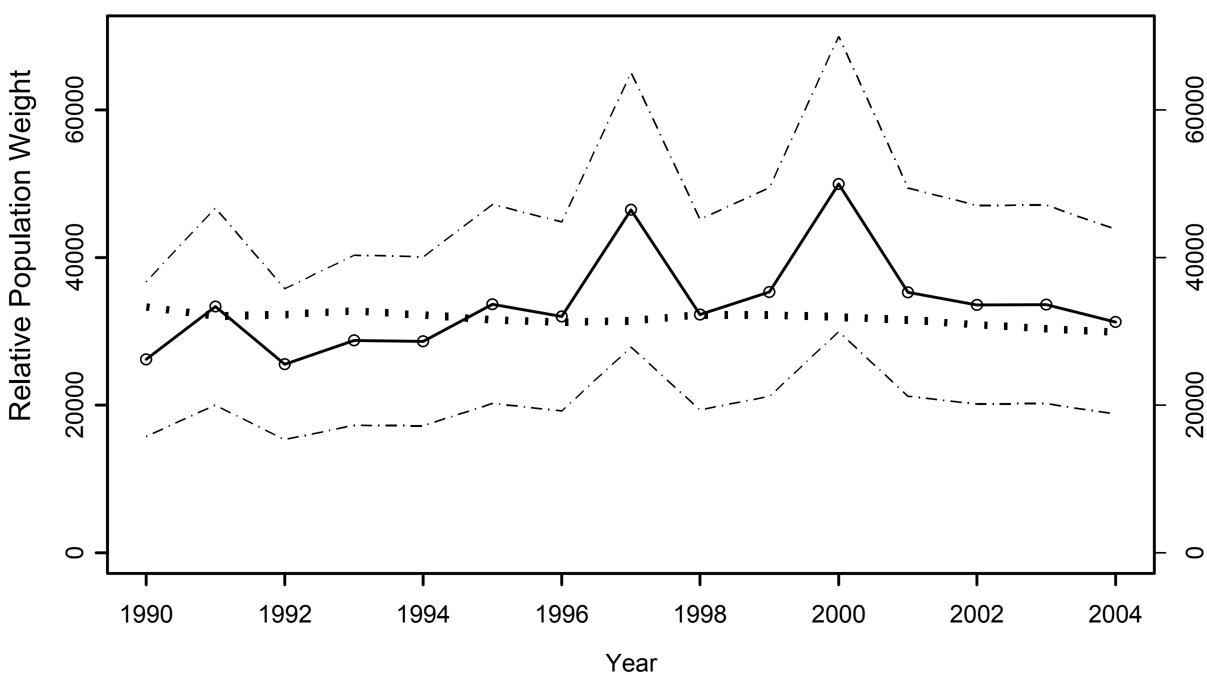

Figure 9B-16. Observed and predicted GOA rougheye rockfish longline survey relative population weight. Observed biomass=solid line and Model 2 predicted biomass=dotted line. Outer dashed lines represent 95% CIs of sampling error for observed biomass.

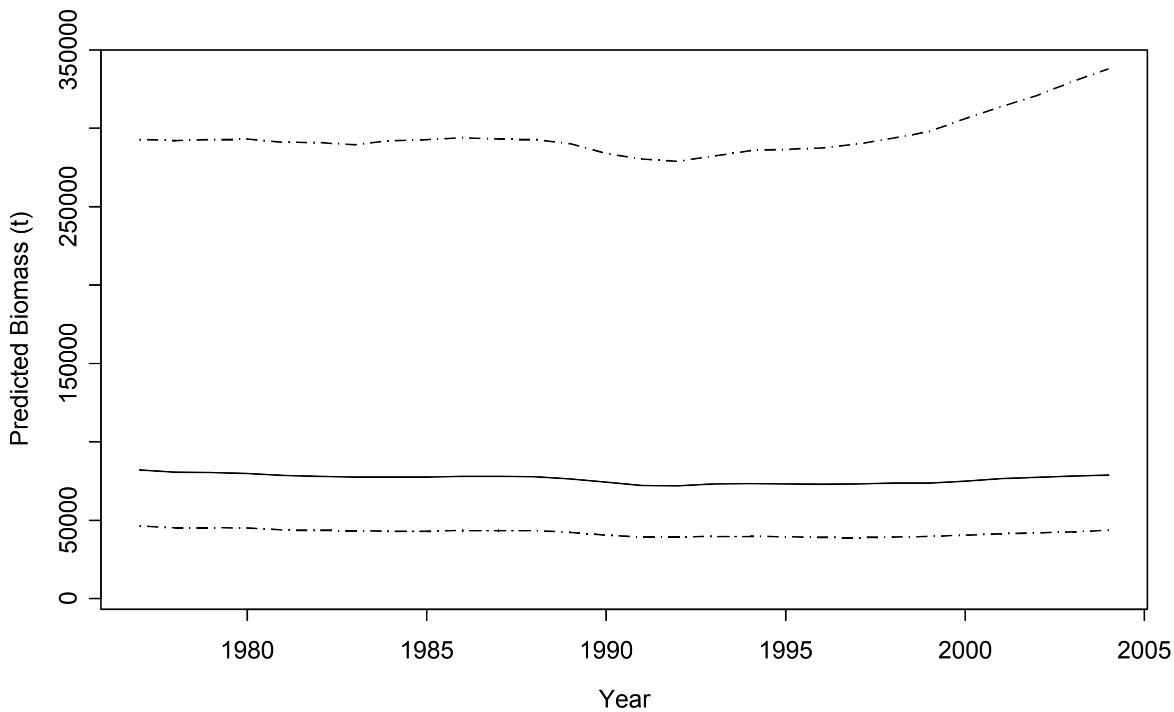

Figure 9B-17. Time series of predicted total biomass for Model 2. Dashed lines represent 95% confidence intervals from 5 million MCMC runs.

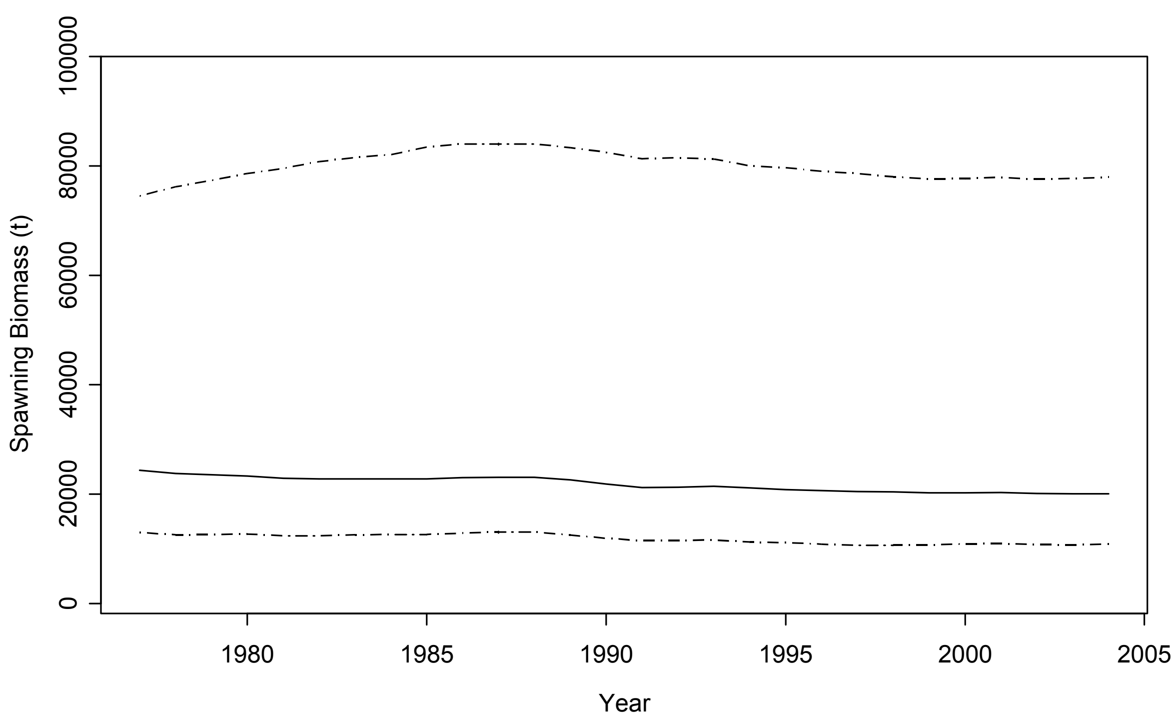

Figure 9B-18. Time series of predicted spawning biomass of GOA rougheye rockfish for Model 2. Dashed lines represent 95% confidence intervals from 5 million MCMC runs.

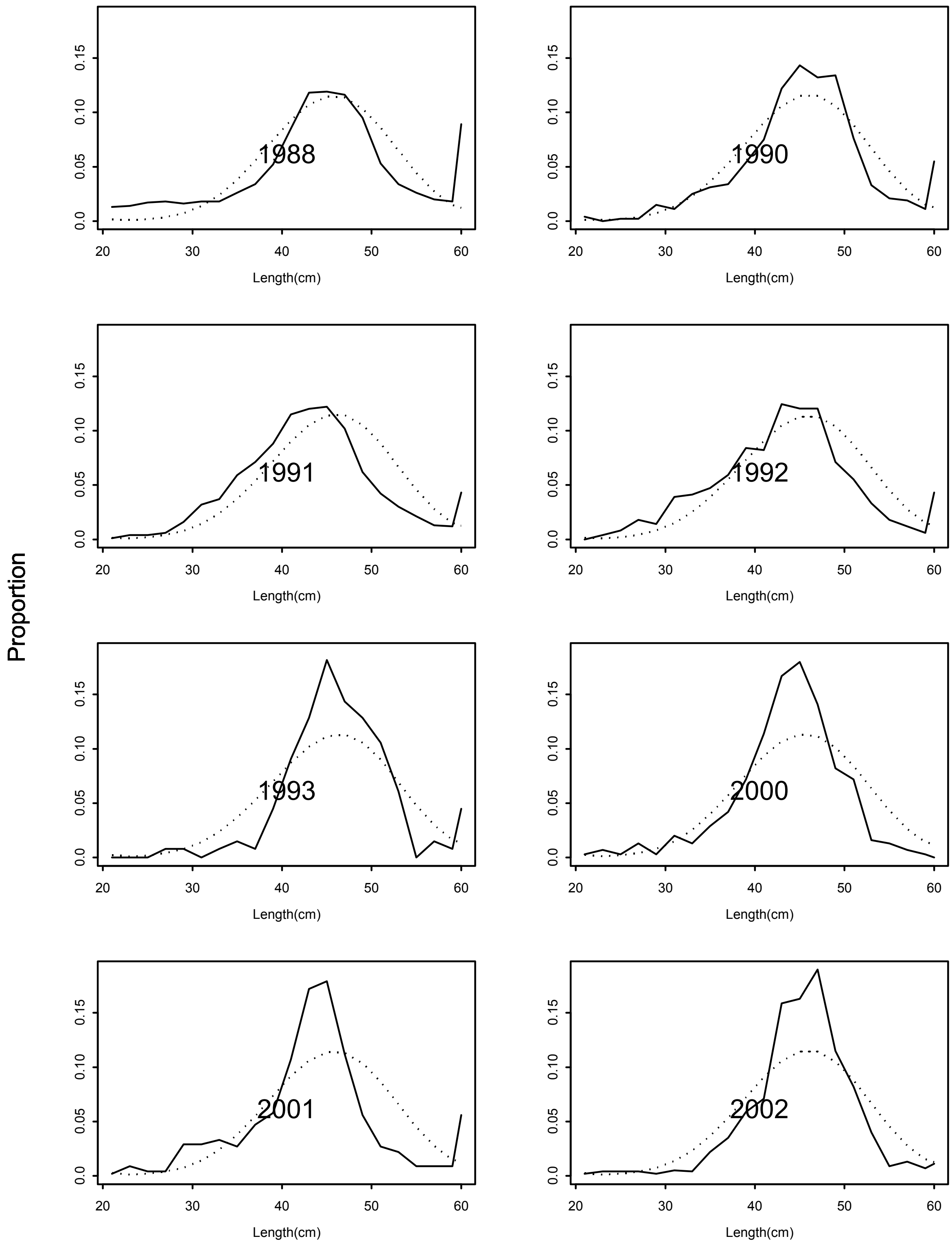

Figure 9B-19. Fishery length compositions for GOA rougheye rockfish for base model. Observed=solid line, Model 2 predicted=dotted line.

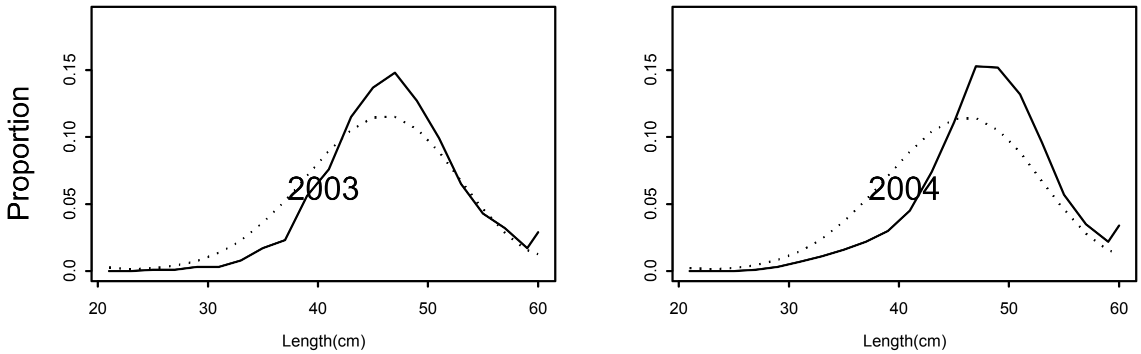

Figure 9B-19 (continued). Fishery length compositions for GOA rougheye rockfish. Observed=solid line, Model 2 predicted=dotted line.

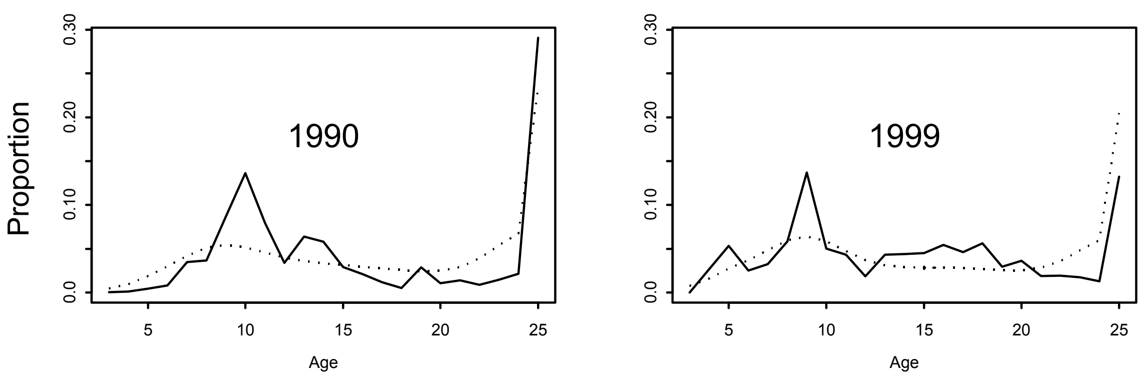

Figure 9B-20. Trawl survey age composition by year for GOA rougheye rockfish. Observed=solid line, Model 2 predicted=dotted line.

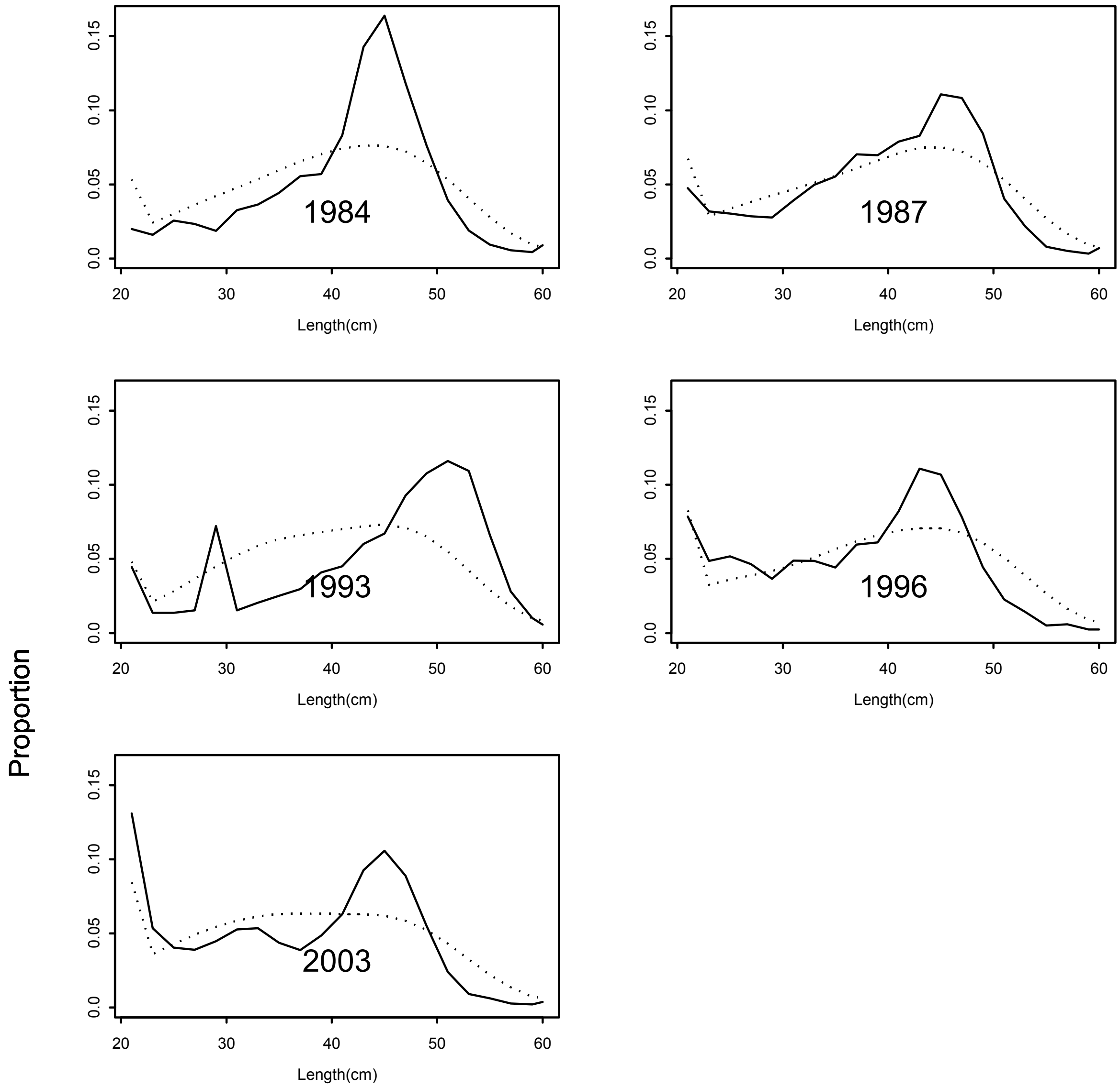

Figure 9B-21. Trawl survey length composition by year for GOA rougheye rockfish. Observed=solid line, Model 2 predicted=dotted line. Size compositions for 1990 and 1999 are not included in the model because they are used to estimate the size-age transition matrix.

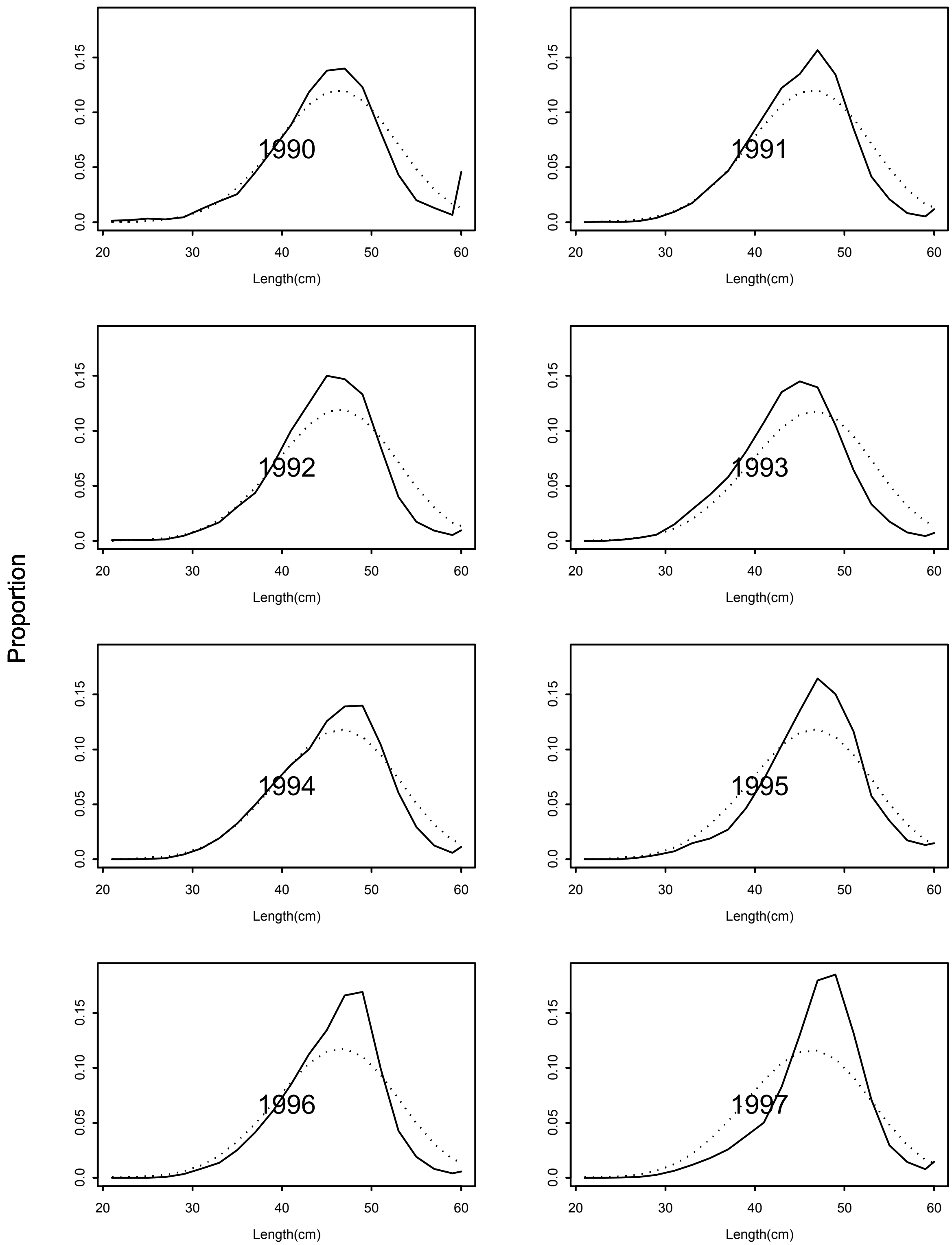

Figure 9B-22. Longline survey length composition by year for GOA rougheye rockfish. Observed=solid line, Model 2 predicted=dotted line.

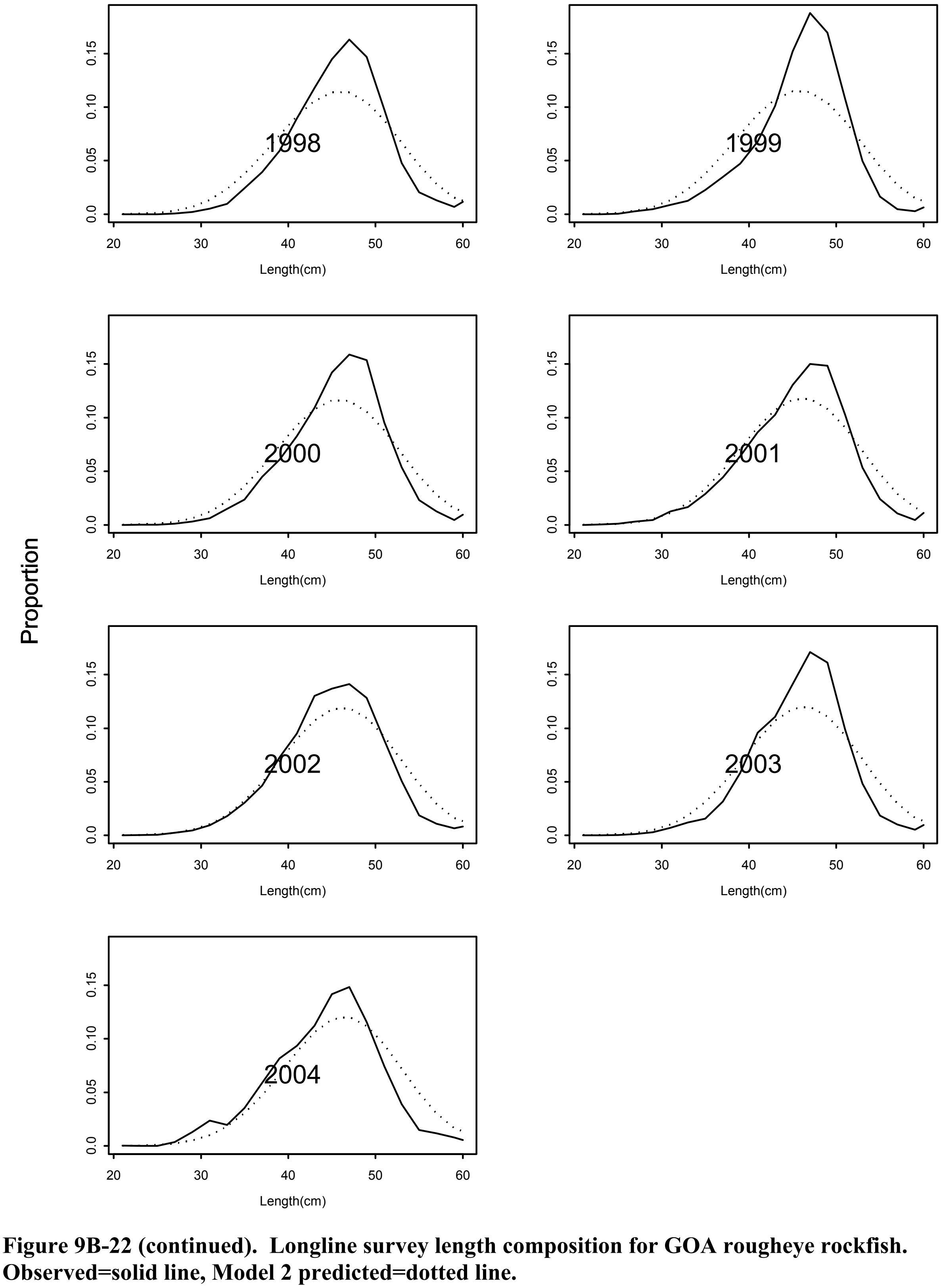

Figure 9B-22 (continued). Longline survey length composition for GOA rougheye rockfish. Observed=solid line, Model 2 predicted=dotted line.

Figure 9B-23. Time series of estimated fully selected fishing mortality for GOA rougheye rockfish from Model 2.

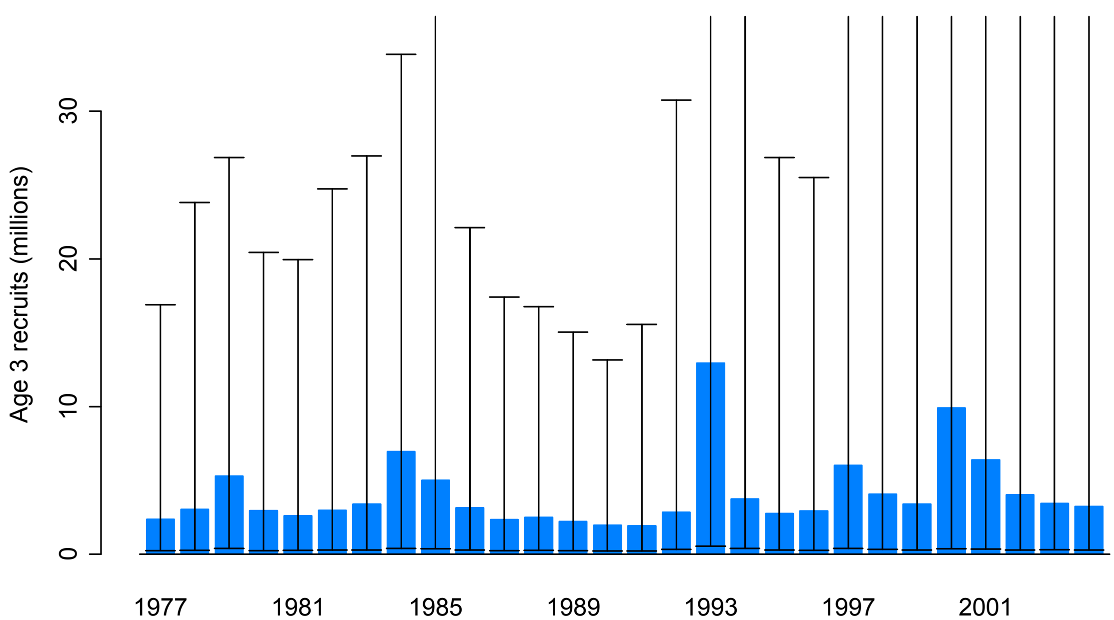

Figure 9B-24. Estimated recruitments (age 3) for GOA rougheye rockfish from Model 2.

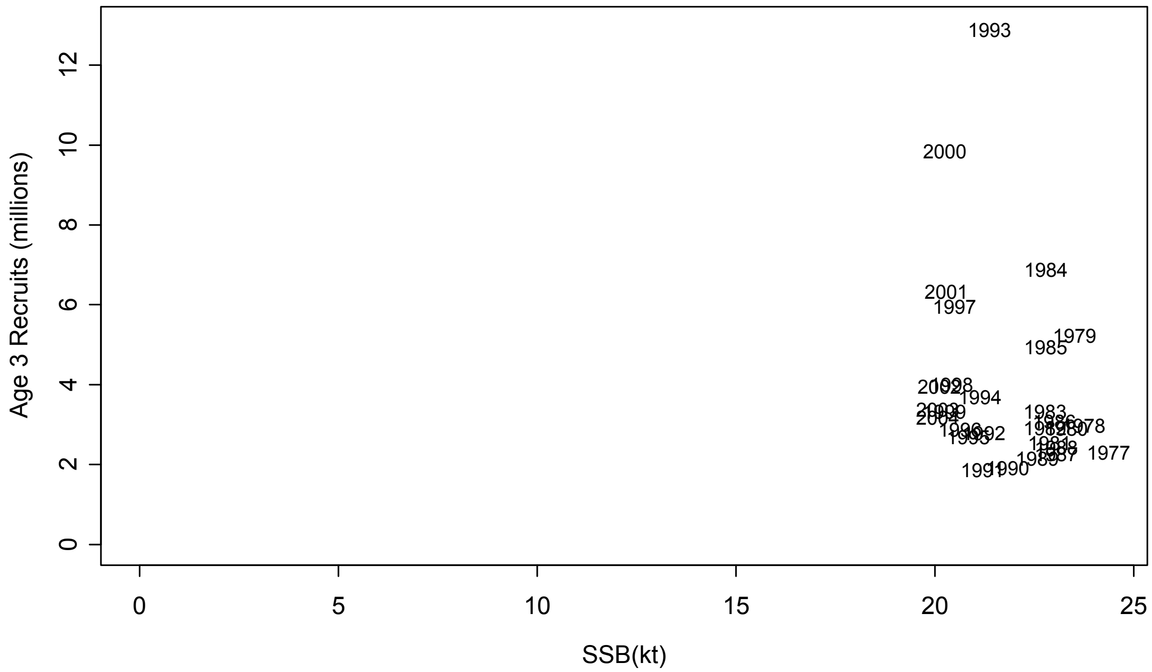

Figure 9B-25. Scatterplot of Model 2 estimated spawner-recruit data for GOA rougheye rockfish estimated from Model 2. Label is year class of age 3 recruits. SSB = Spawning stock biomass.

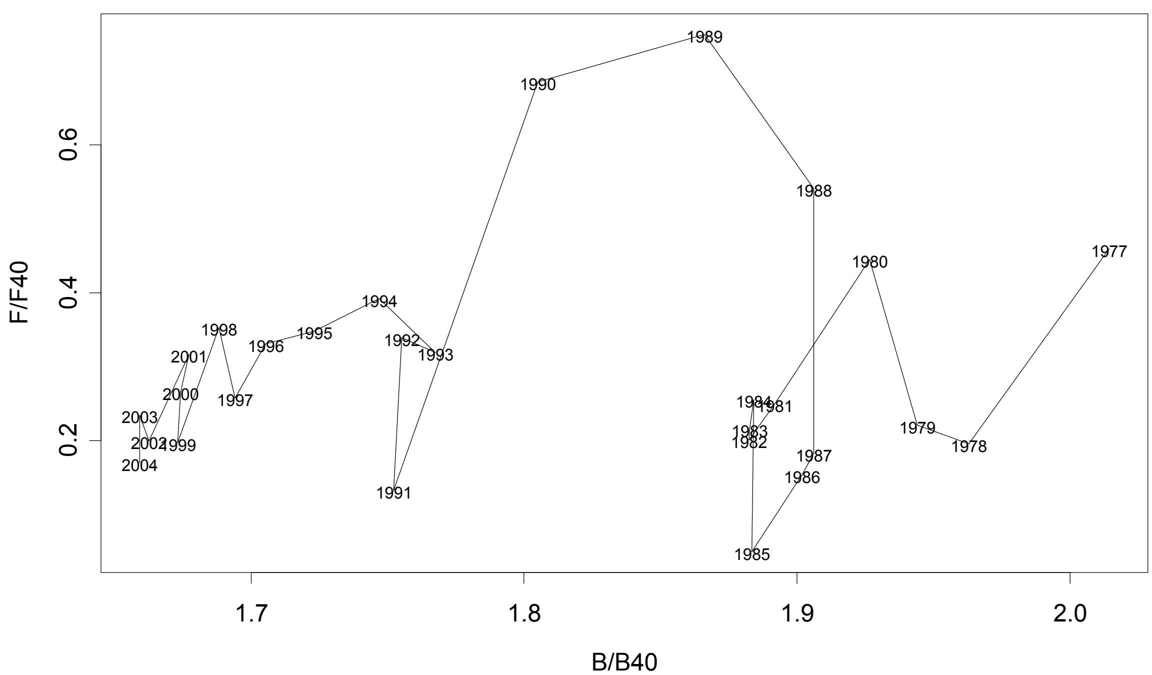

Figure 9B-26. Time series of Model 2 estimated fishing mortality over $F_{40\%}$ versus estimated spawning biomass over $B_{40\%}$.

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