Summary of the 2001 stock assessment

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Summary

This paper reports estimates of halibut abundance and available setline yield in 2002 at a harvest rate of 20%—about 105 million pounds coastwide, up from 95 million pounds last year. In the past, Areas 2A and 2B were combined for assessment purposes; this year they are treated separately. That change and the correction of an error in last year's assessment increases the 2A and 2B estimates. The analytical assessment in Areas 2C and 3A this year uses all setline survey stations rather than just a standard subarea, resulting in a decrease in estimated abundance in 2C and a small increase in 3A. An update of survey-based estimates of relative abundance in Area 4 has resulted in a reduction of estimated abundance in Area 4B and an increase in 4CDE.

Introduction

Each year the IPHC staff assesses the abundance and potential yield of Pacific halibut using all available data from the commercial fishery and scientific surveys (Appendix A). Exploitable biomass in each of IPHC regulatory areas 2B, 2C, and 3A is estimated by fitting a detailed population model to the data from that area.

A biological target level for total removals is then calculated by applying a fixed harvest rate—presently 20%—to the estimate of exploitable biomass. This target level is called the "constant exploitation yield" or CEY for that area in the coming year. The corresponding target level for directed setline catches, called the setline CEY, is calculated by subtracting from the total CEY an estimate of all other removals—sport catches, bycatch of legal-sized fish, wastage of legal-sized fish in the halibut fishery, and fish taken for personal use.

In Areas 3B and 4 exploitation rates were low until very recently and no surveys were done before 1996. For both reasons an analytical assessment is not feasible. Instead, exploitable biomass in those areas relative to that in Area 3A is estimated from recent surveys and the analytical estimate of abundance in Area 3A is scaled accordingly to estimate exploitable biomass in Areas 3B and 4. The same procedure is used to estimate exploitable biomass in Area 2A by scaling the 2B estimate. Total and setline CEY for those areas are then calculated as explained above.

Staff recommendations for catch limits in each area are based on the estimates of setline CEY but may be higher or lower depending on a number of statistical, biological, and policy considerations. Similarly, the Commission's final quota decisions are based on the staff's recommendations but may be higher or lower.

This paper summarizes the staff's estimates of total abundance, recruitment trends, exploitable biomass, and total and setline CEY by area, as calculated at the end of 2000 for the 2001 fishery. A detailed assessment report is published in the annual Report of Assessment and Research Activities, available in print and online at http:/iphc.washington.edu.

Selectivities, exploitable biomass, and CEY

Younger and smaller halibut are not as catchable as older and larger ones. The relative catchability of fish at each age—a percentage or proportion—is called the selectivity at that age. The exploitable biomass of each age group is calculated by multiplying its total biomass by its selectivity. The exploitable biomass of the whole stock, summed over all ages, is therefore the biomass of fully catchable fish that would provide the same catch per effort as the mix of partly and fully vulnerable fish in the stock in any given year.

Selectivity differs among areas and changes over time. In Alaska, the selectivity of younger fish has decreased substantially because size at age has decreased. When the model is fitted, commercial selectivity is estimated year by year and exploitable biomass is calculated accordingly. Call this "variable ebio". It is this measure of exploitable biomass that should vary in proportion to commercial CPUE.

There is another measure of exploitable biomass called "fixed ebio" that is calculated with a fixed set of selectivities in all areas and years. The fixed selectivities were intermediate between the higher 2B and lower 3A estimates in 1996, and the 20% target harvest rate is based on them. To calculate CEY, the 20% harvest rate is applied to this measure.

Since 1996 estimated commercial selectivities have declined further. Fixed ebio is now only a little less than variable ebio in Area 2AB, a little more in Area 2C, and substantially more in Area 3A.

While useful for monitoring abundance and calculating CEY, exploitable biomass has little biological or intuitive meaning. This year's assessment also reports historical estimates of spawning biomass and total legal-sized biomass as more straightforward measures of abundance.

Assessment methods

The assessment continues to rely on commercial and survey catch rates and age compositions to estimate historical and present stock sizes (Appendix B). Yield recommendations are again based on a model fit in which age-specific survey catchability and selectivity are held constant. Commercial catchability and selectivity are allowed to change gradually over time to account for changes in fishing practices and halibut growth rates. Because of the minimum size limit, age-specific commercial selectivity is strongly affected by growth changes. This is not true for survey data, which include all fish caught.

Assessment data and results for Areas 2A and 2B

Areas 2A and 2B have been combined for assessment purposes since the beginning of model-based analytical assessments in the early 1980s. The model has been fitted to the pooled data from the two areas to estimate total abundance in both areas, and the total apportioned between areas on the basis of the total bottom area and an average of the last three setline survey results in each regulatory area. The estimated proportion in 2A was 11% last year. With the addition of the 2001 survey results it is 12% this year. Survey results for all years when both areas were surveyed completely were:

	CPUE in 2A	CPUE in 2B	Proportion of 2AB biomass in 2A
1995	29	144	0.08
1997	35	158	0.09
1999	37	88	0.15
2001	41	102	0.15

In the 2000 assessment the combined Area 2AB assessment model fit was inadvertently run with the Area 2B data file, meaning that the reported Area 2AB abundance estimates in fact reflected only the abundance in Area 2B. As a result of the data error, the 2AB abundance estimate was low by about 5% last year. The setline CEY estimate was low by about 70,000 pounds in 2A and 700,000 pounds in 2B. Using the correct data file naturally results in an increase of about 5% in the 2A and 2B estimates for 2001 (Appendix C).

There is some biological rationale for combining 2A and 2B: clearly there is a seasonal migration of 2A fish between 2B and 2A, and there is some indication from tagging of greater mixing between 2A and 2B than elsewhere. Equally important, though, were the obstacles to performing a standalone 2A assessment: no survey data before 1995, spotty age composition data, uncertainty about the level of bycatch, and sparse and highly variable commercial CPUE data. Combining 2A with 2B effectively swamped these defects in the 2A data.

There is no serious obstacle to doing a standalone 2B assessment. The data for 2B are the best on the coast: a long history of full commercial utilization, good commercial and survey data series, and less change in growth than in Alaska. While there may be some migration of older fish from 2A into 2B, the numbers cannot be large enough to have any practical effect on the analytical estimate of 2B abundance.

The analytical estimate of exploitable biomass in 2B is 95% of the analytical estimate for 2A and 2B combined, well above the 85-92% seen in the surveys. It is clear from the difference between the analytical and survey estimates that the analytical assessment is underestimating abundance in 2A. For management purposes, therefore, it makes most sense to do a standalone assessment of abundance in 2B, and to use that value along with the survey results to estimate present biomass in 2A.

That is what was done in this year's assessment. Estimated abundance in 2B (from the standalone 2B assessment) is about 11% higher than last year owing to the combined effects of correcting the data error, separating 2A and 2B, and adding the 2001 data (Fig. 1). Estimated abundance in Area 2A is calculated as 14% of 2B abundance (equivalent to 12% of total abundance in the two areas). It is 24% higher than last year because it scales up with 2B and both the 2B value and the scaling factor are larger.

Total CEY values change in proportion to estimated abundance, but setline CEY's do not, because of differences among areas and years in the deductions for other removals (sport catch, bycatch etc.). Relative to last year's assessment, setline CEY is up by 12% in 2B (to 11.75 M lb from 10.51) and by 15% in 2A (to 1.31 M lb from 1.14).

Assessment data and results for Area 2C

In previous years, only survey stations in the outside waters of 2C were used in the assessment even though inside stations were fished in all surveys, because before 1996 the inside stations were distributed purposively on known commercial grounds rather than being placed systematically like the outside stations. It is preferable to use inside as well as outside stations in

the assessment so as to have a comprehensive index of abundance, and a comparison of the data showed no difference in CPUE trends between the old survey series using only outside stations and an expanded series using all stations, so this year all stations were used in the assessment.

When last year's assessment was re-run with this change, the result was a decrease of 15% in estimated abundance, which was a surprise in view of the close correspondence of the old and new survey CPUE series. Adding the 2001 data and projecting forward to 2002 increased the estimate, so the net change from last year's estimate of exploitable biomass in 2001 to this year's estimate of ebio in 2002 is a decrease of only about 5%, but it is clear that the change in the survey data series had a substantial negative effect.

In 2C there were fewer surveys than in 2B and 3A, and the survey data are quite variable from year to year whereas the commercial CPUE series is complete and very consistent from year to year (Fig. 2), so one way to check on the appropriateness of the change in survey data is to see whether the new fit agrees better or worse with the commercial data. Model fits that essentially ignore the survey data produce estimates very close to the value obtained with the survey CPUE series that uses all stations, so the lower estimate in 2C appears to be the right one. With the new biomass estimate, setline CEY down by 3% from last year (to 8.50 M lb from 8.78).

Assessment data and results for Area 3A

Before 1996, the setline survey in Area 3A only covered the shelf west of 148º W (just west of Prince William Sound). The eastern part of the shelf (Yakutat region) was added in 1996, and stations in Shelikof Strait, Cook Inlet, and Prince William Sound in 1998. Before now, only stations in the western part of 3A surveyed in all years were used in the assessment. That provided a consistent CPUE series but, just as in 2C, it is preferable to use all stations in the assessment so as to have a comprehensive CPUE series. In 3A the added stations are also quite numerous (total number fished is about 360 now vs 120 in 1995) so using all stations provides a less variable mean CPUE.

A comparison of the partial and complete survey data since 1996 showed that the stations added in the east generally have a lower CPUE than the stations in the west, so the survey CPUE series based on all stations shows a drop that does not appear in the series based on just the western stations. That feature of the 3A survey data can be accounted for in the assessment by allowing survey catchability to decrease in 1996. The size of the decrease in CPUE due to the survey expansion is estimated to be 22% when the model is fitted. This appears as the abrupt drop in predicted survey CPUE in 1996 in the bottom left panel of Fig. 3.

With those two changes made (new survey stations added and survey catchability allowed to decrease in 1996), and the 2001 data added, this year's estimate of exploitable biomass in 3A is 11% higher than last year's. Setline CEY is up by 10% (to 24.14 M lb from 21.94).

Extrapolation of the Area 3 estimate to Areas 3B and 4

Exploitable biomass in these areas is estimated by extrapolating the analytical estimate of abundance in Area 3A to each area on the basis of total bottom area and the average of the last three survey catch rates. Specifically, an index of total biomass in each area (including 3A) is computed as the product of setline survey CPUE and total bottom area. Absolute biomass is then obtained by scaling the absolute 3A estimate by the ratio of the indices. For example, 4A

biomass is estimated as the absolute 3A estimate multiplied by the ratio of the 4A to the 3A survey index.

In recent years "total bottom area" was defined as the area between 0 and 500 fm, but in fact the survey only goes down to 275 fm and halibut densities below 300 fm are probably very low in the summer when the surveys are conducted. This year the total bottom area used for calculating the survey-based index was redefined as the area between 0 and 300 fm. In most places the change is inconsequential because there is little bottom area between 300 and 500 fm, but 4B is reduced by about 30% (Table 2).

A setline survey index cannot be computed directly for the eastern Bering Sea shelf (4CDE) because no setline survey is done there. NMFS conducts a trawl survey there every year, and a setline survey CPUE is predicted from the average trawl CPUE and the ratio of setline to trawl CPUE in areas of overlap in 4A and 4D. For the last few years the predicted value was 30 lb/skate. An update this year produced a prediction of 40 lb/skate, which has the effect of increasing the 4CDE scaling factor.

The scaling factors (abundance relative to 3A) used last year and this year are:

	3B	4A	4B	4CDE
Factor used in 2000	94%	38%	37%	37%
Factor used in 2001	94%	41%	25%	47%

This year's 3A estimate and scaling factors result in setline CEY estimates that are up by 12% in 3B (to 28.56 M lb from 25.46), up by 22% in 4A (to 11.96 M lb from 9.82) down by 25% in 4B (to 7.51 M lb from 10.06), and up by 55% in 4CDE (to 11.81 M lb from 7.63). The 4CDE value is a rough estimate and is likely to be quite variable in the future.

Recent trends in weight at age

Between the late 1970s and the late 1990s there was a dramatic decrease in the average weight of halibut in commercial landings. At the modal age of 12 years, average weight declined by about 50% in Area 3A and 40% in Area 2B. In recent years weight at age has leveled off in Area 2 and Area 3A, but is still declining farther west (Figure 4).

Table 1. Last year's CEY estimates for 2001, removals in 2001, and this year's CEY estimates for 2002 (millions of net pounds).

	2A	2B	2C	3A	3B	4A	4B	4CDE	Total
2001 total CEY at 20% [1]	1.49	11.87	11.20	27.80	26.13	10.56	10.29	10.29	109.63
2001 deductions	0.35	1.36	2.42	5.91	0.67	0.74	0.23	2.66	14.34
2001 setline CEY	1.14	10.51	8.78	21.89	25.46	9.82	10.06	7.63	95.29
2001 catch limit	1.14	10.51	8.78	21.89	16.53	4.97	4.91	4.45	73.18
2001 commercial landings [2]	1.15	10.10	8.40	21.94	16.55	4.98	4.48	4.07	71.67
Other removals									
Sport catch (except 2A) [3]	---	1.02	1.73	5.02	0.01	0.08	0.00	0.00	7.86
Legal-sized bycatch	0.54	0.11	0.22	1.70	0.48	0.54	0.20	2.64	6.43
Personal use	0.00	0.30	0.17	0.07	0.02	0.09	0.00	0.08	0.73
Legal-sized wastage	0.00	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.23
Total deductions	0.54	1.47	2.16	6.82	0.54	0.74	0.23	2.75	15.25
Total removals	1.69	11.57	10.56	28.76	17.09	5.72	4.71	6.82	86.92
2002 exploitable biomass [4]	9.25	66.10	53.30	154.80	145.50	63.50	38.70	72.80	603.95
2002 total CEY at 20%	1.85	13.22	10.66	30.96	29.10	12.70	7.74	14.56	120.79
2002 setline CEY at 20%	1.31	11.75	8.50	24.14	28.56	11.96	7.51	11.81	105.54

Notes:

1. Estimates of 2001 setline CEY (first row) are the figures reported in the 2000 assessment. The 2B figure is the one computed with the lower (DFO Pacific Region) of the two sport catch series discussed in last year's assessment. A slightly different figure appeared in last year's assessment tables.

2. Figures for commercial landings in the second row include research catches, which are the reason for the small overages in some areas.

3. In Area 2A only, the 2001 catch limit, 2001 commercial landings, and 2002 setline CEY include sport catch and treaty subsistence catch. The figure for "total other removals" does not include sport catch. The breakdown of commercial and sport catches in 2A in 2001 was: treaty commercial 0.412 million pounds, non-treaty commercial 0.264, research 0.017, sport 0.441, treaty subsistence 0.02.

4. Area 2A ebio is 14% of the 2B ebio.

Table 2. Bottom areas (thousand square nautical miles), recent setline survey CPUE (pounds/skate), and relative exploitable biomass by regulatory area. Area 2A does not include California. The Closed Area is included in Area 4CDE.

Area	Bottom area 0-500 fm	Bottom area 0-300 fm	Setline CPUE (average of last 3 survey years)	Exploitable biomass relative to Area 3A	Proportion of coastwide biomass
2A	14.1	12.1	38	0.04	0.01
2B	29.7	28.1	117	0.26	0.07
2C	16.1	15.0	225	0.27	0.07
3A	51.2	49.5	256	1.00	0.28
3B	31.8	30.2	395	0.94	0.26
4A	21.6	18.5	339	0.41	0.11
4B	23.2	16.2	197	0.25	0.07
4D edge	5.0	5.0	175	0.07	0.02
4CDE shelf	120.0	120.0	42	0.40	0.11

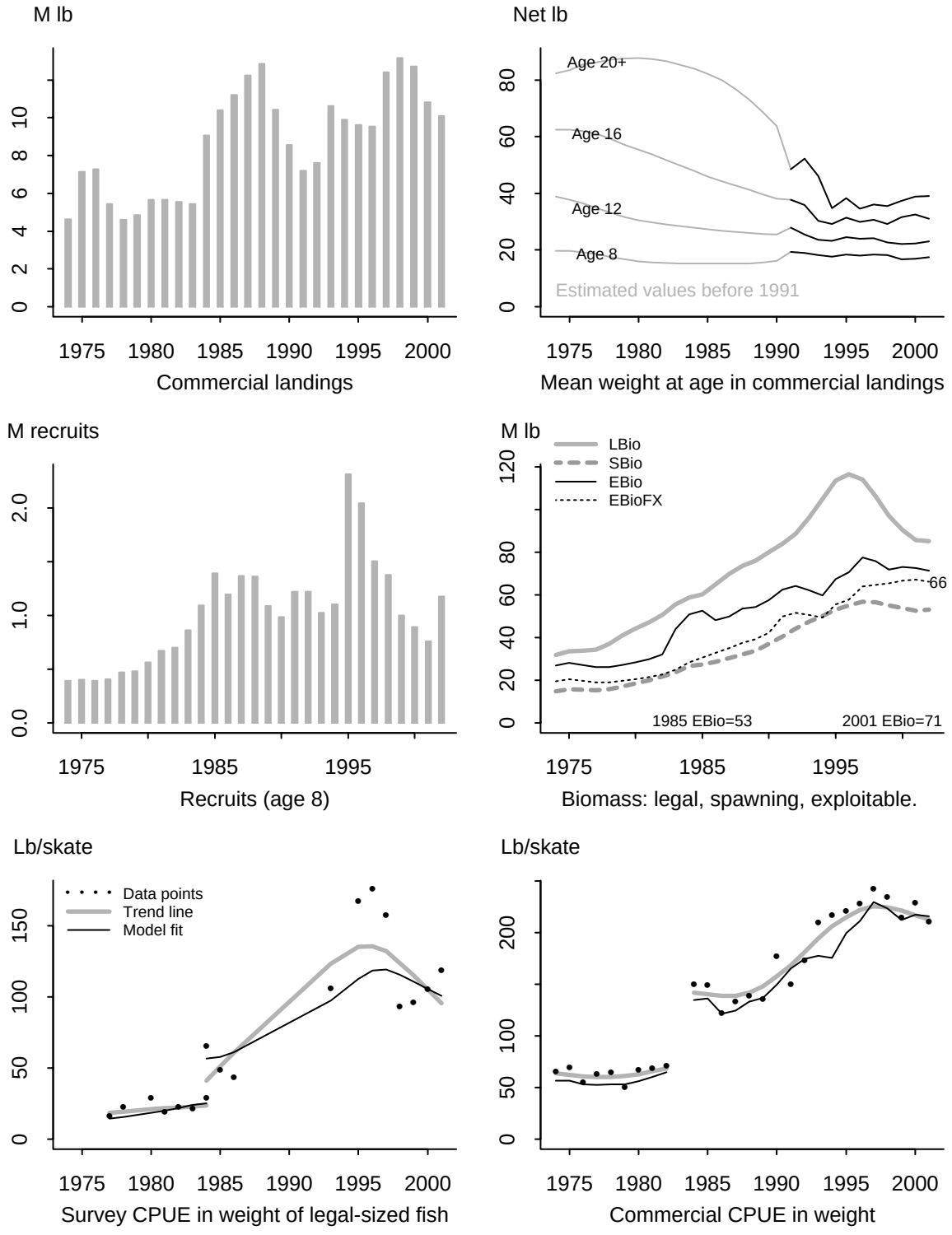

Figure 1. Fit of the standard model in Area 2B.

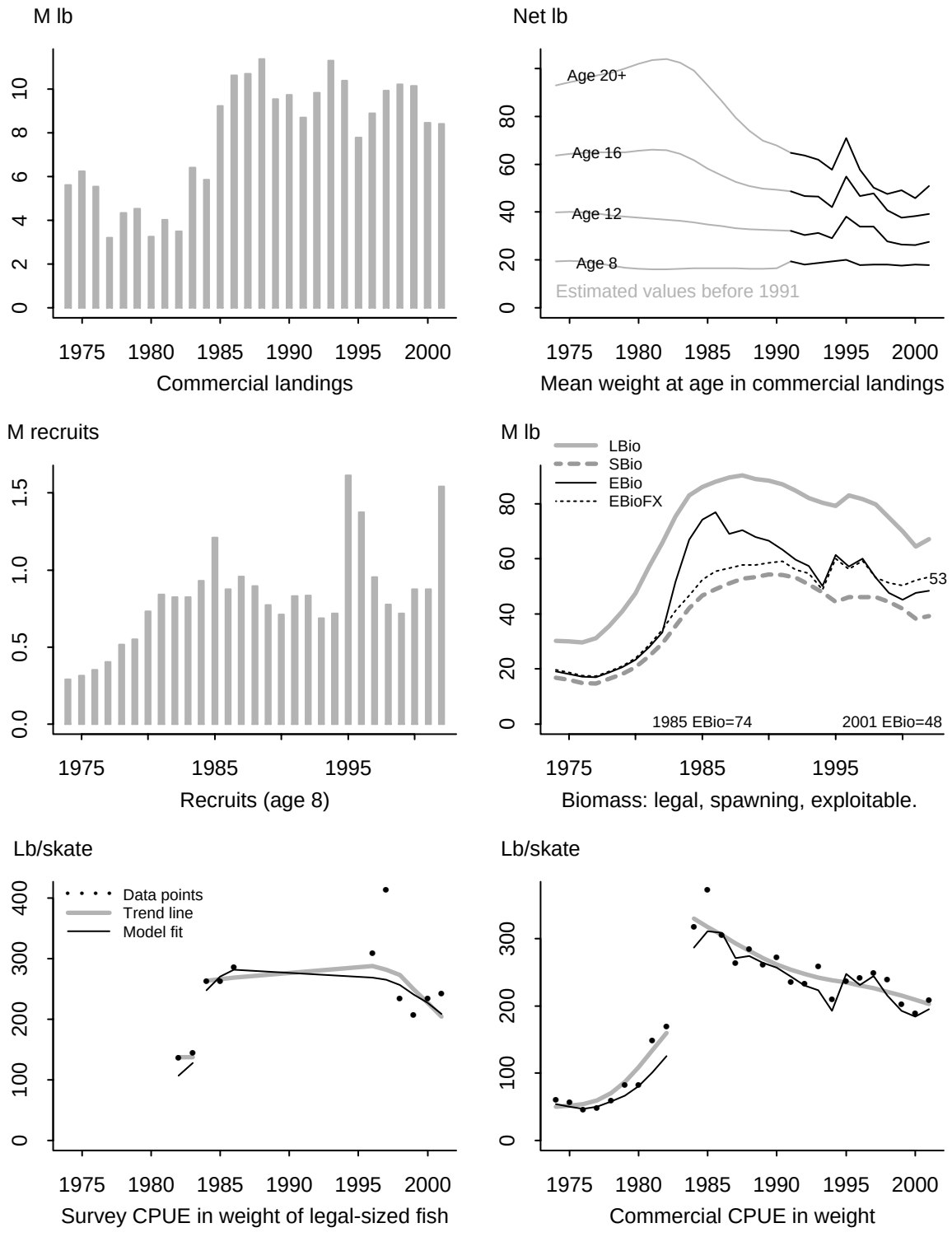

Figure 2. Fit of the standard model in Area 2C.

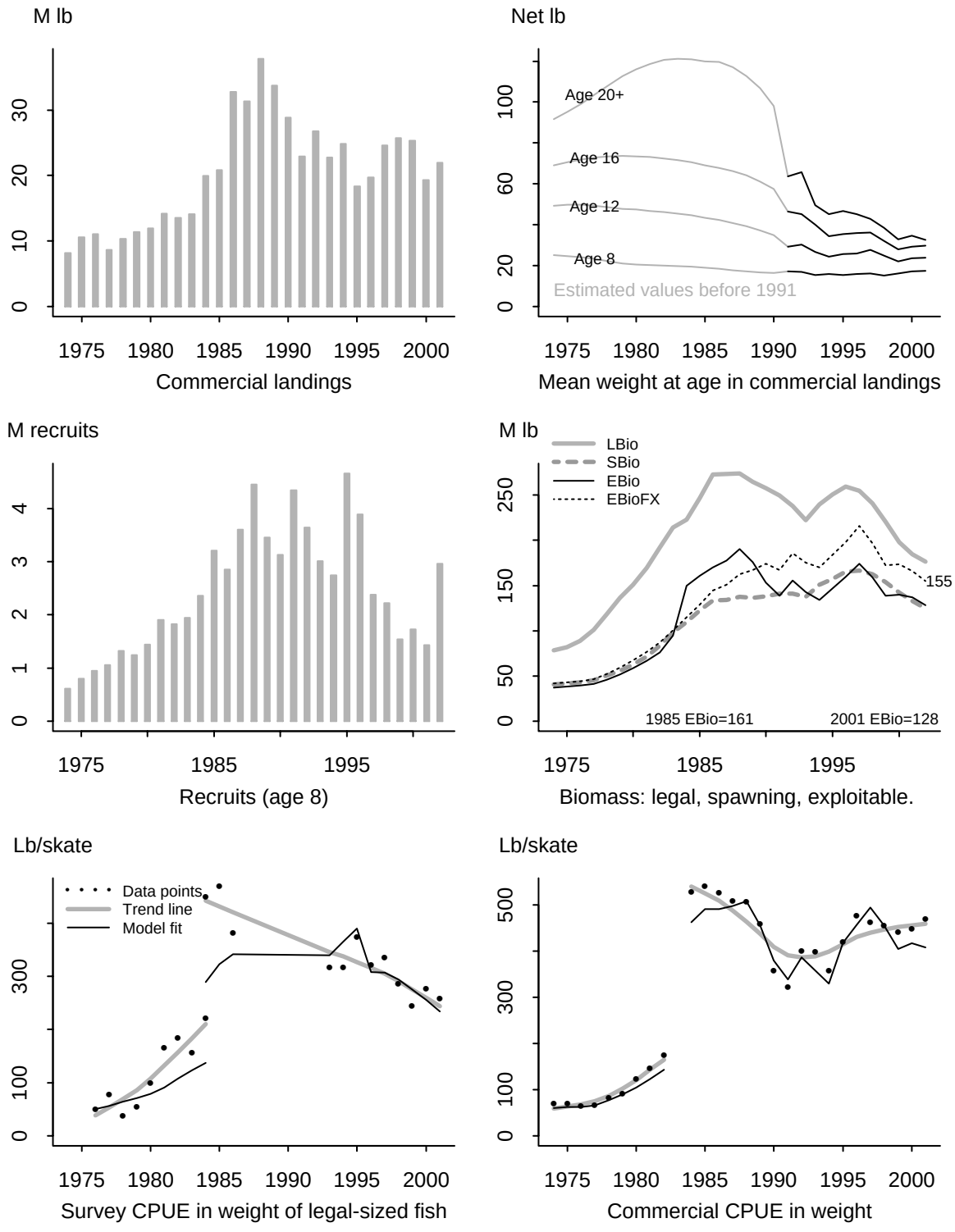

Figure 3. Fit of the standard model in Area 3A.

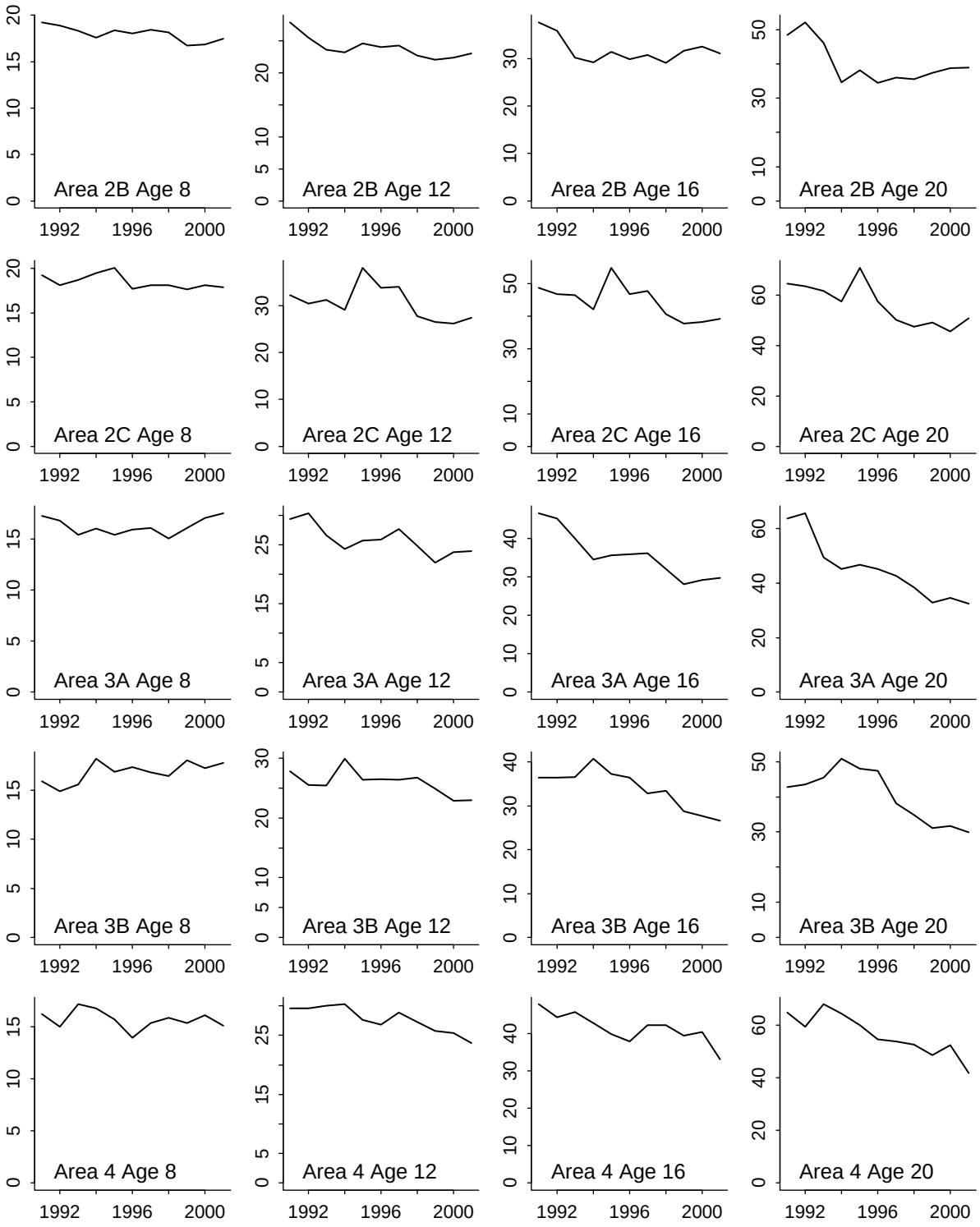

Figure 4. Recent trends in average weight at age in commercial landings.

Appendix A. Selected fishery and survey data summaries.

Table A1. Commercial catch (million pounds, net weight).

	2A	2B	2C	3A	3B	4	Total
1974	0.52	4.62	5.60	8.19	1.67	0.71	21.31
1975	0.46	7.13	6.24	10.60	2.56	0.63	27.62
1976	0.24	7.28	5.53	11.04	2.73	0.72	27.54
1977	0.21	5.43	3.19	8.64	3.19	1.22	21.88
1978	0.10	4.61	4.32	10.30	1.32	1.35	22.00
1979	0.05	4.86	4.53	11.34	0.39	1.37	22.54
1980	0.02	5.65	3.24	11.97	0.28	0.71	21.87

	2A	2B	2C	3A	3B	4A	4B	4C	4D	4E	Total
1981	0.20	5.66	4.01	14.23	0.45	0.49	0.39	0.30	0.01	0.00	25.74
1982	0.21	5.54	3.50	13.52	4.80	1.17	0.01	0.24	0.00	0.01	29.01
1983	0.27	5.44	6.38	14.13	7.75	2.50	1.34	0.42	0.15	0.01	38.39
1984	0.43	9.05	5.87	19.77	6.69	1.05	1.10	0.58	0.39	0.04	44.97
1985	0.49	10.39	9.21	20.84	10.89	1.72	1.24	0.62	0.67	0.04	56.10
1986	0.58	11.23	10.61	32.80	8.82	3.38	0.26	0.69	1.22	0.04	69.63
1987	0.59	12.25	10.68	31.31	7.76	3.69	1.50	0.88	0.70	0.09	69.45
1988	0.49	12.86	11.36	37.86	7.08	1.93	1.59	0.71	0.45	0.01	74.34
1989	0.47	10.43	9.53	33.73	7.84	1.02	2.65	0.57	0.67	0.01	66.95
1990	0.33	8.57	9.73	28.85	8.69	2.50	1.33	0.53	1.01	0.06	61.60
1991	0.35	7.19	8.69	22.93	11.93	2.25	1.51	0.68	1.44	0.10	57.08
1992	0.43	7.63	9.82	26.78	8.62	2.70	2.32	0.79	0.73	0.07	59.89
1993	0.50	10.63	11.29	22.74	7.86	2.56	1.96	0.83	0.84	0.06	59.27
1994	0.37	9.91	10.38	24.84	3.86	1.80	2.02	0.71	0.71	0.12	54.73
1995	0.30	9.62	7.77	18.34	3.12	1.62	1.68	0.67	0.64	0.13	43.88
1996	0.30	9.55	8.87	19.69	3.66	1.70	2.07	0.68	0.71	0.12	47.34
1997	0.41	12.42	9.92	24.63	9.07	2.91	3.32	1.12	1.15	0.25	65.20
1998	0.46	13.17	10.20	25.70	11.16	3.42	2.90	1.26	1.31	0.19	69.76
1999	0.45	12.70	10.14	25.32	13.83	4.37	3.57	1.76	1.89	0.26	74.31
2000	0.48	10.81	8.44	19.29	15.41	5.15	4.69	1.74	1.93	0.35	68.30
2001	0.69	10.10	8.40	21.94	16.55	4.98	4.48	1.74	1.87	0.46	71.20

Table A2. Bycatch mortality of legal-sized halibut (80+ cm; in million pounds net weight).

	2A	2B	2C	3A	3B	4	Total
1974	0.25	0.90	0.37	4.48	2.82	1.89	10.71
1975	0.25	0.90	0.45	2.61	1.66	1.10	6.97
1976	0.25	0.94	0.50	2.74	1.94	1.18	7.56
1977	0.25	0.72	0.41	3.37	1.54	1.98	8.27
1978	0.25	0.55	0.21	2.44	1.31	3.40	8.17
1979	0.25	0.69	0.64	4.49	0.69	3.45	10.21
1980	0.25	0.51	0.42	4.93	0.87	5.71	12.69
1981	0.25	0.53	0.40	3.99	1.10	4.37	10.64
1982	0.25	0.30	0.20	3.20	1.68	2.94	8.57
1983	0.25	0.29	0.20	2.08	1.22	2.47	6.52
1984	0.25	0.52	0.21	1.51	0.92	2.29	5.70
1985	0.25	0.55	0.20	0.80	0.34	2.25	4.38
1986	0.25	0.56	0.20	0.67	0.20	2.62	4.50
1987	0.25	0.79	0.20	1.59	0.40	2.67	5.91
1988	0.25	0.77	0.20	2.13	0.04	3.27	6.67
1989	0.25	0.72	0.20	1.80	0.44	1.94	5.36
1990	0.25	1.03	0.67	2.63	1.21	4.15	9.96
1991	0.25	1.22	0.55	3.13	1.04	2.92	9.10
1992	0.28	1.02	0.57	2.64	1.12	3.35	8.97
1993	0.28	0.65	0.33	1.92	0.47	2.01	5.66
1994	0.28	0.57	0.40	2.35	0.85	3.48	7.93
1995	0.38	0.71	0.22	1.46	0.83	3.21	6.80
1996	0.47	0.17	0.23	1.40	0.96	3.57	6.80
1997	0.47	0.11	0.24	1.55	0.73	3.80	6.90
1998	0.81	0.12	0.24	1.47	0.73	3.72	7.09
1999	0.66	0.11	0.23	1.28	0.74	3.34	6.36
2000	0.54	0.13	0.25	1.29	0.65	3.23	6.09
2001	0.54	0.11	0.22	1.70	0.48	3.39	6.44

Table A3. Total removals: commercial catch + sport catch + legal-sized wastage + legal-sized bycatch + personal use (millions of pounds net weight).

	2A	2B	2C	3A	3B	4	Total
1974	0.77	5.52	5.97	12.67	4.49	2.60	32.02
1975	0.71	8.03	6.69	13.21	4.22	1.73	34.59
1976	0.49	8.22	6.03	13.78	4.67	1.90	35.10
1977	0.48	6.16	3.67	12.20	4.73	3.20	30.44
1978	0.36	5.17	4.62	13.02	2.63	4.75	30.54
1979	0.32	5.56	5.34	16.19	1.08	4.82	33.31
1980	0.29	6.17	3.99	17.38	1.15	6.42	35.41
1981	0.47	6.20	4.73	18.96	1.55	5.57	37.47
1982	0.51	5.87	4.19	17.44	6.48	4.38	38.88
1983	0.58	5.78	7.15	17.14	8.97	6.89	46.51
1984	0.80	9.63	6.68	22.50	7.42	5.46	52.50
1985	0.94	11.30	10.31	23.79	11.43	6.69	64.45
1986	1.17	12.17	11.97	37.23	9.43	8.53	80.50
1987	1.29	13.48	12.03	36.48	8.50	9.84	81.62
1988	0.99	13.93	12.85	44.76	7.24	8.07	87.85
1989	1.05	11.51	11.48	40.00	8.47	7.03	79.55
1990	0.78	10.06	11.98	36.02	10.12	9.84	78.79
1991	0.77	8.83	11.95	32.42	13.46	9.49	76.92
1992	0.97	9.09	12.68	34.46	9.98	10.23	77.40
1993	1.04	12.00	13.74	30.59	8.46	8.56	74.39
1994	0.83	11.18	13.11	32.86	4.83	9.12	71.93
1995	0.92	11.55	9.80	24.51	4.02	8.11	58.91
1996	1.00	10.93	11.28	26.11	4.70	9.09	63.10
1997	1.25	13.75	12.37	31.86	9.92	12.79	81.94
1998	1.66	14.53	12.98	32.12	12.00	13.03	86.32
1999	1.45	14.01	12.45	31.02	14.69	15.55	89.17
2000	1.38	12.29	11.17	25.98	16.14	17.41	84.37
2001	1.68	11.58	10.56	28.76	17.10	17.25	86.92

Table A4. Commercial CPUE (net pounds per skate).

Values before 1984 are multiplied by the J-C hook correction for catch in weight of legal-sized fish (2.2). 1983 is excluded because it consists of a mixture of J- and C-hook data. No value is shown for area/years after 1980 with fewer than 500 skates of reported catch/effort data. Values for Areas 2A and 2B are slightly different from past years because of the reweighting of fixed-hook and snap CPUE described in the text.

	2A	2B	2C	3A	3B	4
1974	131	141	126	142	125	301
1975	131	149	117	145	149	211
1976	72	117	93	131	142	184
1977	182	135	99	135	161	176
1978	86	138	124	172	116	167
1979	110	106	177	189	81	146
1980	82	144	175	261	249	124

	2A	2B	2C	3A	3B	4A	4B	4C	4D	4E
1981	---	147	318	312	---	---	217	243	---	---
1982	47	151	366	375	478	226	---	199	---	---
1983	---	---	---	---	---	---	---	---	---	---
1984	63	148	314	524	475	366	161	---	197	---
1985	62	147	370	536	602	333	234	---	330	---
1986	60	120	302	522	515	265	---	427	238	---
1987	57	131	260	504	476	341	220	384	---	---
1988	134	137	281	503	655	453	224	---	201	---
1989	124	134	258	455	590	409	268	331	384	---
1990	168	175	269	353	484	434	208	288	381	---
1991	158	148	233	319	466	471	329	223	398	---
1992	115	171	230	397	440	372	278	249	412	---
1993	147	208	256	393	514	463	218	256	851	---
1994	93	215	207	354	377	463	198	167	480	---
1995	116	219	234	416	476	349	189	---	475	---
1996	159	226	238	473	556	515	269	---	---	---
1997	226	241	246	458	562	482	275	335	671	---
1998	194	232	236	451	611	525	287	287	627	---
1999	342	213	199	437	538	498	310	270	535	---
2000	263	227	186	443	577	548	318	223	556	---
2001	142	209	205	465	405	459	284	197	517	---

Table A5. IPHC setline survey CPUE of legal sized fish in weight (net pounds per skate). Figures for Area 2B refer to the Charlotte region only. Figures for all other areas refer to all stations fished. This is a change from previous years and the series for Areas 2C, 3A, and 4A have changed as a result. The eastward expansion of the 3A survey in 1996 lowered average CPUE by around 25%; the raw values in the table should not be taken at face value. Similarly the 4A value for 1999 is elevated because the Bering Sea edge in 4A was not fished that year. *No corrections* are applied; values before 1984 are raw J-hook catch rates.

J-hook surveys

	2A	2B	2C	3A
1974	---	---	---	---
1975	---	---	---	---
1976	---	---	---	---
1977	---	15	---	73
1978	---	21	---	34
1979	---	---	---	51
1980	---	28	---	95
1981	---	18	---	162
1982	---	21	133	180
1983	---	20	142	153

C-hook surveys

	2A	2B	2C	3A	3B	4A	4B	4C	4D
1984	---	64	260	446	---	---	---	---	---
1985	---	47	260	466	---	---	---	---	---
1986	---	42	283	377	---	---	---	---	---
1987	---	---	---	---	---	---	---	---	---
1988	---	---	---	---	---	---	---	---	---
1989	---	---	---	---	---	---	---	---	---
1990	---	---	---	---	---	---	---	---	---
1991	---	---	---	---	---	---	---	---	---
1992	---	---	---	---	---	---	---	---	---
1993	---	105	---	313	---	---	---	---	---
1994	---	---	---	313	---	---	---	---	---
1995	29	166	---	370	---	---	---	---	---
1996	---	175	306	317	352	---	---	---	---
1997	35	156	411	331	415	237	282	71	111
1998	---	92	232	281	436	304	216	---	---
1999	37	95	204	241	441	367	204	---	---
2000	---	104	232	273	378	286	216	---	213
2001	41	117	239	255	365	209	171	---	201

Appendix B. Recent changes in assessment methods and harvest policy.

1982-1994: stock size was estimated with CAGEAN, a strictly age-structured model fitted to commercial catch-at-age and catch-per-effort data. Because of a decrease in growth rates between the late 1970s and early 1990s, there were persistent underestimates of incoming recruitment and total stock size in the assessments done in the early 1990s.

Until 1985, allowable removals were calculated as a proportion of estimated annual surplus production (ASP), the remaining production being allocated to stock rebuilding. In 1985 the Commission adopted a constant harvest rate policy, meaning that allowable removals are determined by applying a fixed harvest rate to estimated exploitable biomass. This harvest level is called the Constant Exploitation Yield, or CEY. The fixed harvest rate was set at 28% in 1985, increased to 35% in 1987, and lowered to 30% in 1993.

1995: a new age- and length-structured model was implemented that accounted for the change in growth and was fitted to survey as well as commercial catch-at-age and catch-per-effort data. The new model produced substantially higher biomass estimates. In Area 3A this resulted from accounting for the change in growth schedule. In Area 2B, where the change in growth had been much less than in Alaska, it resulted from fitting the model to survey catch-per-effort, which showed a larger stock increase since the mid-1980s than commercial catch-per-effort. Quotas were held at the 1995 level to allow time for a complete study of the new model and results,

1996: differences in estimated selectivity between British Columbia and Alaska led to the consideration of two alternatives for fitting the model, one in which survey selectivity was a fixed function of age and the other in which it was a function of length. Spawner-recruit estimates from the new model resulted in a lowering of the target harvest rate to 20%. Quotas were increased somewhat, but not to the level indicated by the new biomass estimates.

1997: setline surveys of the entire Commission area indicated substantially more halibut in western Alaska (IPHC Areas 3B and 4) than the analytical assessment. Biomass in those areas was estimated by scaling the analytical estimates of absolute abundance in Areas 2 and 3A by the survey estimate of relative abundance in western Alaska. CEY estimates increased again, and quotas were increased again, but still to a level well below the CEY's.

1998: the working value of natural mortality was lowered from 0.20 to 0.15, reducing analytical estimates of biomass in Areas 2 and 3A by about 30%. At the same time setline survey estimates of abundance in Areas 3B and 4 relative to Areas 2 and 3A increased, so biomass estimates in the western area decreased by a smaller amount.

1999: setline survey catch rates in the 1990s were adjusted downward to account for the effect of changing to all-salmon bait when the surveys resumed in 1993. This reduced biomass estimates by 20-30%.

2000: the bait correction applied in 1999 was removed, which increased biomass estimates by 30-40%, approximately back to the level in the 1998 assessment. In addition, a purely age-structured model was adopted in place of the age- and size-structured model used in 1999. The 2000 model produced similar estimates of present biomass but lower estimates of historical biomass.

2001: instead of a combined Area 2AB assessment, a standalone assessment of Area 2B was done and the biomass estimate extrapolated to 2A on the basis of survey results, which increased the abundance estimate by 4%. Also in 2A and 2B, snap CPUE (scaled up by 1.35) was given the same weight as fixed-hook CPUE; negligible effect. All survey stations in 2C and 3A were used in the assessment rather than just the standard survey areas, which increased the biomass estimate by 7% in 3A and lowered it by 15% in 2C.

Appendix C. Summary of Area 2A/2B miscalculations and recalculations.

The intended procedure in last year's assessment (the 2000 assessment) was to estimate total abundance in Area 2AB (2A and 2B combined) by fitting the fishery model to the combined 2AB dataset, and then to apportion the estimated total 89% to 2B and 11% to 2A, as indicated by survey data through 2000. What happened was that the estimate from a model fit to the 2B dataset was erroneously reported as the combined 2AB estimate, and that was apportioned. The erroneous estimate of the total was 95% of the intended value, so the estimates of total CEY in Areas 2A and 2B in last year's assessment were 5% less than they should have been.

The procedure in this year's assessment (the 2001 assessment) is to estimate abundance separately in Area 2A and 2B. Specifically, biomass in Area 2B, and only 2B, is estimated from a standalone model fit to the Area 2B data. Biomass in Area 2A is then estimated as an additional amount equal to 14% of the 2B estimate. The scaling factor is 14% because survey data through 2001 indicate that 2A has 12% of the total 2AB biomass (up from 11% last year), and that is equivalent to 2A being 14% of 2B.

The tables below show the incorrect and corrected 2000 assessment estimates for 2001, along with this year's estimates for 2002 calculated by the old and new procedures. In each table, the underlined figure is the ebio estimate for which all other values in the that table were calculated.

Table 1. The incorrect estimates for 2001 reported in the 2000 assessment. The Area 2B ebio estimate (66.71 M lb) was erroneously reported as the combined 2AB estimate and distributed 89% to 2B and 11% to 2A.

Reported (incorrect) values. 2A and 2B combined. 2A = 11% of 2AB	**Area2A**	**Area 2B**	**Area 2AB**
2001 bio	7.34	59.36	<u>66.71</u>
Total CEY at 20%	1.47	11.87	13.34
Setline CEY	1.12	10.51	11.63

Table 2. The estimates for 2001 that should have appeared in the 2000 assessment, based on the correct 2AB figure (70.14 M lb), also distributed 89% to 2B and 11% to 2A.

Corrected 2001 values. 2A and 2B combined. 2A = 11% of 2AB	**Area2A**	**Area 2B**	**Area 2AB**
2001 bio	7.72	62.68	<u>70.14</u>
Total CEY at 20%	1.54	12.54	14.08
Setline CEY	1.19	11.18	12.37

Table 3. The estimates for 2001 that would have appeared in the 2000 assessment if 2A and 2B had been separated as in this year's assessment, with 2B ebio estimated from a standalone model fit (the same 66.71 M lb erroneously reported as the 2AB estimate in Table 1), and then 2A ebio estimated as an additional amount equal to 12% of 2B (equivalent to 11% of the 2AB total).

Recalculated 2001 values. 2A and 2B separated. 2A = 12% of 2B	**Area2A**	**Area 2B**	**Area 2AB**
2001 ebio	8.01	66.71	74.72
Total CEY at 20%	1.60	13.34	14.94
Setline CEY	1.25	11.98	13.23

Table 4. The estimates for 2002 that appear in this year's assessment (the 2001 assessment) with 2A and 2B separated. Ebio in 2B is estimated from a standalone model fit, and 2A ebio is estimated as an additional amount equal to 14% of the 2B estimate (equivalent to 12% of the 2AB total).

The 2002 estimates from this year's assessment. 2A and 2B separated. 2A = 14% of 2B	**Area2A**	**Area 2B**	**Area 2AB**
2002 ebio	9.25	66.10	75.35
Total CEY at 20%	1.85	13.22	15.07
Setline CEY	1.31	11.75	13.06

Table 5. The estimates for 2002 that would appear in this year's assessment if this year's estimates had been calculated using last year's procedure, whereby a combined 2AB estimate would be apportioned 88% to 2B and 12% to 2A.

The 2002 estimates using last year's procedure. 2A and 2B combined. 2A = 12% of 2AB estimate	**Area 2A**	**Area 2B**	**Area 2AB**
2002 ebio	8.62	63.24	71.86
Total CEY at 20%	1.72	12.65	14.37
Setline CEY	1.18	11.18	12.36