

Summary of the 2000 stock assessment

William G. Clark and Steven R. Hare

Summary

Biomass estimates in the 1999 assessment were sharply lower than in the 1998 assessment because of a bait adjustment to recent setline survey catch rates in all areas, lower weights at age in Alaska, and very low estimated recent recruitment in Area 3A. Since then, comparative fishing in summer 2000 has shown the bait adjustment to be unnecessary, weight at age has increased a bit, and the estimates of recent recruitment in Area 3A have come up. Although it still appears that coastwide recruitment has declined since 1996, biomass estimates are back up to approximately the level of the 1998 assessment. Coastwide setline CEY is 95 million pounds.

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 2AB, 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. 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 reports 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 more detailed account of the assessment is given elsewhere by Clark and Hare (2001).

Assessment methods

The assessment continues to rely on commercial and survey catch rates and age compositions to estimate historical and present stock sizes. Yield recommendations are again

based on a fit in which age-specific survey catchability and selectivity are held constant. Commercial catchability is still allowed to change over time, but the allowable rate of change has been reduced this year because the recent series of low survey catch rates in Area 2B, continued in 2000, now makes survey and commercial catch rate trends look quite similar in both Canada and Alaska. Because commercial catch rates are much less variable from year to year than survey catch rates, the estimated stock trends in fact tend to follow the commercial catch rates more than the survey catch rates where there is a difference (as there still is in 2B).

From 1995 through 1999 the assessment employed a population model that fitted a time-varying growth schedule to predict the observed size distribution of each age group as well as the observed age composition of survey and commercial catches. Age-specific selectivities were not estimated directly but were calculated from a fairly rigid (2-parameter) function of length. When the model was fitted, the parameters of the length-based function were required to vary over time in such a way as to keep the calculated age-specific survey selectivities constant.

This year's assessment reverts to a much simpler population model in which age-specific selectivities are estimated directly and no attempt is made to model growth or predict the distribution of size at age in the catches. Comparisons of fits of this year's model and last year's to the same data indicate that in last year's model the rigid length-based selectivity function imposed subtle constraints on the pattern of age-specific selectivities that could be achieved in the fit, with the result that in Areas 2C and 3A historical abundance tended to be overestimated and recent recruitment underestimated. Thus while the old model and the new model give similar estimates of present exploitable biomass, the long-term trends in biomass and recruitment in Alaska look more reasonable in this year's fits. There is little difference between this year's and last year's fits in Canada.

Removal of the bait adjustment

Systematic setline surveys were suspended after 1986 and resumed in 1993. At that time chum salmon was adopted as a standard bait, whereas salmon and herring on alternate hooks had been used as bait in the 1980s.

Experiments done in 1999 showed that skates baited entirely with salmon caught about twice as many halibut as skates baited entirely with herring. These results suggested that if half of survey hooks had been baited with herring in the 1990s, catch rates would have been 25% lower. This was not certain because of the additional difference in baiting pattern (full skates vs. alternating hooks), but as a precaution the staff applied a 25% downward adjustment to recent survey catch rates when doing the 1999 assessment, and that lowered biomass estimates by 20-30%.

In summer 2000 the staff conducted a direct comparison of survey catch rates using the two bait configurations (all salmon and alternating salmon/herring) and found no practical difference between them. All-salmon skates caught about 10% more halibut (in number) than salmon/herring skates in Alaska and about 10% fewer in Canada, but the difference was not statistically significant except among legal-sized fish in Alaska. Even there it was too small (20% in both numbers and weight) to require an adjustment in the assessment (Table 1).

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 results for Area 2AB

Stock size in 1985 is well determined by the catch at age data, because by now all the year classes that were present in the fishery have passed through it. We know how many were alive then because we have counted them as they were removed (and allowed for natural mortality). In terms of variable ebio, stock size was 53 M lb in 1985. Since 1985 commercial catch rates have increased by about 50% (Figure 1, center right panel). In the mid-1990s survey catch rates were about triple the level of survey catch rates in the mid-1980s, but the last three years have indicated a relative change of about 100%, much closer to what the commercial data indicate (Figure 1, center left panel). A commonsense estimate of present abundance would therefore be a variable ebio of 50-100% above the 1985 level. The fitted estimate is 73 M lb or about 40% above 1985, which essentially follows the commercial trend but allows for an estimated 10% increase in commercial catchability (fishing power) between 1985 and now. In terms of fixed ebio, the 2001 estimate is 68 M lb, of which 11% is assigned to Area 2A and 89% to 2B (Table 2).

This year’s fit is quite pessimistic as regards recent recruitment (Figure 1, top left panel), but in this respect it is at odds with the 2C assessment. There is little doubt that the two will agree closely when the estimates firm up, because relative year-class strengths have always been similar in 2B and 2C.

Assessment results for Area 2C

As in Area 2AB, survey catch rates have been low for the past three years after some high values in the mid-1990s (Fig. 2, center left panel). There are many fewer early survey points in 2C than in 2AB, and the recent ones are highly variable. Overall the survey results indicate little or no difference in abundance between 1985 and now, but the scatter makes any conclusion questionable. Meanwhile the commercial catch rates are very consistent in showing a decline of about one-third between 1985 and now (Fig. 2, center right panel), and this is what the model fit reflects, estimating a variable ebio of 48 M lb (56 M fixed) in 2001.

Assessment results for Area 3A

Survey and commercial catch rates agree quite well in 3A, survey values declining 20-25% from the 1985 level of 150 M lb and commercial values 10-15% (Fig. 3, center panels). The model estimate of 111 M lb is 25% below the 1985 level. This may be a little low; on the other hand the high survey value in 2000 appears anomalously high, and it is propping up the estimate to some extent. In terms of fixed ebio, the 2001 estimate is 139 M lb.

Estimates of recent recruitment in Area 3A are still low but not dismal as in last year's fit.

Extrapolation to Areas 3B and 4

In Areas 3B and 4, exploitation rates were very low until recently and there are no survey data before 1996. Exploitable biomass in those areas is estimated by extrapolating the analytical estimate of abundance in Area 3A to each area on the basis of total bottom area (0-500 fathoms) and a forward-weighted average of recent survey catch rates relative to 3A. The scaling factors this year are very similar to last year's, but the estimates are all substantially higher because the 3A estimate is substantially higher (Table 2).

References

Clark, W.G., and S.R. Hare. 2001. Assessment of the Pacific halibut stock in 2000. Int. Pac. Halibut Comm. Report on Assessment and Research Activities 2000: pages unknown. Also online at: <http://www.iphc.washington.edu/halcom/research/sa/papers/sa00.pdf>.

Table 1. Results of the 2000 bait experiment. The value estimated is the ratio of CPUE of skates baited entirely with salmon to the CPUE of skates baited with salmon and herring on alternate hooks.

Size class	Area	Point estimate	Lower bound	Upper bound	Significance
Legal sized	3A	1.21	1.01	1.44	Y
	2B	0.93	0.74	1.17	N
Sublegal	3A	0.98	0.71	1.35	N
	2B	0.82	0.54	1.26	N
Total catch	3A	1.12	0.93	1.33	N
	2B	0.89	0.70	1.12	N

Table 2. Removals in 2000 and CEY in 2001 (in millions of net pounds).

Area	2A	2B	2C	3A	3B	4A	4B	4CDE	Total
2000 catch limit	0.83 ¹	10.60	8.40	18.31	15.03	4.97	4.91	4.45	67.50
2000 commercial landings²	0.46	10.78	8.46	19.33	15.44	5.04	4.71	4.04	68.26
Other removals									
Sport catch	0.34	1.58	1.98	4.60	0.02	0.10	—	—	8.62
Legal-sized bycatch	0.34	0.14	0.23	1.21	0.58	0.52	0.20	2.55	5.77
Personal use	0.00	0.30	0.17	0.07	0.02	0.09	0.00	0.08	0.73
Legal-sized wastage	0.01	0.03	0.04	0.03	0.05	0.03	0.03	0.03	0.25
Total other removals	0.69	2.05	2.42	5.91	0.67	0.74	0.23	2.66	15.37
Total removals	1.15	12.83	10.88	25.24	16.11	5.78	4.94	6.70	83.63
2001 exploitable biomass	7.44	60.18	56.00	139.00	130.66	52.82	51.43	51.43	548.96
2001 total CEY	1.49	12.04	11.20	27.80	26.13	10.56	10.29	10.29	109.80
2001 setline CEY	1.14 ¹	9.99 ³	8.78	21.89	25.46	9.82	10.06	7.63	94.77

¹ Catch limit and setline CEY include sport catch in Area 2A only.

² Includes research catches.

³ With the lower series of 2B sport catch estimates (including 0.887 M lb in recent years), 2AB exploitable biomass is 66.71 instead of 67.62 as in the table. With 11% of the total in 2A, this change results in a 2001 setline CEY of 1.12 M lb in 2A and 10.51 M lb in 2B.

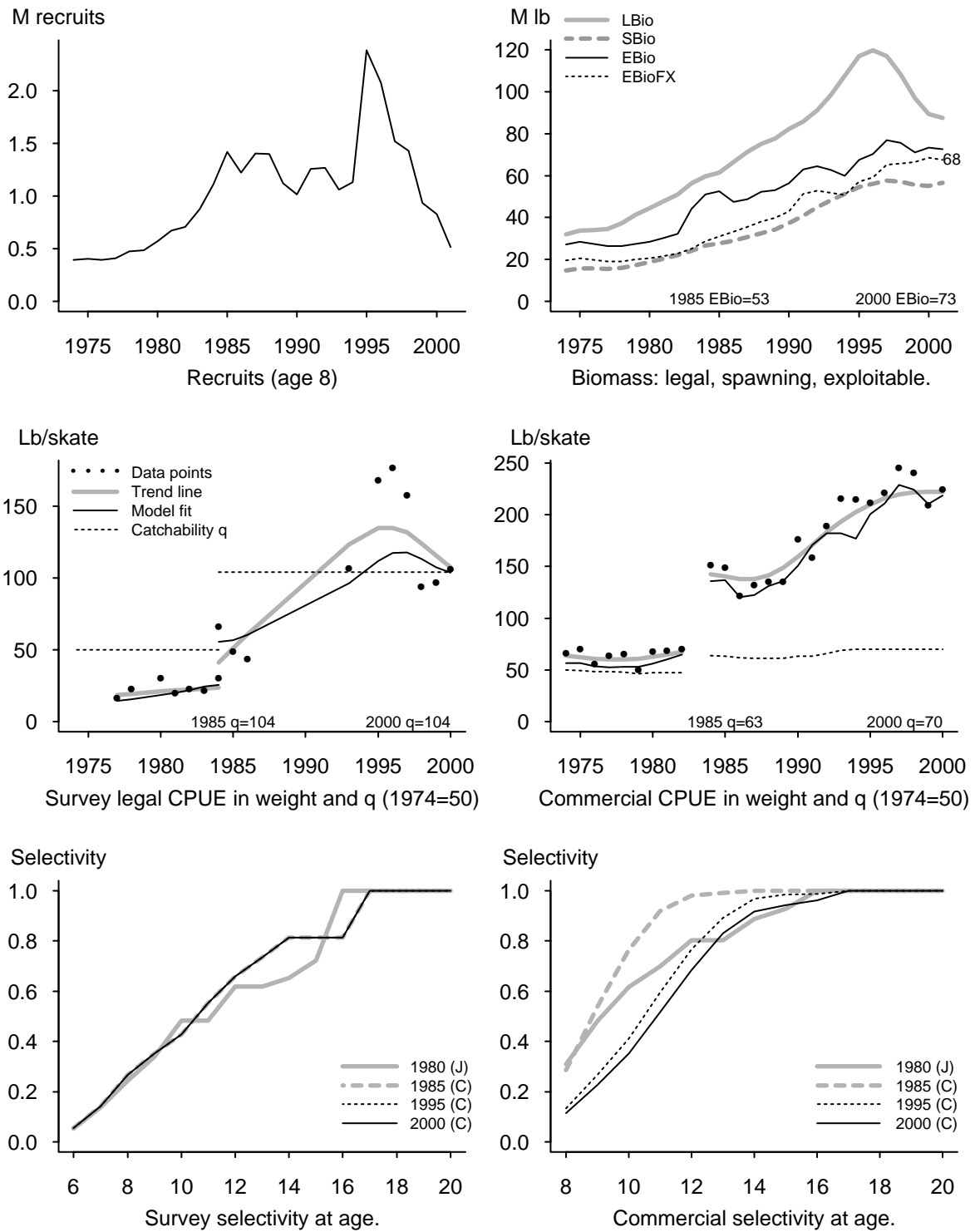


Figure 1. Fit of the standard model in Area 2AB.

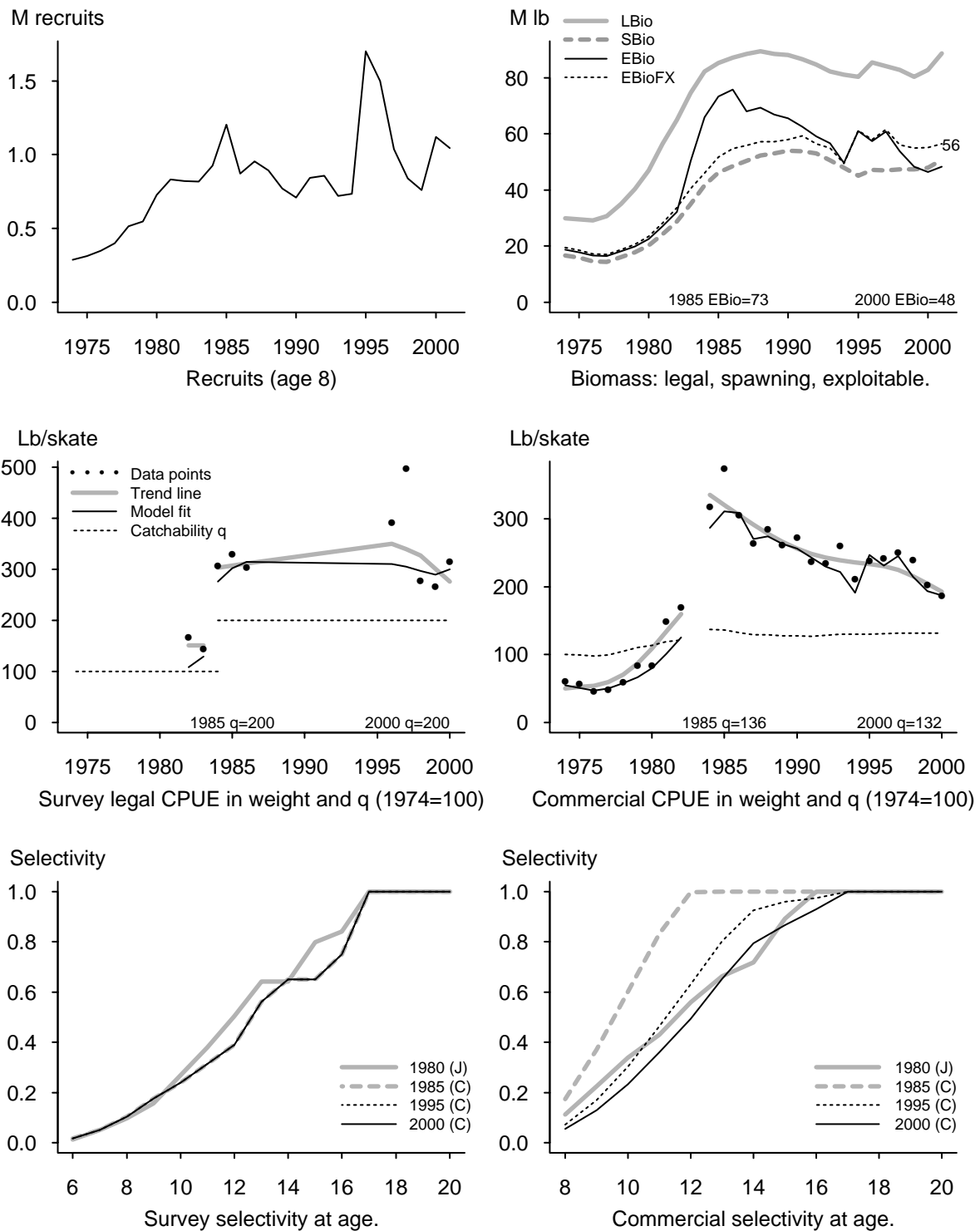


Figure 2. Fit of the standard model in Area 2C.

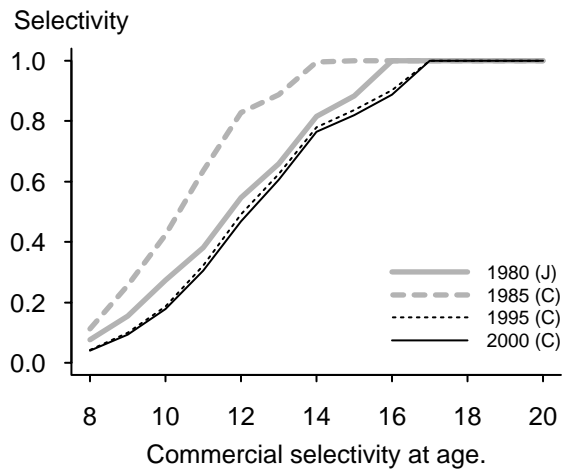
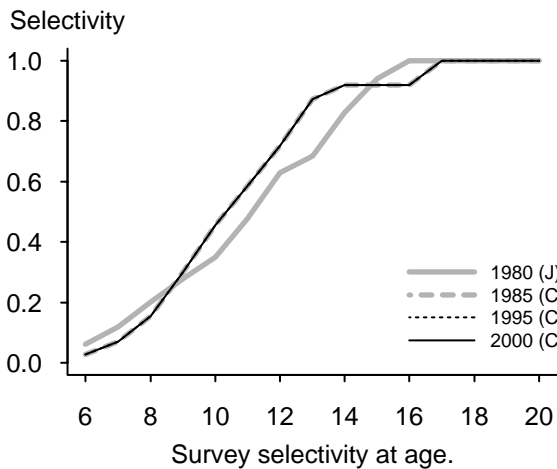
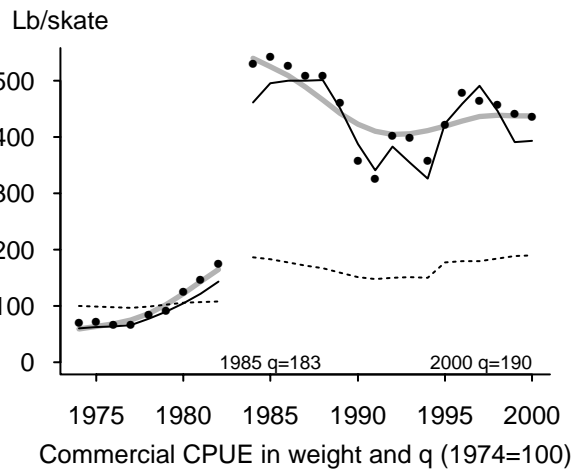
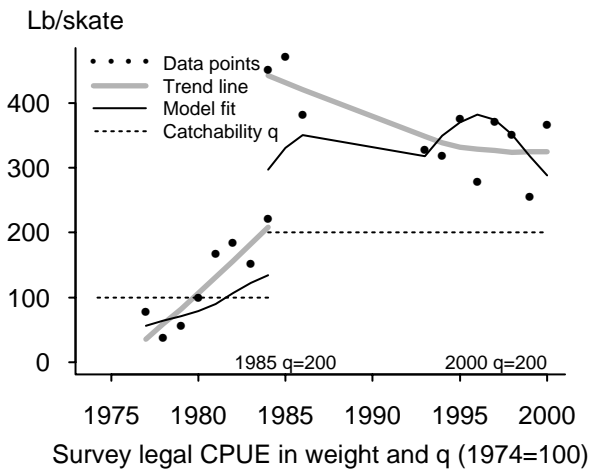
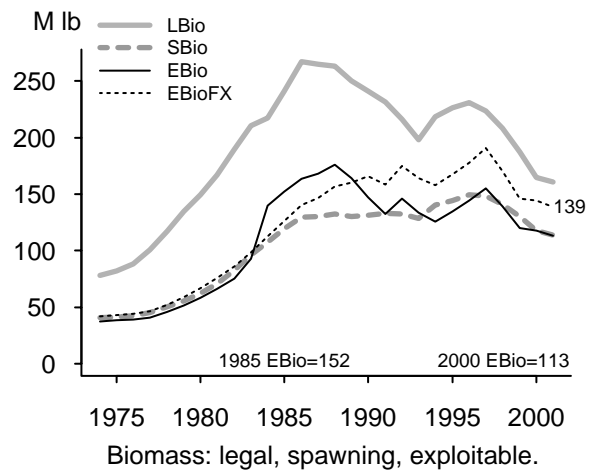


Figure 3. Fit of the standard model in Area 3A.

Appendix A. Selected fishery and survey data summaries.

Table A1. Commercial + research 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	13.15	10.20	25.70	11.16	3.42	2.90	1.26	1.31	0.19	69.74
1999	0.45	12.70	10.17	25.29	13.83	4.37	3.57	1.76	1.89	0.26	74.31
2000	0.46	10.78	8.46	19.33	15.44	5.04	4.71	1.75	1.95	0.35	68.27

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	1.90	10.71
1975	0.25	0.90	0.45	2.61	1.66	1.10	6.98
1976	0.25	0.94	0.50	2.74	1.94	1.18	7.56
1977	0.25	0.73	0.41	3.37	1.55	1.98	8.27
1978	0.25	0.55	0.21	2.44	1.31	3.40	8.16
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	1.09	4.37	10.64
1982	0.25	0.30	0.20	3.20	1.68	2.95	8.58
1983	0.25	0.29	0.20	2.08	1.22	2.47	6.51
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	4.39
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	2.68	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	1.95	5.37
1990	0.25	1.03	0.67	2.63	1.21	4.15	9.96
1991	0.25	1.22	0.55	3.12	1.03	2.91	9.09
1992	0.28	1.02	0.57	2.65	1.12	3.34	8.97
1993	0.28	0.65	0.33	1.92	0.47	2.01	5.65
1994	0.28	0.57	0.40	2.35	0.85	3.48	7.93
1995	0.38	0.71	0.22	1.46	0.82	3.21	6.80
1996	0.38	0.17	0.23	1.40	0.96	3.57	6.71
1997	0.38	0.11	0.24	1.55	0.73	3.80	6.81
1998	0.38	0.12	0.24	1.47	0.73	3.72	6.66
1999	0.34	0.11	0.23	1.28	0.74	3.33	6.04
2000	0.34	0.14	0.23	1.21	0.58	3.28	5.77

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	4.48	2.61	32.02
1975	0.71	8.03	6.69	13.21	4.22	1.73	34.60
1976	0.49	8.22	6.03	13.78	4.67	1.90	35.10
1977	0.48	6.17	3.67	12.20	4.73	3.20	30.45
1978	0.36	5.17	4.62	13.02	2.63	4.75	30.55
1979	0.32	5.57	5.34	16.19	1.08	4.82	33.32
1980	0.29	6.18	3.99	17.39	1.15	6.42	35.41
1981	0.47	6.21	4.73	18.96	1.54	5.57	37.48
1982	0.51	5.91	4.19	17.44	6.48	4.39	38.92
1983	0.58	5.83	7.15	17.14	8.97	6.89	46.56
1984	0.80	9.69	6.68	22.50	7.42	5.47	52.56
1985	0.94	11.57	10.31	23.79	11.43	6.69	64.71
1986	1.17	12.35	11.97	37.23	9.43	8.53	80.68
1987	1.29	13.74	12.03	36.48	8.50	9.84	81.88
1988	0.99	14.19	12.85	44.76	7.24	8.06	88.10
1989	1.05	11.83	11.48	40.00	8.47	7.03	79.87
1990	0.78	10.44	11.98	36.02	10.12	9.84	79.17
1991	0.77	9.10	11.96	32.35	13.46	9.48	77.12
1992	0.97	9.38	12.68	34.46	9.98	10.23	77.69
1993	1.05	12.33	13.74	30.59	8.46	8.55	74.72
1994	0.83	11.51	13.11	32.86	4.83	9.12	72.26
1995	0.92	12.25	9.79	24.52	4.01	8.11	59.60
1996	0.91	11.63	11.27	26.11	4.70	9.13	63.75
1997	1.16	14.45	12.37	31.86	9.92	12.83	82.59
1998	1.23	15.20	12.97	32.13	12.00	13.04	86.56
1999	1.14	14.73	12.48	30.99	14.69	15.54	89.57
2000	1.15	12.82	10.87	25.24	16.11	17.42	83.61

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.

	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	---	146	318	312	---	---	217	243	---	---
1982	---	149	366	375	478	226	---	199	---	---
1983	---	---	---	---	---	---	---	---	---	---
1984	69	149	314	524	475	366	161	---	197	---
1985	69	146	370	536	602	333	234	---	330	---
1986	61	119	302	522	515	265	---	427	238	---
1987	59	129	260	504	476	341	220	384	---	---
1988	171	133	281	503	655	453	224	---	201	---
1989	124	133	258	455	590	409	268	331	384	---
1990	168	174	269	353	484	434	208	288	381	---
1991	164	156	233	319	466	471	329	223	398	---
1992	114	187	230	397	440	372	278	249	412	---
1993	155	213	256	393	514	463	218	256	851	---
1994	97	212	207	354	377	463	198	167	480	---
1995	132	209	234	416	476	349	189	---	475	---
1996	168	219	238	473	556	515	269	---	---	---
1997	216	243	246	458	562	482	275	335	671	---
1998	197	238	236	451	611	525	287	287	627	---
1999	311	207	199	437	538	498	310	270	535	---
2000	---	222	182	431	577	532	319	226	565	---

Table A5. IPHC setline survey CPUE of legal sized fish in weight (net pounds per skate).

Series refer to standard survey areas: all of 2A, 2B north of Vancouver Is., outside stations in 2C, 3A west of 147°W, all of 3B, the Aleutian portion of 4A, all of 4B, 4C, and 4D. *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	162	180
1983	---	20	140	147

C-hook surveys

	2A	2B	2C	3A	3B	4A	4B	4C	4D
1984	---	64	301	446	---	---	---	---	---
1985	---	47	324	466	---	---	---	---	---
1986	---	42	299	377	---	---	---	---	---
1987	---	---	---	---	---	---	---	---	---
1988	---	---	---	---	---	---	---	---	---
1989	---	---	---	---	---	---	---	---	---
1990	---	---	---	---	---	---	---	---	---
1991	---	---	---	---	---	---	---	---	---
1992	---	---	---	---	---	---	---	---	---
1993	---	105	---	323	---	---	---	---	---
1994	---	---	---	313	---	---	---	---	---
1995	29	166	---	370	---	---	---	---	---
1996	---	175	387	273	352	---	---	---	---
1997	35	156	492	366	415	300	282	71	111
1998	---	92	272	346	436	394	216	---	---
1999	37	95	260	251	441	367	204	---	---
2000	---	104	309	361	378	382	218	---	212