The conditional constant catch (CCC) harvest policy: Summary and estimated CCC yield for 2004

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Introduction

In 2002, the IPHC put forward for consideration a new harvest policy, termed the "Conditional Constant Catch" (CCC) policy. Details of the policy can be found in Clark and Hare (in press) and Hare and Clark (2003). Following presentation of the proposed policy both at the IPHC 2002 Annual Meeting and at a subsequent retreat with the IPHC Commissioners, the decision was made to formally recommend adoption of the CCC policy in setting of catches for 2004. Pursuant to that end, this document provides the details required to implement the policy and updates some aspects not reported upon in the two previous documents.

Summary of CCC policy

The CCC policy, if adopted, requires selection of a catch ceiling, a ceiling harvest rate, and two minimum spawning biomass safeguard levels or reference points. The catch ceiling provides an upper cap on total removals; the ceiling harvest rate an upper cap on the maximum harvest rate. It is important to note that "catch" in this context refers to total removals, i.e., commercial catch, bycatch, sport catch, personal use, and wastage. The lower this ceiling, the more often the annual removals will be equal to the catch ceiling thereby giving greater stability in year to year removals. The ceiling harvest rate is implemented when the projected removals (harvest rate multiplied by exploitable biomass) are lower than the catch ceiling. This is in essence the current harvest policy. A constant harvest rate policy has been shown to be quite robust but can lead to substantial year to year variability in removals. At the lower biomass range, the ceiling harvest rate would be in effect until the projected removals would result in the spawning biomass dropping below a specified threshold. Below the minimum spawning biomass threshold is a minimum spawning biomass limit. All removals would cease should the limit be reached, i.e., the harvest rate is set to zero. At spawning biomass levels that fall between the biomass reference points, the harvest rate is scaled down linearly from the maximum at the threshold, to zero at the limit. A graphic of how the CCC policy would operate is illustrated in Figure 1.

To assess the performance of the CCC policy, simulations were conducted for IPHC Regulatory Areas 2B, 2C, and 3A – both individually and as one large management area (Hare and Clark 2003). The population dynamics were modeled according to our current understanding (Clark and Hare 2002). The most important dynamic factors are individual growth rate and recruitment. Growth rate is now believed to be related to the density of the stock while recruitment, at least over the range of observed stock sizes, is environmentally driven. To check the robustness of the CCC policy, simulations were conducted over a range of alternative growth and recruitment hypotheses. Policy performance was measured with a variety of indicators, including average annual catch, catch variability, effect on spawning biomass, and frequency that catch is within 90% of the catch ceiling. A range of catch ceilings and ceiling harvest rates were examined for each area. For Area 2B, the catch ceilings ranged from 12.5 to 17.5 million pounds; for Area 2C the ceilings were 10.0 to 15.0 million pounds and in Area 3A the ceilings examined were 25 to 35 million pounds (25 to 30 million pounds in Hare and Clark 2003, updated in this report). Maximum harvest rates of 0.20 to 0.40 (in increments of 0.05) were examined for all areas. Finally, minimum spawning biomass thresholds and limits were established for each area. The rationale used was to set the limit (i.e., the biomass level at which all removals ceased) equal to the minimum observed biomass. The biomass threshold (i.e., the level at which the harvest begins to be scaled down) was set at 1.5 times the biomass limit.

Tables 1-3 summarize the results of the simulations. These tables are the same as those in Hare and Clark 2003, except for the updated range of catch ceilings for Area 3A. In Hare and Clark (2003), summary tables were presented for a range of hypotheses and recruitment distributions. The tables presented here are for a single subset of the simulations, i.e., representing our "Most Likely" scenario of halibut population dynamics. These simulations included the designated minimum biomass thresholds and limits. Recruitment was assumed to follow Recruitment Distribution 1, explained below under the heading of "Catch ceilings".

Ceiling harvest rates

While the CCC policy does incorporate a threshold reference point to trigger remedial action, an overriding concern is conservation of the stock and avoiding any approach to the limit reference point. Considering that the highest modeled harvest rate resulted in the highest average yield under the most likely scenarios of growth and recruitment, one might argue for a substantially higher harvest rate than our present value of 0.20, but the increases in yield are quite modest. Likewise, the increase in proportion of time that 90% of the ceiling removals are obtained is modest above a harvest rate of 0.25.

In the absence of threshold and limit reference points, the probability of spawning stock biomass dropping below the historical minimum increases substantially at harvest rates above 0.25 (Hare and Clark 2003, p. 136). Inclusion of these reference points in the management policy should avoid this occurrence, if the reference points are determined accurately. The reference points are determined through assessing the average performance of the stock over the long term but the performance during a particular climate regime can vary from the long-term average. In view of this and the fact that the benefits in yield at harvest rates above 0.25 are relatively minor, we recommend adoption of a harvest rate of 0.25 as a conservative operational value for the CCC policy.

Catch ceilings

Catch ceilings will need to be established for each area. Using the 0.25 harvest rate established above, we examined simulation results across a range of catch ceilings. As an operational guideline, we recommend using a combination of a catch ceiling and 0.25 harvest rate that achieves 90% of the catch ceiling ≥ 60% of the time. The rationale for this choice is that it achieves a substantial portion of the maximum possible yield and protects the stock over the long term, while not introducing a substantial and destabilizing shift in removals at current biomass levels. A further issue concerns future geographic distribution of recruitment in the northeast Pacific. The distribution of recruitment has varied over time and we recommend choosing the more conservative assumption about recruitment, i.e., that recruitment in the future will be more similar to the previous twenty years (Recruitment Distribution 1) than to the long-term average (Recruitment Distribution 2). The logic for this is that distribution is associated with long-term climate warming and this directional trend appears unlikely to reverse in the foreseeable future. This implies that recruitment will be stronger into the central part of the halibut range than into the more southerly portions.

2004 CCC yield guidelines

For Areas 2B, 2C and 3A, the CCC harvest policy can be used to directly compute the 2004 estimated yields once the exploitable biomass has been estimated in the stock assessment. Using the decision rule described above, the catch ceiling for Area 2B is 13 millions lbs, for 2C it is 12 million lbs, and for 3A it is 35 million lbs. With a harvest rate of 0.25, the catch ceiling is imposed when the exploitable biomass is four times the catch ceiling, i.e., 52 millions lbs in 2B, 48 million lbs in 2C and 140 million lbs in 3A. Below those exploitable biomass levels, the recommended harvest rate of 0.25 applies. This harvest rate applies until the spawning biomass drops down to the threshold. Currently, the spawning biomass is well above the threshold in all areas and is unlikely to be a factor in the near future.

For Areas 3B, 4A, and 4B there are now stand alone assessments that provide estimates of exploitable biomass. The input data and assessment model output are of insufficient duration to allow a dynamic analysis of catch and harvest rate ceilings as was made for Areas 2B, 2C, and 3A. We elected not to establish catch ceilings for Areas 3B, 4A and 4B, but to base recommended harvest rates on the 3A ceiling harvest rate. Area 3B we consider to be approximately as productive as Area 3A and therefore adopted a 0.25 harvest rate ceiling. Areas 4A and 4B have less of an exploitation history than the central Gulf areas and conservatism arguments lead us to adopt a lower ceiling harvest rate of 0.20 for those two areas.

Areas 2A and 4CDE remain without standalone assessment models and thus all harvest policy parameters must be leveraged from other areas. Area 2A is leveraged by Area 2B while Area 4CDE is leveraged by Area 3A. Recent survey catch rates show Area 2A biomass approximately 13% of Area 2B biomass. This fraction was used to obtain the 2A ceiling catch of 1.69 million pounds. The Area 2B maximum harvest catch rate of 0.25 is also adopted for Area 2A. Area 4CDE has a production fraction of 0.37 compared to Area 3A. We also elected not to establish a ceiling catch for 4CDE. Similar concerns as were voiced for Areas 4A and 4B led to a ceiling harvest rate of 0.20. The complete set of ceiling catches and harvest rates are given in Table 4.

Recapture of catch forfeited due to imposition of catch ceiling

If the CCC harvest policy is adopted, there will be years in which total removals will be limited by the catch ceiling. A natural question is how much of the forfeited catch will be recaptured in subsequent years, particularly in years where the biomass is cycling downwards. Due to the dynamic nature of the halibut population, this question cannot be answered analytically but must be investigated via simulation. The amount of foregone catch that will be recaptured depends on several interacting factors. These include the duration of recruitment regimes (both positive and negative), the magnitude of the catch ceiling, and the ceiling harvest rate.

To estimate the fraction of forfeited catch recaptured in subsequent years, we compared the harvest trajectories for policies with no catch ceiling (such as our current harvest policy) with policies utilizing a range of catch ceilings. To compare the trajectories the same sequence of recruits must be used. Figure 2 shows catch trajectories for the combined Areas 2B/2C/3A for three different ceiling harvest rates (0.20, 0.25, 0.30) and three different catch ceilings (50, 55, 60, million pounds). In the plots, the amount of catch foregone is that part of the curves above the catch ceiling and below the trajectory for the No Ceiling harvest policy. Following a negative recruitment regime there is a decline in biomass and, therefore, in removals. With a catch ceiling, some biomass is conserved and therefore removals do not drop as quickly as for a No Ceiling harvest policy. The extra amount of removals in these periods of declining harvest are shown by the regions where the trajectories for the harvest ceiling policies are above the No Ceiling trajectory. Summed over many years, or over many Monte Carlo simulations, the fraction of forfeited catch recaptured is the ratio of the amount of extra removals during downward times to the amount of removals forfeited due to the ceiling.

The fraction of forfeited catch eventually recaptured, by area, across a range of ceiling harvest rates and ceiling removal levels is summarized in Table 5. Across the different ceilings and areas the fraction of forfeited catch recaptured varies from nearly zero to nearly 1.0. The fractions near 1.0 however occur only where there is a combination of a very low ceiling harvest rate and a high catch ceiling level. Under those circumstances very little harvest is forfeited since the ceiling is generally not reached. In these cases, catch limit variability is also very high. Conversely, the cases where the least amount of forfeited harvest is recaptured are the combination of a high harvest rate and low harvest ceiling. In these cases, the ceiling is frequently reached and a large amount of harvest is forfeited. Between these extremes, in the ranges that are considered reasonable for all the areas, the fraction of forfeited catch that would be recaptured is generally around 0.2 for Areas 2B and 2C and 0.1 for Area 3A.

Conclusions

The CCC harvest policy was developed in response to a perceived need to reduce annual variability in harvest recommendations as well a desire to insulate the harvest policy from the annual stock assessment. As a long lived animal exploited at a relatively low level, annual halibut catches should not be expected to sharply rise or fall from year to year. With the Constant Harvest Rate (CHR) policy however, this was sometimes the case since the policy mandated that a constant fraction of the estimated exploitable biomass be taken each year. If the assessment model is overhauled, or important parameters such as natural mortality change, annual estimates of the exploitable biomass can, and have, abruptly changed from one year to the next. Recognition that it was not the stock biomass, only our perception of it, that varied so greatly generally resulted in harvest recommendations that differed from the CHR computation.

A major advantage to the CCC policy is that it is a policy based on the long term, repeatedly demonstrated, productivity of the halibut stock rather than exclusively on annual estimates of production. The catch ceilings and ceiling harvest rates ensure that the spawning stock will be conserved even in times of low productivity. At the current high biomass levels in the center of the halibut range (Areas 2 and 3A), the catch ceilings are likely to be a factor for the next few years. Over the long term, the average catches with the ceilings are not much lower than catches that are not limited by a ceiling. When biomass declines in times of lower recruitment, some of the forfeited catch – up to 20% - will be recaptured thus tempering the catch decline.

The CCC harvest policy is currently being investigated as a sex-specific policy in response to the assessment now being sex specific. The largest concern is the impact of the current harvest policy on the abundance of older females in the population. An initial yield per recruit analysis of halibut with and without an 81 cm size limit (Hare and Clark, in progress) provides an initial view of the impact on females. Results from a dynamic analysis – with updated estimates of recruitment, size at age, and selectivity at length – will help to further refine the parameters of the CCC harvest policy.

References

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Table 1. Performance measures for a CCC harvest policy in Area 2B

Average annual yield (million lbs.)				
	Catch ceiling			
Max. HR	12.5	15.0	17.5	No ceiling
0.00	0	0	0	0
0.20	11.0	11.4	11.4	11.4
0.25	11.5	12.3	12.5	12.5
0.30	11.7	12.8	13.3	13.4
0.35	11.9	13.1	13.8	14.0
0.40	12.0	13.3	14.1	14.5

Standard deviation of yield (million lbs.)				
	Catch ceiling			
Max. HR	12.5	15.0	17.5	No ceiling
0.00	0	0	0	0
0.20	1.7	2.3	2.3	2.3
0.25	1.5	2.5	2.8	2.9
0.30	1.3	2.5	3.2	3.3
0.35	1.1	2.4	3.3	3.7
0.40	1.1	2.3	3.4	4.1

Average spawning biomass (million lbs.)				
	Catch ceiling			
Max. HR	12.5	15.0	17.5	No ceiling
0.00	131	131	131	131
0.20	56	53	53	53
0.25	53	47	46	46
0.30	51	44	41	41
0.35	49	42	37	36
0.40	48	40	35	33

Yield ≥ 90% of Constant catch (percent of years)				
	Catch ceiling			
Max. HR	12.5	15.0	17.5	No ceiling
0.00	0	0	0	0
0.20	56	25	1	0
0.25	66	46	15	0
0.30	74	54	33	0
0.35	80	58	42	0
0.40	85	62	47	0

Table 2. Performance measures for a CCC harvest policy in Area 2C

Average annual yield (million lbs.)				
	Catch ceiling			
Max. HR	10.0	12.5	15.0	No ceiling
0.00	0	0	0	0
0.20	9.3	10.0	10.0	10.0
0.25	9.6	10.7	11.0	11.0
0.30	9.8	11.1	11.7	11.8
0.35	9.9	11.3	12.1	12.4
0.40	9.9	11.4	12.3	12.8

Standard deviation of yield (million lbs.)				
	Catch ceiling			
Max. HR	10.0	12.5	15.0	No ceiling
0.00	0	0	0	0
0.20	1.0	1.8	1.8	1.8
0.25	0.7	1.9	2.3	2.3
0.30	0.6	1.8	2.6	2.7
0.35	0.5	1.7	2.8	3.2
0.40	0.5	1.8	2.9	3.6

Average spawning biomass (million lbs.)				
	Catch ceiling			
Max. HR	10.0	12.5	15.0	No ceiling
0.00	127	127	127	127
0.20	54	50	49	49
0.25	52	44	43	43
0.30	51	41	38	37
0.35	50	40	35	33
0.40	50	39	33	30

Yield ≥ 90% of Constant catch (percent of years)				
	Catch ceiling			
Max. HR	10.0	12.5	15.0	No ceiling
0.00	0	0	0	0
0.20	69	32	2	0
0.25	83	52	15	0
0.30	90	60	37	0
0.35	95	65	46	0
0.40	96	69	51	0

Table 3. Performance measures for a CCC harvest policy in Area 3A

Average annual yield (million lbs.)

Max. HR	Catch ceiling 25.0	30.0	35.0	No ceiling
0.00	0	0	0	0
0.20	24.8	27.6	27.8	28.1
0.25	25.0	29.0	31.0	31.6
0.30	25.0	29.6	32.3	34.6
0.35	25.0	29.8	33.0	36.9
0.40	25.0	29.9	33.4	38.8

Standard deviation of yield (million lbs.)

Max. HR	Catch ceiling 25.0	30.0	35.0	No ceiling
0.00	0	0	0	0
0.20	0.6	2.7	3.3	3.3
0.25	0.1	1.9	4.0	4.6
0.30	0.0	1.2	3.6	5.9
0.35	0.0	0.8	3.2	7.3
0.40	0.0	0.7	3.0	8.5

Average spawning biomass (million lbs.)

Max. HR	Catch ceiling 25.0	30.0	35.0	No ceiling
0.00	240	240	240	240
0.20	137	126	124	124
0.25	136	120	112	112
0.30	136	117	106	102
0.35	136	116	102	93
0.40	136	115	99	85

Yield ≥ 90% of Constant catch (percent of years)

Max. HR	Catch ceiling 25.0	30.0	35.0	No ceiling
0.00	0			0
0.20	97	65	12	0
0.25	100	84	55	0
0.30	100	93	65	0
0.35	100	97	73	0
0.40	100	98	79	0

Table 4. Harvest and biomass specifications required to implement the CCC harvest policy. See text for area specific rationale on ceiling harvest rates and catches. The catch ceilings are implemented when exploitable biomass (Ebio) level is greater then the values listed in the fourth column. Spawning biomass threshold and limits have only been determined for Areas 2B, 2C, and 3A.

IPHC Area	Ceiling harvest rate	Catch ceiling (M lbs)	Ebio for catch ceiling	Spawning biomass threshold	Spawning biomass limit
2A	0.25	1.69	6.76		
2B	0.25	13.00	52.00	27	18
2C	0.25	12.00	48.00	24	16
3A	0.25	35.00	140.00	66	44
3B	0.25				
4A	0.20				
4B	0.20				
4CDE	0.20				

Table 5. The fraction of forfeited catch that would be subsequently recaptured under the CCC harvest policy across a range of ceiling harvest rates and catch ceilings.

Area 2B/2C/3A combined

	Catch ceiling		
ceiling HR	50	55	60
0.20	0.14	0.18	0.35
0.25	0.11	0.15	0.17
0.30	0.09	0.14	0.16
0.35	0.07	0.13	0.16
0.40	0.05	0.12	0.16

Area 2C

	Catch ceiling		
ceiling HR	10	12.5	15
0.20	0.16	0.42	0.85
0.25	0.15	0.22	0.65
0.30	0.13	0.21	0.32
0.35	0.12	0.22	0.26
0.40	0.12	0.22	0.27

Area 2B

	Catch ceiling		
ceiling HR	12.5	15	17.5
0.20	0.19	0.58	0.86
0.25	0.18	0.24	0.59
0.30	0.18	0.23	0.32
0.35	0.17	0.23	0.28
0.40	0.17	0.24	0.29

Area 3A

	Catch ceiling		
ceiling HR	25	30	35
0.20	0.06	0.21	0.79
0.25	0.02	0.12	0.22
0.30	0.01	0.09	0.14
0.35	0.00	0.07	0.14
0.40	0.00	0.06	0.13

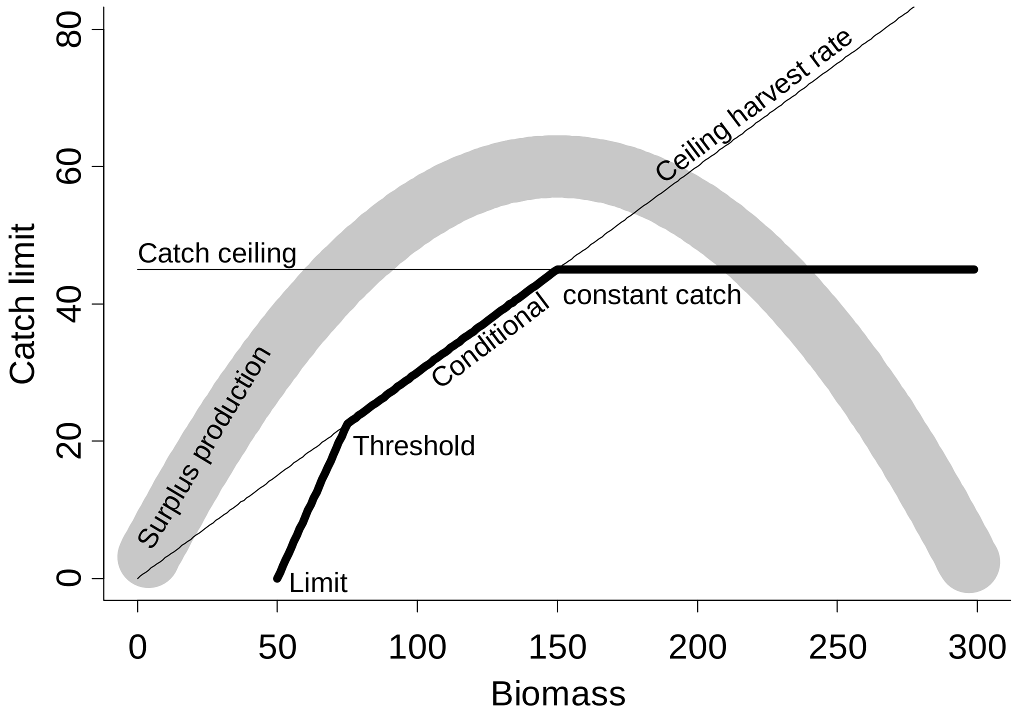

Figure 1. A graphic illustration of the conditional constant catch harvest policy in relation to biomass level and surplus production (modified from Clark and Hare, In Press).

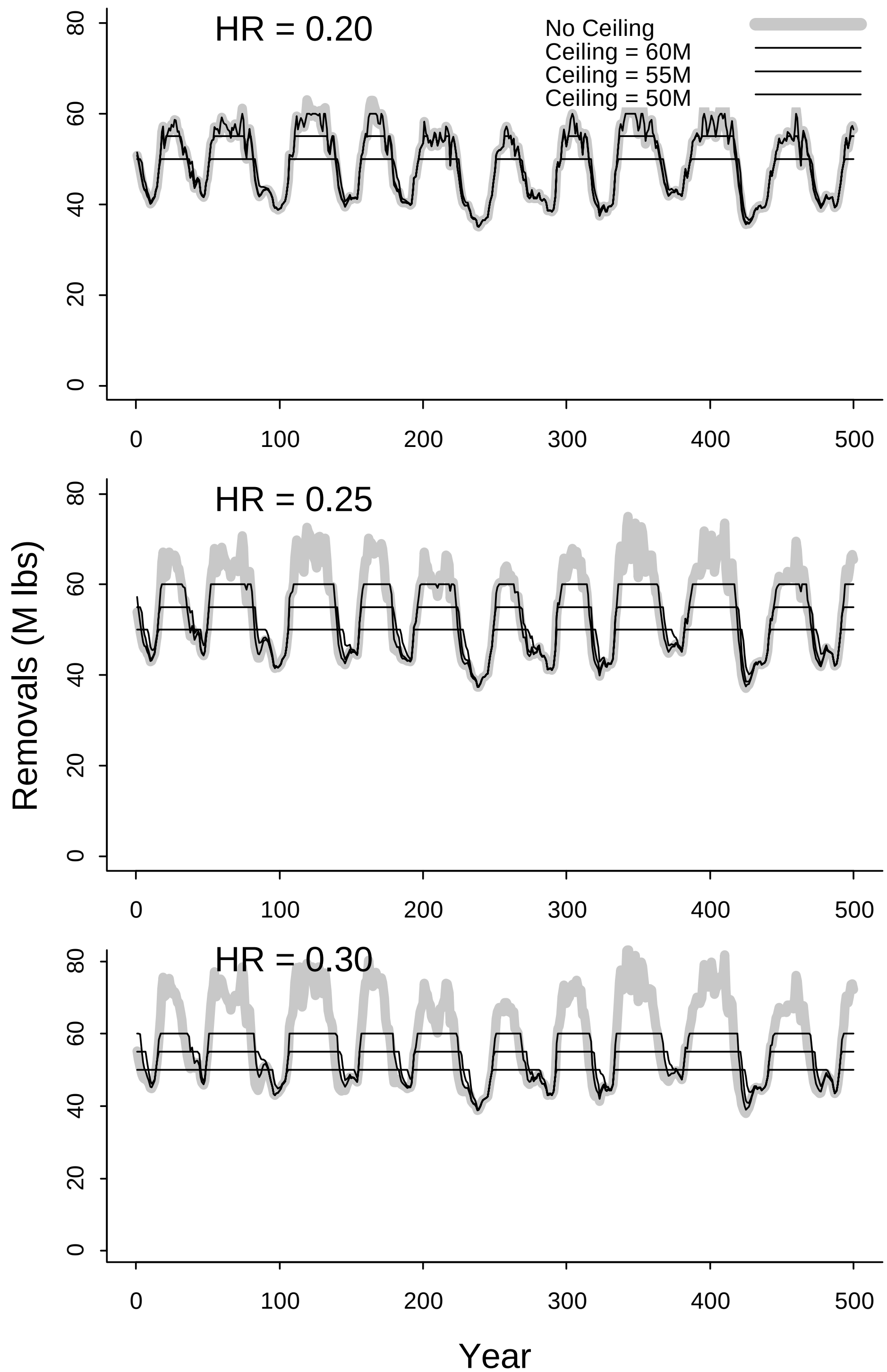

Figure 2. Yield trajectories under three different ceiling harvest rates and three different ceiling removal levels.

Summary of the 2003 stock assessment

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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, going back to 1974. This year for the first time the same model has been fitted to data from Areas 3B, 4A, and 4B, which go back to 1996. Before that there were no surveys conducted in those areas and catch limits were mostly much lower than they have been during the last several years. Exploitable biomass in Areas 2A and 4CDE is estimated by applying a survey-based estimate of relative abundance to the analytical estimate of biomass in the adjoining area (2B for 2A, 4A for 4CDE).

A biological target level for total removals is calculated by applying a fixed harvest rate 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.

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.

Features of the 2003 assessment

Length-specific selectivity

The term “selectivity” means relative vulnerability to capture by setline gear. Older and larger fish are more vulnerable than smaller and younger fish, but until last year it was uncertain whether the most important determinant of selectivity was size or age. In the last several years’ assessments selectivity was treated as a function of age because that approach produced lower estimates and was therefore the conservative choice.

The fit of this model to Area 3A data last year showed very poor year-to-year continuity, symptomatic of a wrong description of selectivity in the model. Treating setline survey selectivity as length-specific rather than age-specific largely eliminated the problem. Accumulated data showing very similar trends in catch at length in IHPC setline surveys and NMFS trawl surveys provided further evidence that setline selectivity is, after all, determined mainly by size rather than by age (Clark and Hare 2003).

In this year’s assessment selectivity is treated as an empirical function of observed mean length at age in survey catches. Separate schedules are estimated for commercial and survey catches, but the same length-specific schedules are used for females and males. Because they differ in mean length at age, the derived age-specific selectivities of females and males are different.

Separate accounting of females and males

In previous years, the assessment model was a standard age-structured model of the stock, with the estimated number at each age in each year being the combined number of females and males. This was adequate when selectivity was treated as a function of age, but not now when selectivity is treated as a function of length, because females are larger at each age. More importantly, estimating abundance by sex provides estimates of the higher fishing mortality rates sustained by females and estimates of female spawning biomass. The staff was particularly concerned that size-selective fishing combined with the decline in size at age over the last several years could have resulted in a decrease in fishing mortality on males at the expense of females, and therefore a drop in female spawning biomass. As reported below, the sex-specific assessment shows that female spawning biomass is still well above the historical minimum that last occurred in the mid-1970s.

We have sampling data on the sex composition of survey catches but not commercial landings. The latter could be estimated internally by fitting the model to survey catch at age/sex and commercial catch at age only, but the survey sex ratio at age is in fact quite variable, so it was decided to estimate commercial sex composition external to the model and use the external estimates of commercial catch at age/sex as model data. It turned out to be quite feasible to use smoothed functional estimates of sex ratio at length within age in survey catches to key out the commercial length distributions at age to sex (Clark 2004a).

Explicit allowance for the bias and variance of age readings

For many years, the ages of halibut (and other species) were determined by counting the annuli seen when viewing the surface of the whole otolith. This method is reliable through about age 15 but thereafter underestimates the true age by an increasing margin. The true age can be determined by breaking and burning the otolith and counting rings as viewed on a cross section. The bias of surface readings can be corrected in the assessment by doing all the calculations with fish grouped by true age and then predicting and fitting the observed distribution of surface readings. The variance of both surface and break-and-burn readings can be handled the same way (Clark 2004b). Figure 1 shows how the same age composition would appear in the model calculations, as an observed surface age reading distribution, and as an observed break-and-burn age reading distribution.

Analytical (model-based) estimates of abundance in Areas 3B, 4A, and 4B

Estimating abundance by fitting an age-structured model requires a sufficiently long series of survey data that the decline of several year-classes can be tracked as they pass through the fishery, and sufficiently large catches that fishing mortality is a substantial fraction of total mortality. Lacking that kind of data, abundance in Areas 3B and 4 has been estimated with a survey-based method, wherein an index of abundance in all areas was computed by multiplying average survey CPUE by total bottom area, and the biomass in, for example, Area 3B was estimated by multiplying the model-based estimate of Area 3A biomass by the ratio of the Area 3B and Area 3A survey-based index values.

Surveys began in 1996 in Area 3B, and in 1997 in Areas 4A and 4B. Catch limits were raised substantially in 1997 and have remained at that higher level since. So we now have 7-8 years of survey data and higher catches, which in conjunction with this year's very simple length-based assessment model makes it possible to fit the model and obtain analytical estimates in those areas. In Areas 2A and 4CDE the survey-based method is still used.

Quality of model fits

The fitted model uses the same parameter values (natural mortality, survey and commercial catchabilities, and length-specific selectivities) for females and males. It is therefore very parsimonious, but it nonetheless predicts the catch at age of females and males very well (Fig. 2). This is remarkable because mean size at age differs greatly between the sexes and has declined substantially for both during the period covered by the model fit (Fig. 3). The derived age-specific selectivities therefore vary tremendously by sex and among years, but the model predictions still do a very good job of tracking not only the age composition of the catch of each sex but also the relative magnitudes of the catches of females and males, which are quite different (Fig. 4). The ability of this simple model to predict the catches by age and sex over such a wide range of observed and predicted values leaves little doubt that variation in size at age accounts for the bulk of variation in selectivity at age.

Effects of model changes on abundance estimates

The 2003 model can be fitted in various ways to show the incremental effect of the new features. Figure 5 shows the effects step by step in Area 2C, where they were largest. Fits are shown with data through 2001 (abundance estimates through 2002) to avoid confusing the effects of model changes with the effects of the change from surface to break-and-burn readings. The quantity plotted is estimated recruitment, which is the fundamental abundance estimate in any assessment.

The baseline at the bottom of Figure 5 shows the series of recruitment estimates from last year's assessment model, which had fixed age-specific survey selectivities and drifting age-specific commercial selectivities. The line above that shows the effect of switching to fixed length-specific survey and commercial selectivities but not treating females and males separately. (In this fit the calculations are actually performed separately for each sex, but age-specific selectivity is determined by the overall mean length at age rather than the mean length at age for each sex, so fishing mortality at age is the same for females and males. This model is basically the same as earlier length-specific models used by the staff, and it produces almost the same estimates as the alternative length-specific model reported in last year's assessment.) The next line up shows the added effect of treating females and males separately (i.e., having age- and sex-specific selectivities determined by sex-specific mean length at age). The topmost (black) line shows the added effect of correcting for the bias and variance of surface ages; it is the 2003 assessment model fit. At the left of the graph are the mean 1974-2001 recruitment levels for each model fit. In Area 2C the cumulative change in the mean is a 50% increase. The overall increases in other areas are smaller but still substantial: 20% in Area 2B and 35% in Area 3A.

Length-specific fits have always produced substantially higher estimates of abundance than age-specific fits in Alaska. (The effect has always been much less in British Columbia because the change in size at age was smaller there.) That component of the increase is therefore as expected, and it makes sense that treating the sexes separately would compound the effect, because it introduces a larger variation in length at age. It is somewhat surprising that correcting the ages not only redistributes but also increases the recruitment estimates. That feature must result from an increase in the number of natural deaths that occurs when lifespans are increased by allowing for greater ages and the same natural mortality rate is used.

Estimates of length- and age-specific selectivities

As in previous length-specific model fits, commercial selectivity is estimated to be higher in Area 2B than in Area 3A, with Area 2C intermediate (Fig. 6). The estimates for Areas 3B, 4A, and 4B are similar to the Area 2C estimates.

Because length-specific commercial selectivity appears to have been the same for the last thirty years while mean length at age has declined greatly over the last fifteen years, age-specific commercial selectivity has also declined greatly over the last fifteen years (Fig. 7). Because males in the modal age range (10-15) were less vulnerable to begin with, the relative decline in age-specific selectivity of males has been greater than that of females. In Area 3A, males reached full vulnerability by age 15 in the 1970s and 1980s; now even the oldest males are only about 20% vulnerable, while the oldest females are still fully vulnerable. The same sort of change has occurred elsewhere. Females always sustained higher fishing mortality rates than males because they were larger, but twenty years ago females and males both reached the size of full vulnerability at some point. Males no longer reach that point, so an even larger share of fishing mortality is falling on the females.

Calculation of exploitable biomass

Exploitable biomass is calculated as the fully selected equivalent of all the fully and partially selected age groups (really age/sex groups) in the stock, so it depends on the commercial selectivities that are used to scale the biomass of each group. The 1999-2002 assessments used a set of age-specific selectivities from the 1999 assessment averaged over regulatory areas, called the "fixed coastwide selectivities". Using a fixed set provided a common measure among areas and years. As shown in Figure 7, these fixed selectivities were a good compromise among areas and between the sexes a few years ago.

They are no longer appropriate, first because they are age-specific rather than length-specific as we now believe to be correct, and second because size at age has declined further since 1999 and the present selectivities are lower than the fixed ones. We therefore need to adopt a new set of length-specific selectivities to calculate exploitable biomass, and it will be lower than the old exploitable biomass, partly because of the decline in size at age since 1999 but mostly because the calculation will be done separately for females and males and the males will contribute less.

It is still desirable to adopt a single coastwide set of selectivities to provide a common measure among areas. Except for Area 3A, all of the regulatory areas in Alaska have selectivity schedules that are close to a line that increases linearly from zero at 80 cm to 1 at 120 cm, so that is a good fixed schedule for those areas. The Area 3A schedule is much lower, but through 120 cm it is a constant fraction (about 70%) of the fixed schedule, so for the great bulk of the stock the relative selectivities of all the age/sex groups are the same. This means that using the fixed schedule in Area 3A and applying a given full-recruitment harvest rate to that biomass will result in the same level of fishing mortality on the same age/sex groups as in the other Alaska areas. It will also provide a common measure of biomass.

The Area 2B schedule is substantially higher than the fixed schedule, and rather than being proportional it is shifted to the left. Using the same fixed selectivity schedule and the same harvest rate in Area 2B as in Alaska would result in a significant reduction in CEY in Area 2B at a time when the stock is clearly doing well at present harvest levels and we have not yet done the new harvest rate evaluation that the new assessment requires. At least for 2004, therefore, we have decided to use the locally estimated selectivity schedule to estimate exploitable biomass in Area 2B. This means that given the same nominal harvest rate, some age-specific fishing mortality rates will be higher in Canada than in Alaska, and that the exploitable biomass figures are not comparable between Canada and Alaska as they are among Alaska areas.

Estimates of historical and present biomass in Areas 2B, 2C, and 3A

The Commission's paramount management objective is to maintain a healthy level of spawning biomass, meaning a level above the historical minimum that last occurred in the mid-1970s. Although low, this spawning stock nevertheless produced average or better year-classes. In the past we always calculated spawning biomass by applying the female maturity schedule to estimated total biomass at age (including males) because we did not have sex-specific estimates of abundance. One of the main reasons for implementing a sex-specific assessment was to obtain direct estimates of female mortality rates and female spawning biomass. We now have those estimates, and fortunately they show that female spawning biomass is 3-4 times what it was in the mid-1970s (Table 1). So on that score the stock is in good shape.

The numbers of fish aged 8 and older are now 5-10 times what they were in 1974, but their total biomass is only 3-5 times the 1974 level, and exploitable biomass (computed with the new length-specific commercial selectivities) only 2-3 times. The difference between the large increase in numbers and the more modest increase in biomass results from the dramatic decline in size at age and therefore selectivity that has occurred over the last fifteen years. A significant part of the age 8+ biomass now consists of males that never get large enough to be caught in any numbers, as shown by their near disappearance from commercial catches in Area 3A (Fig. 4b). Looked at another way, in 1974 a large fraction of the total age 8+ biomass was exploitable; now that fraction is much smaller (Figs. 8a-c).

Estimates of present biomass in Area 3B, 4A, and 4B

In these areas the model is fitted to data from 1996-2003 only (Figs. 8d-f). Before that exploitation rates were low and there were no surveys, which among other things means that there is no way to estimate the sex composition of commercial landings. Although less data goes into the assessment in these areas, the model is simple enough that the abundance and selectivity estimates are very well determined; the coefficients of variation are less than 5%.

The survey-based method that we used for the last several years assumes that survey catchability and selectivity are the same throughout Areas 3 and 4. The model fits indicate that survey catchability in Areas 4A and 4B is about the same as in Area 3A, but that it is higher in Area 3B. The model fits also show that selectivity is lower in Area 3A than in Area 3B and 4. Using the fixed selectivities to calculate exploitable biomass increases the 3A value by about 40%, which has the effect of shrinking the other areas' estimates relative to the Area 3A estimate on the standardized scale, as shown in the table below. In short, the analytical estimates in all three areas are lower than the survey-based estimates relative to Area 3A mainly because selectivity is lower in Area 3A than in those areas. Another factor in the case of Area 3B is higher estimated survey catchability than in Area 3A.

	Area 3B	Area 4A	Area 4B
Survey index as a fraction of 3A	0.71	0.26	0.16
Exploitable biomass calculated with fixed selectivities as a fraction of 3A	0.45	0.14	0.10

Estimates of present biomass in Areas 2A and 4CDE

For these areas we cannot do an analytical assessment so we continue to use the survey-based estimate scaled to an adjoining area. For Area 2B this is 13% of the Area 2B estimate. For Area 4CDE we have been scaling to Area 3A because that was the nearest area with an analytical estimate. We now have an estimate for Area 4A, and by the same procedure can estimate the Area 4CDE biomass as 142% of the Area 4A biomass.

Estimated CEY in 2004

A major change in this year's assessment is the adoption of a new set of length-specific commercial selectivities, which produce much lower estimates of exploitable biomass than the old fixed age-specific selectivities. (Table 1). In the past we calculated CEY by applying the established 20% harvest rate to exploitable biomass, but we cannot do the same thing now because the 20% harvest rate was chosen on the basis of simulations that used the old fixed age-specific selectivities. A new set of simulations with the new, lower selectivities can be expected to lead to a higher target harvest rate, but that work has not yet been done. For this year's CEY calculations, we have adopted a provisional target harvest rate of 25% for Areas 2 and 3. For Area 4, we have stuck with 20% because of uncertainty about the long-term productivity of the Bering Sea/Aleutians region relative to the Gulf of Alaska.

The resulting estimates of setline CEY (Table 2) are considerably higher than last year's in Areas 2A, 2B, and especially 2C, where this year's assessment changes had the largest total effect. In Area 3A setline CEY is a little lower. In Areas 3B and 4 the numbers are much lower—half or less—because of the lowered selectivities and in Area 4 the continued use of a 20% harvest rate.

References

Clark, W.G. 2004a. A method of estimating the sex composition of commercial landings from setline survey data. Int. Pac. Halibut Comm. Report of Assessment and Research Activities 2003: 111-162.

Clark, W.G. 2004b. Statistical distribution of IPHC age readings. Int. Pac. Halibut Comm. Report of Assessment and Research Activities 2003: 99-110.

Clark, W.G., and Hare, S. R.. 2003. Assessment of the Pacific halibut stock at the end of 2002. Int. Pac. Halibut Comm. Report of Assessment and Research Activities 2002:95-120.

Table 1. Various measures of abundance in 2004 compared with 1974. Biomass is in millions of net pounds, numbers in millions. Calculations of spawning and total biomass use mean weight at age/sex in the survey (i.e., including sublegals) while calculations of exploitable biomass use mean weight at age/sex in the commercial landings. This is why exploitable biomass can exceed total biomass. "Old exploitable biomass" is calculated with the fixed coastwide age-specific commercial selectivities used in the 1999-2002 assessments. "New exploitable biomass" is calculated with the length-specific commercial selectivities estimated in the 2003 assessment.

	Area 2B		Area 2C		Area 3A	
	1974	2004	1974	2004	1974	2004
Female spawning biomass	11	35	18	56	40	144
Total biomass age 8+	23	67	42	188	89	429
Total numbers age 8+	1.5	7.5	1.5	9.7	2.5	25.1
Mean weight age 8+	15	9	28	19	36	17
Old exploitable biomass	22	88	30	153	50	360
New exploitable biomass	26	65	30	80	73	146

Table 2. Removals in 2003 and estimates of CEY in 2004 (millions of net pounds).

	2A	2B	2C	3A	3B	4A	4B	4CDE	Total
2003 setline CEY at 20% [1,2]	1.29	11.32	9.11	34.22	29.19	11.22	7.76	10.82	114.93
2003 catch limit [2]	1.31	11.75	8.50	22.63	17.13	4.97	4.18	4.45	74.92
2003 commercial landings [3]	0.82	11.75	8.45	22.68	17.41	4.97	3.87	3.25	73.20
Other removals									
Sport catch	0.40	1.07	2.60	5.00	0.01	0.04	0	0	9.12
Legal-sized bycatch	0.29	0.15	0.17	1.36	0.58	0.50	0.18	2.56	5.79
Personal use	0	0.30	0.17	0.07	0.02	0.17	0	0	0.73
Legal-sized wastage	0.01	0.02	0.03	0.09	0.04	0.02	0.01	0.01	0.23
Total other removals	0.70	1.54	2.97	6.52	0.65	0.73	0.19	2.57	15.87
...excluding sport catch	0.30	0.47	---	---	---	---	---	---	---
Total removals	1.52	13.29	11.42	29.20	18.06	5.70	4.06	5.82	89.07
2004 exploitable biomass [4]	8.5	65	80	146	65	21	15	30	430.5
2004 total CEY at 25% (20% in Area 4)	2.1	16.3	20.0	36.5	16.3	4.2	3.0	6.0	104.4
2004 setline CEY [5]	1.8	15.8	17.0	30.0	15.7	3.5	2.8	3.4	90.0

Notes:

1. Estimates of 2003 setline CEY (first row) are the figures reported in the 2002 assessment.
2. In Area 2A the setline CEY and catch limit include sport catch and treaty subsistence catch.
3. Commercial landings include IPHC survey and other research catches, which can result in small overages.
4. 2004 exploitable biomass is computed with a new set of length-specific selectivities that are lower than the age-specific selectivities used in the 1999-2002 assessments, so these figures are not comparable with last year's exploitable biomass estimates.
5. In Area 2B the setline CEY for 2004 includes sport catch for the first time.

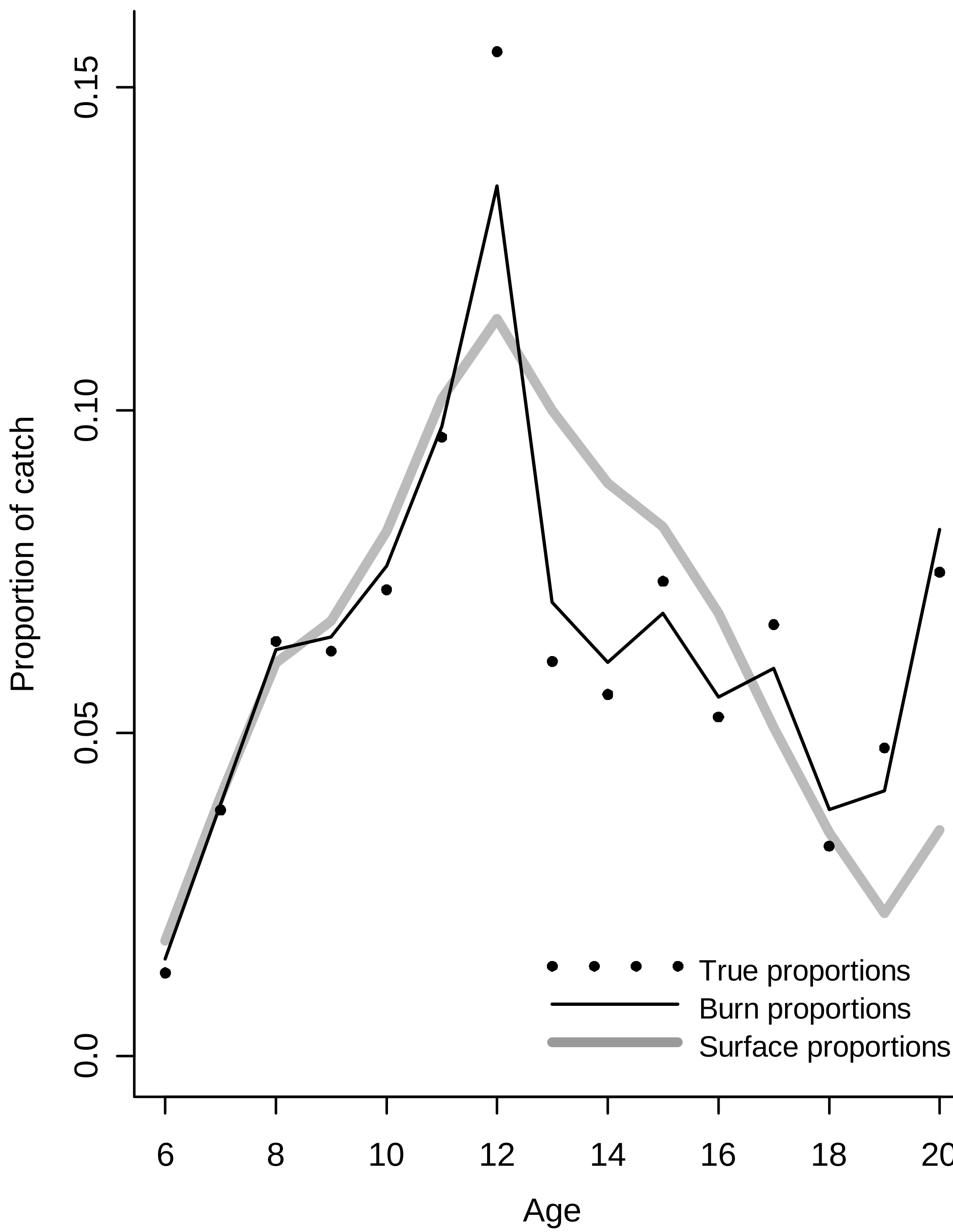

Figure 1. An example of true age proportions in the catch and the corresponding observed distributions of surface and break-and-burn age readings. At ages beyond about 15 surface ages are biased and quite variable; break-and-burn ages are unbiased and less variable.

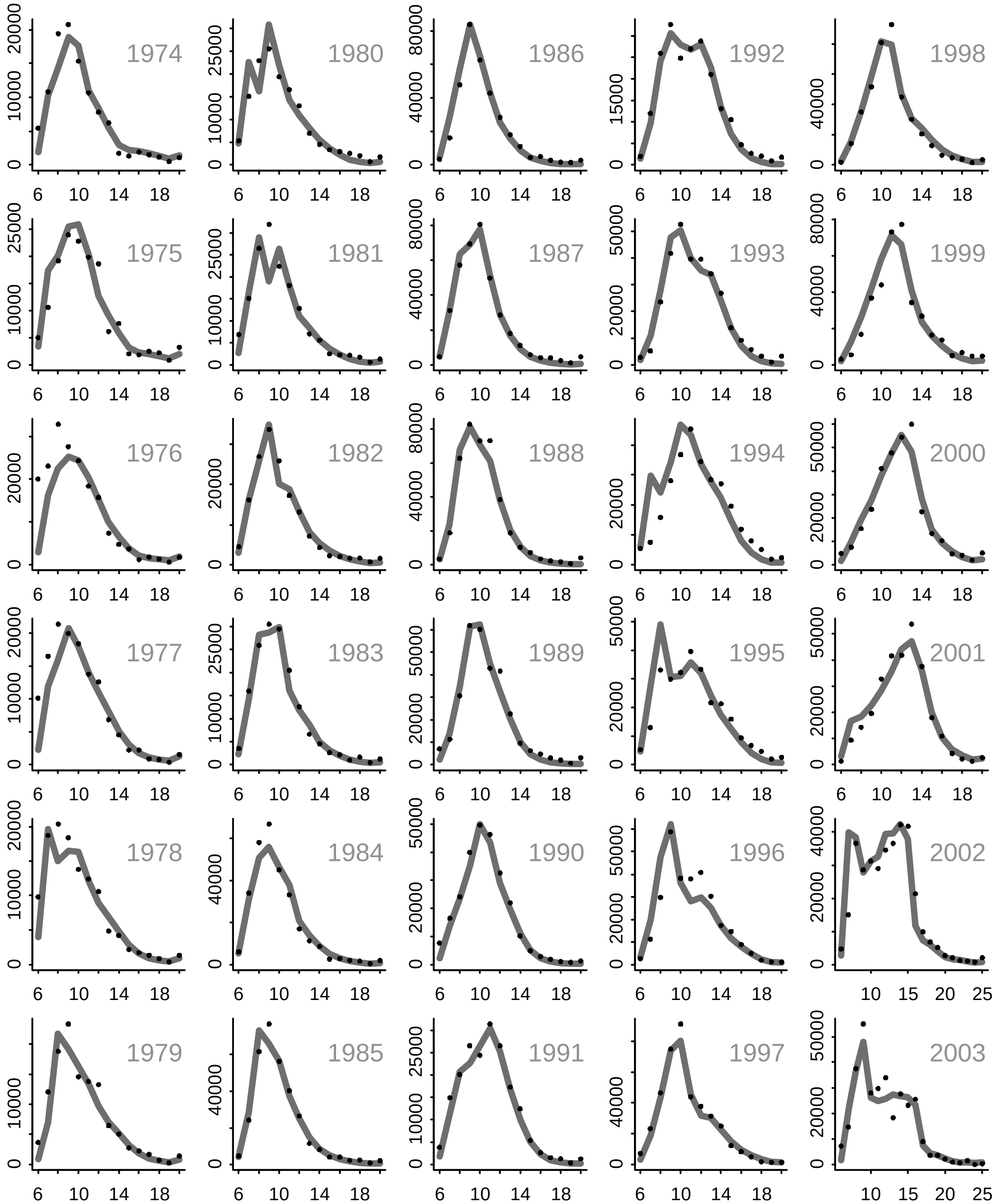

Figure 2a. Observed catch at age of females in Area 2B (points) and model predictions (lines).

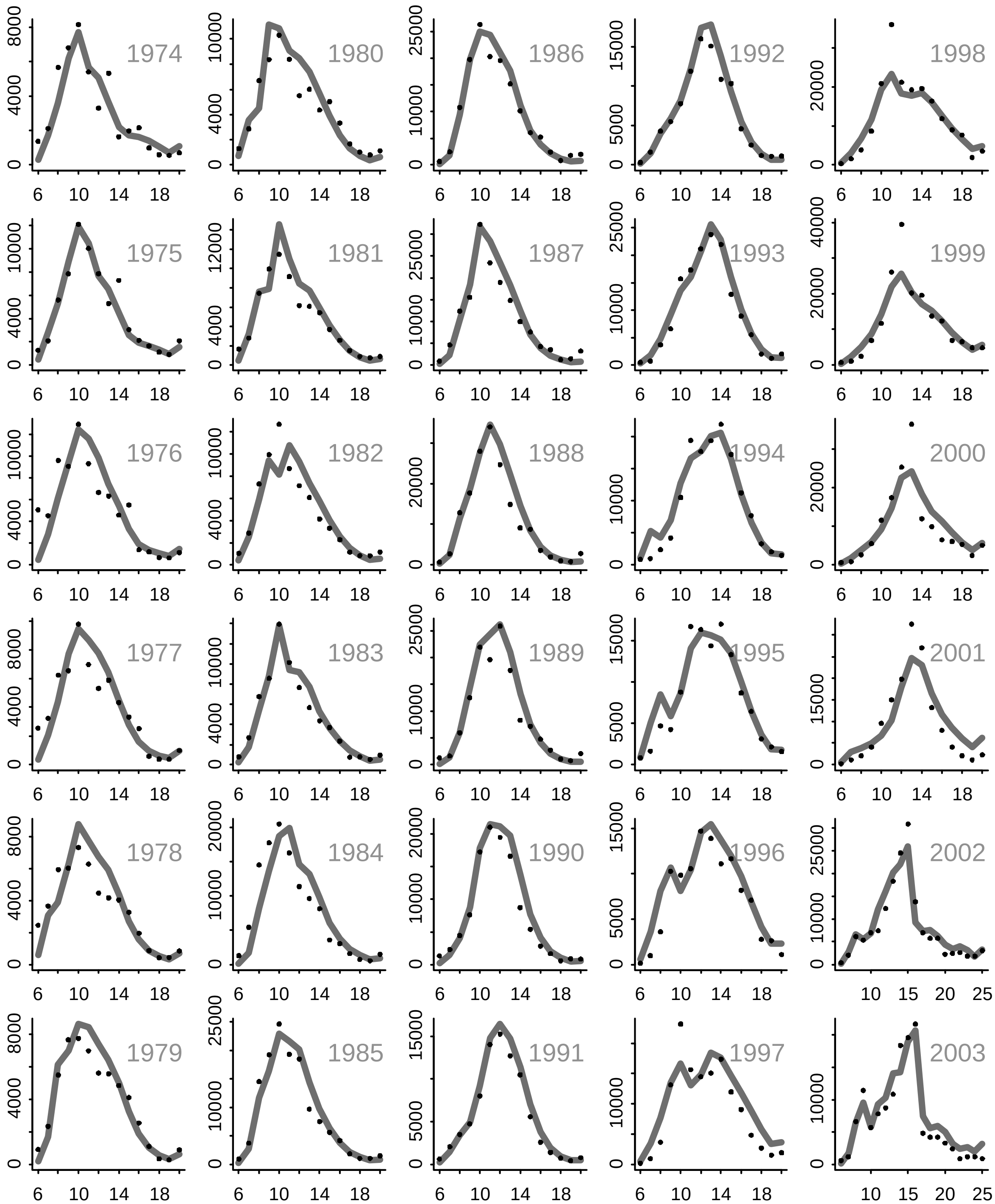

Figure 2b. Observed catch at age of males in Area 2B (points) and model predictions (lines).

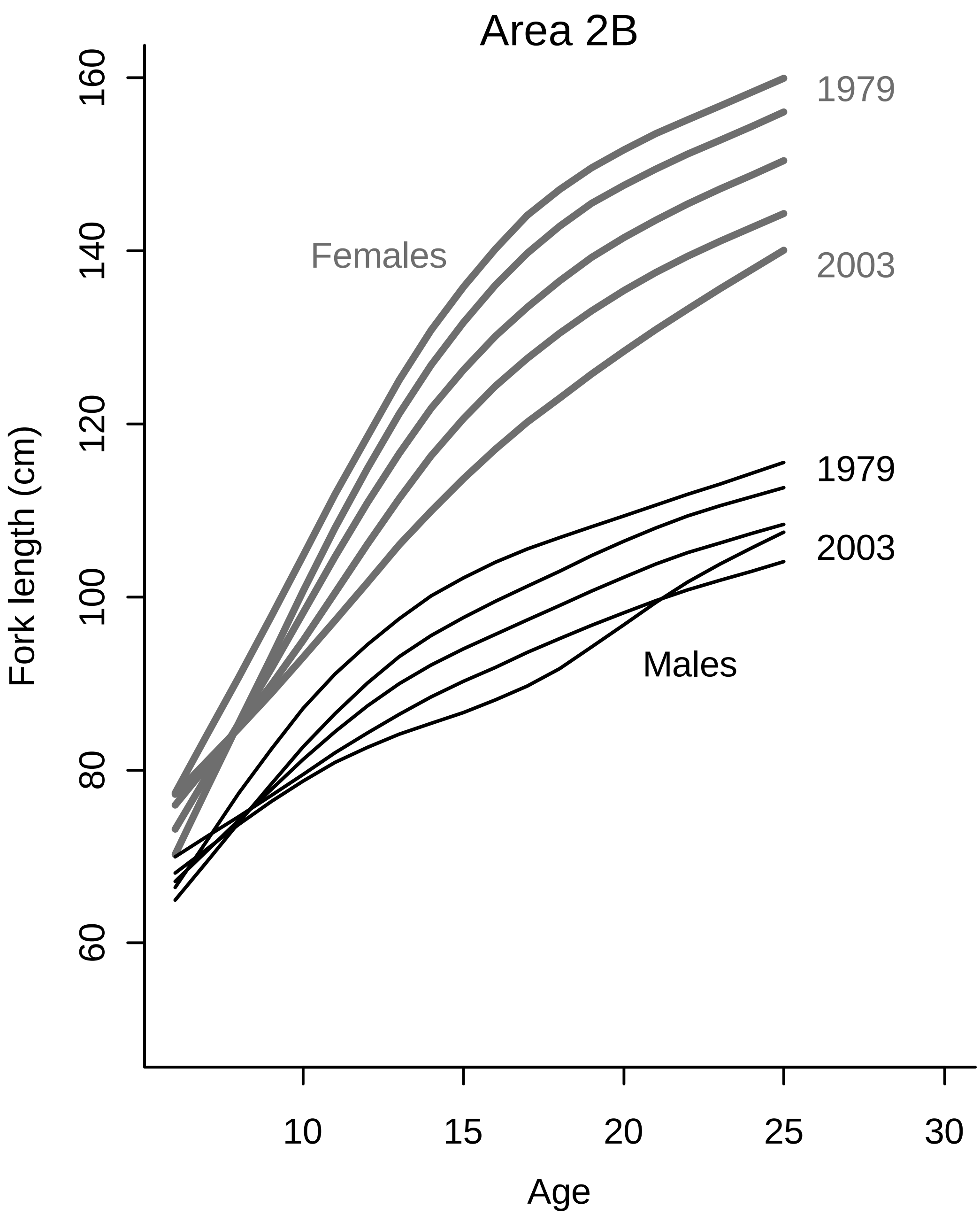

Figure 3. Mean length at age of females and males in setline survey catches in Area 2B. For each sex, the graphs show the observed growth schedules in a sequence of years at intervals between 1979 and 2003. The upturn in the male growth schedule in 2003 is an artifact of the conversion from surface to break-and-burn readings.

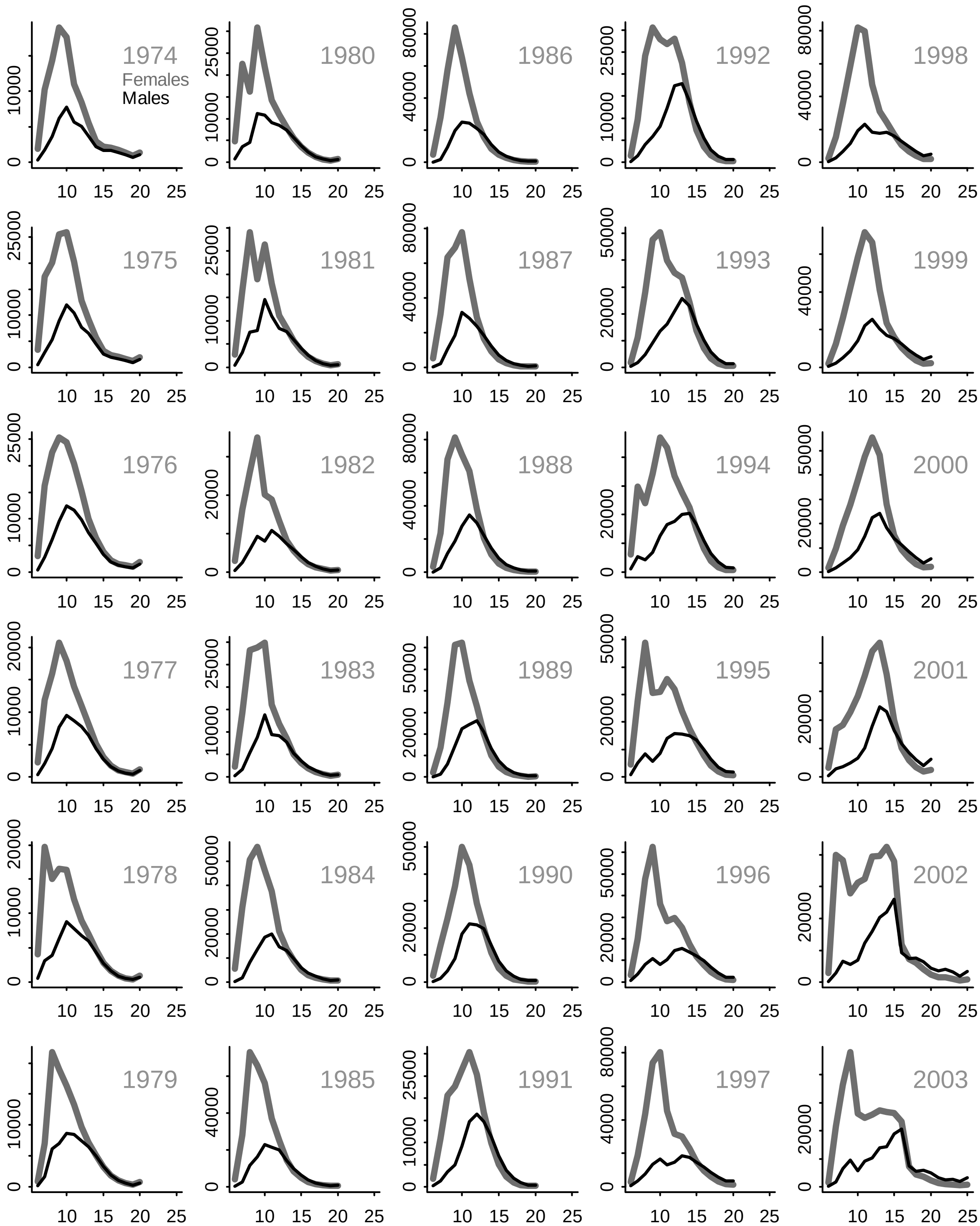

Figure 4a. Catch at age of females and males in Area 2B, by year.

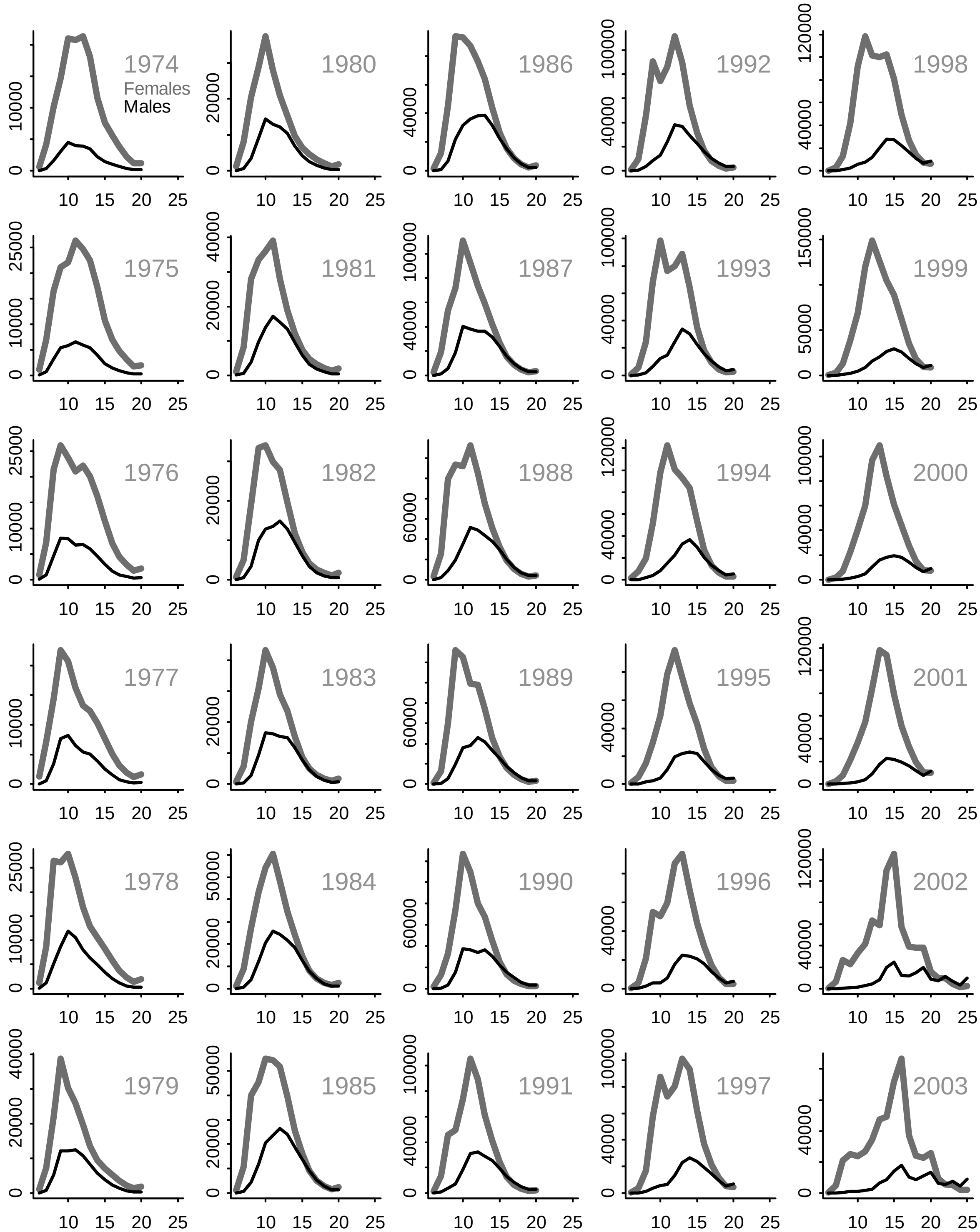

Figure 4b. Catch at age of females and males in Area 3A, by year.

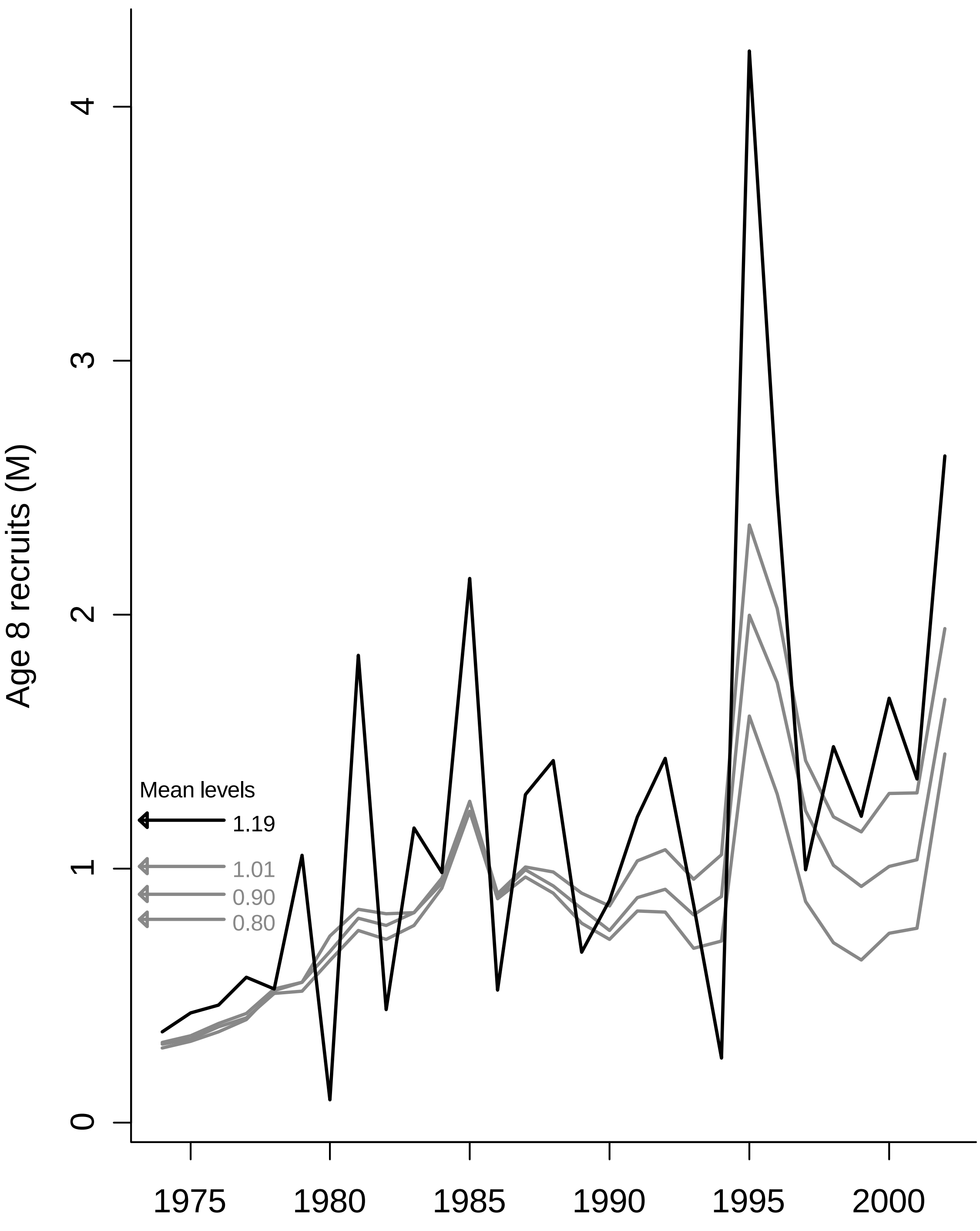

Figure 5. Estimates of recruitment in Area 2C from fits of old and new models. Bottom line shows the 2002 assessment with fixed age-specific survey selectivities; next line up shows the effect of switching to length-specific selectivities; next line up the added effect of treating females and males separately; topmost (black) line the added effect of correcting for surface age bias and variance.

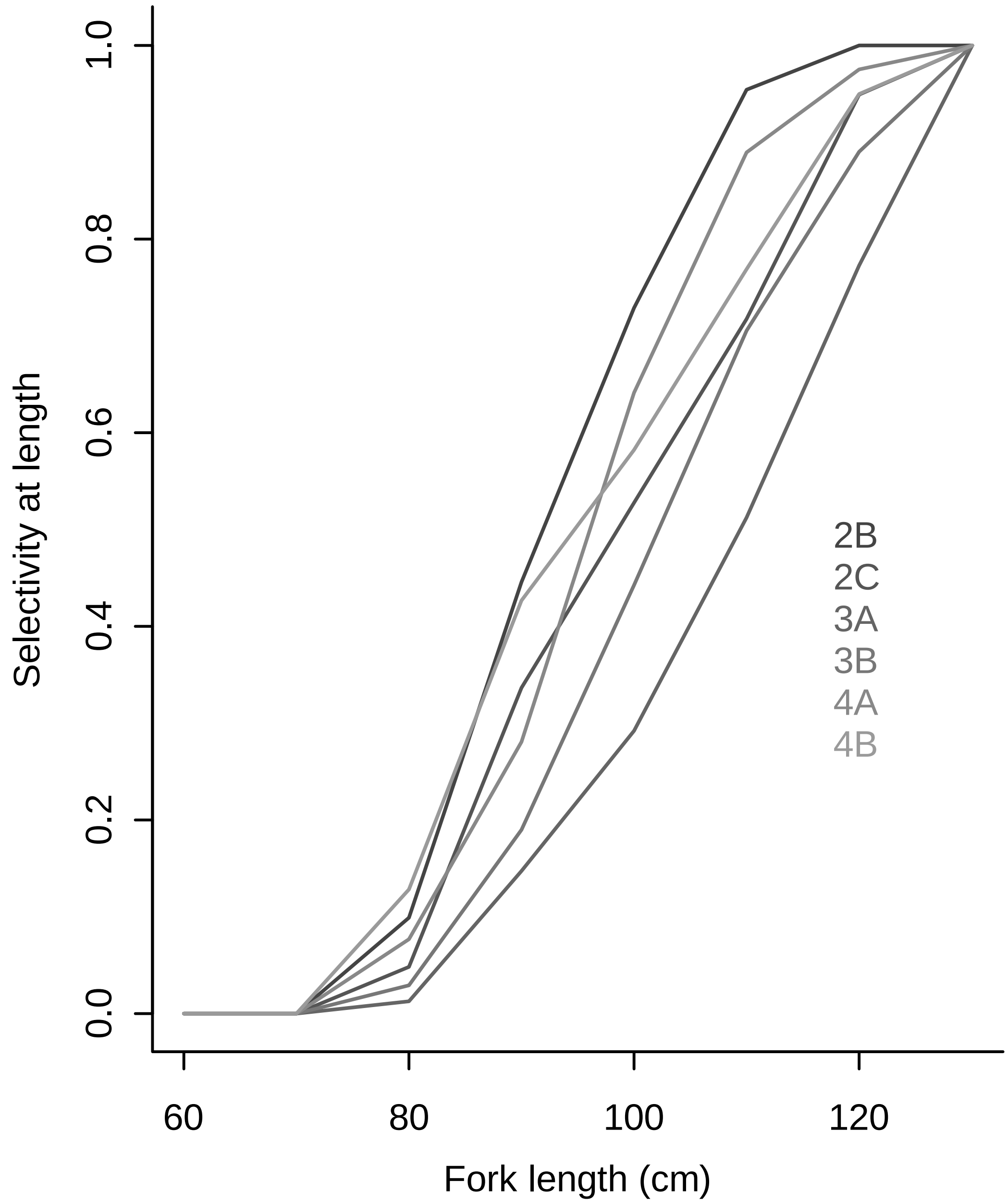

Figure 6. Estimated length-specific commercial selectivity. The topmost line is Area 2B. The bottom line is Area 3A, and the other Alaska areas are clustered in the middle.

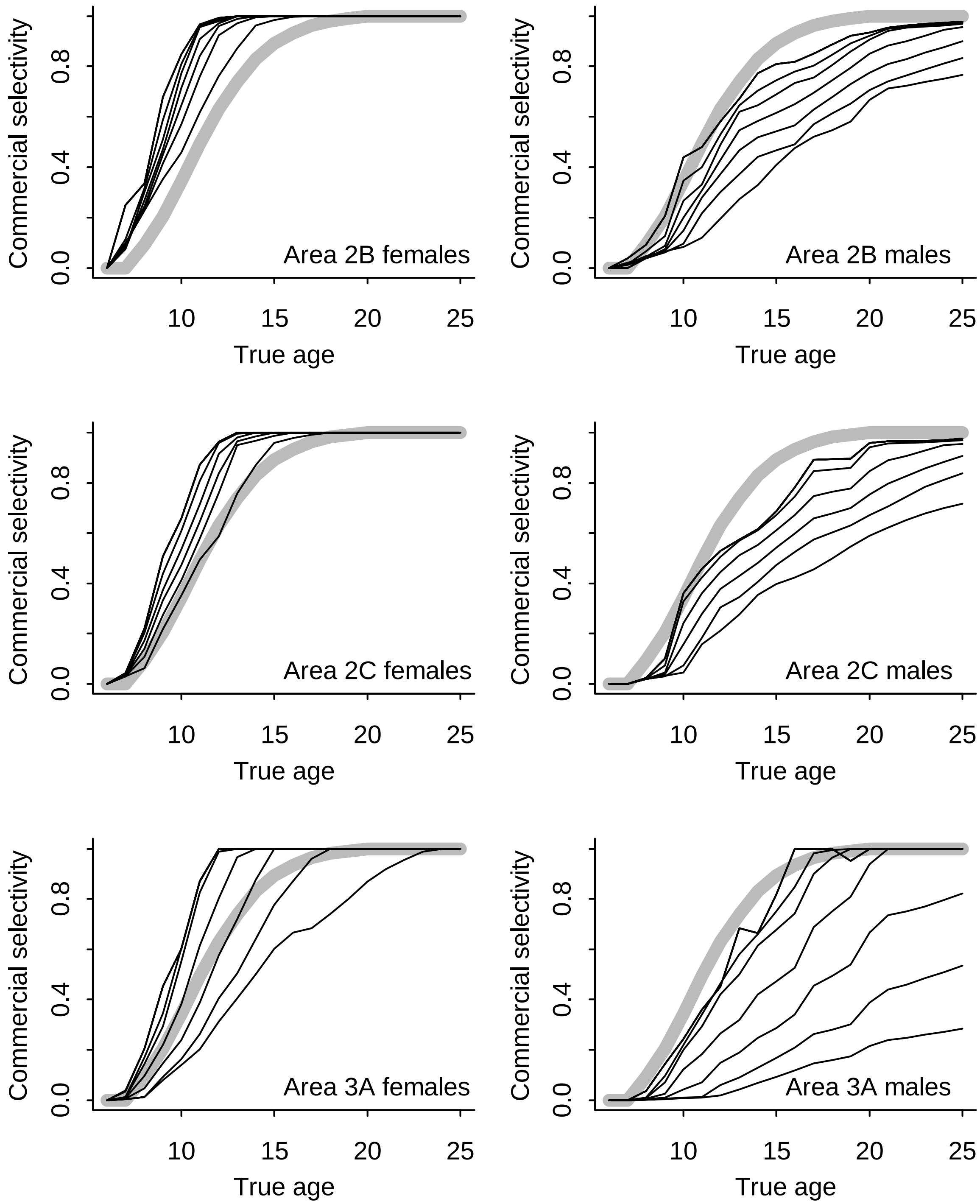

Figure 7. The downward drift of age-specific commercial selectivities over time due to constant length-specific selectivity and declining size at age, plotted by area and sex. The thin black lines in each graph are the selectivities estimated for a particular year; the thick gray line is the set of fixed coastwide selectivities that were used to compute exploitable biomass in the 1999-2002 assessments.

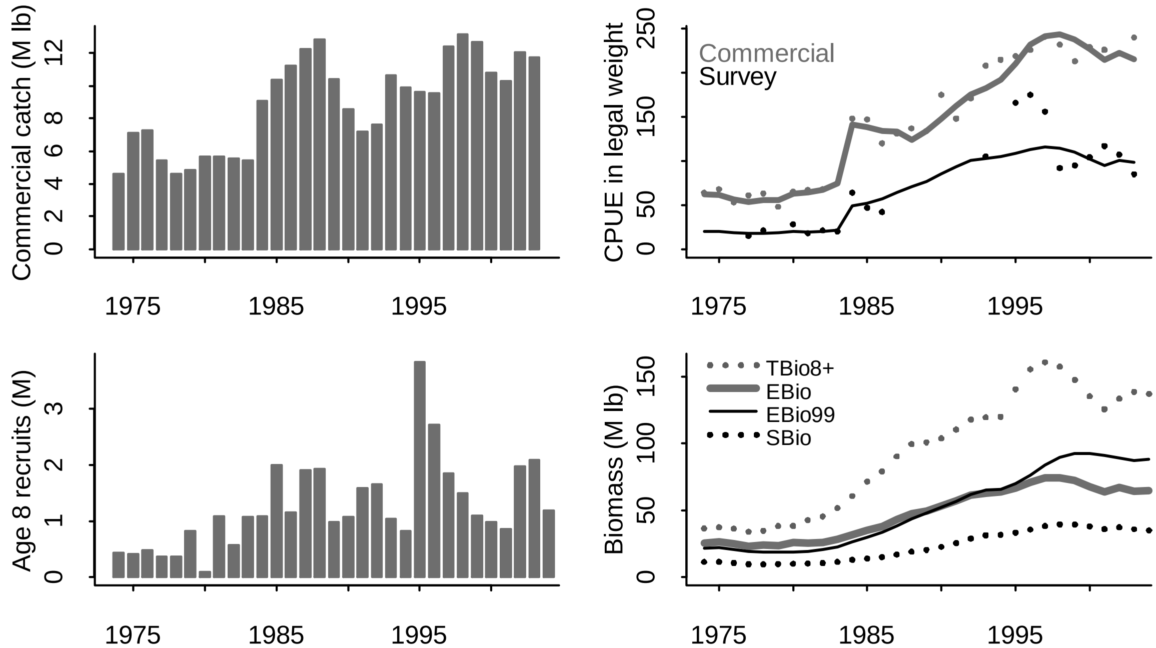

Figure 8a. Features of the Area 2B assessment. In the upper right graph, the points are the observed CPUE values and the lines are the model predictions. In the lower right graph, "TBio8+" is total biomass of fish aged 8 and older, "EBio" is exploitable biomass as calculated this year, "EBio99" is exploitable biomass as calculated last year, and "SBio" is female spawning biomass.

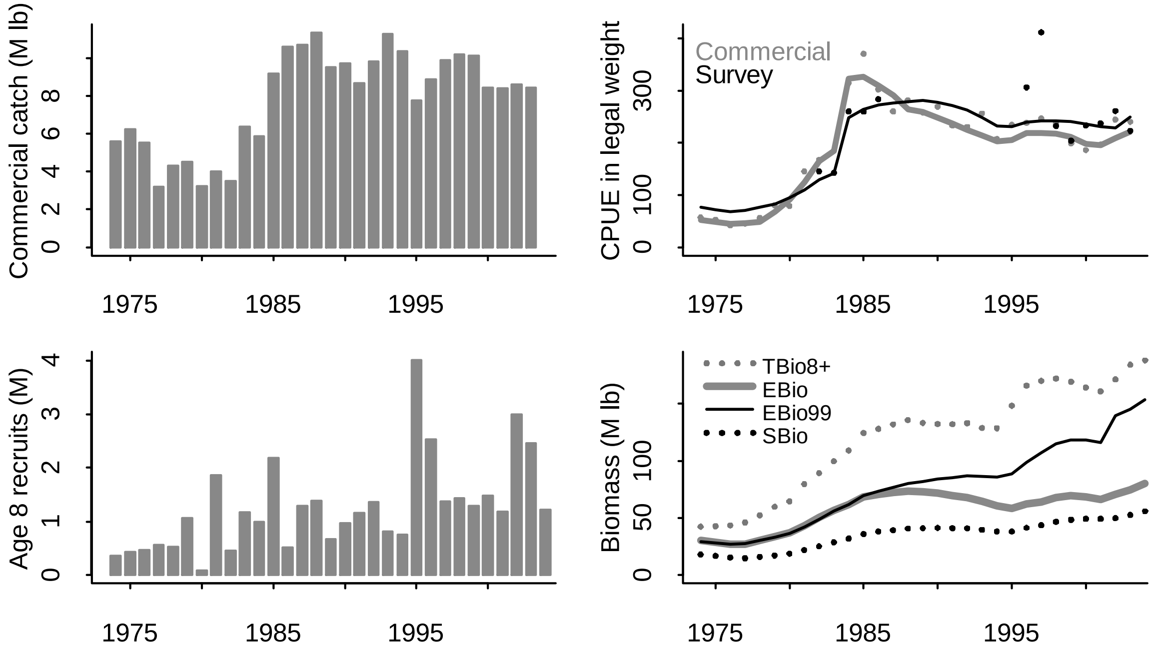

Figure 8b. Features of the Area 2C assessment.

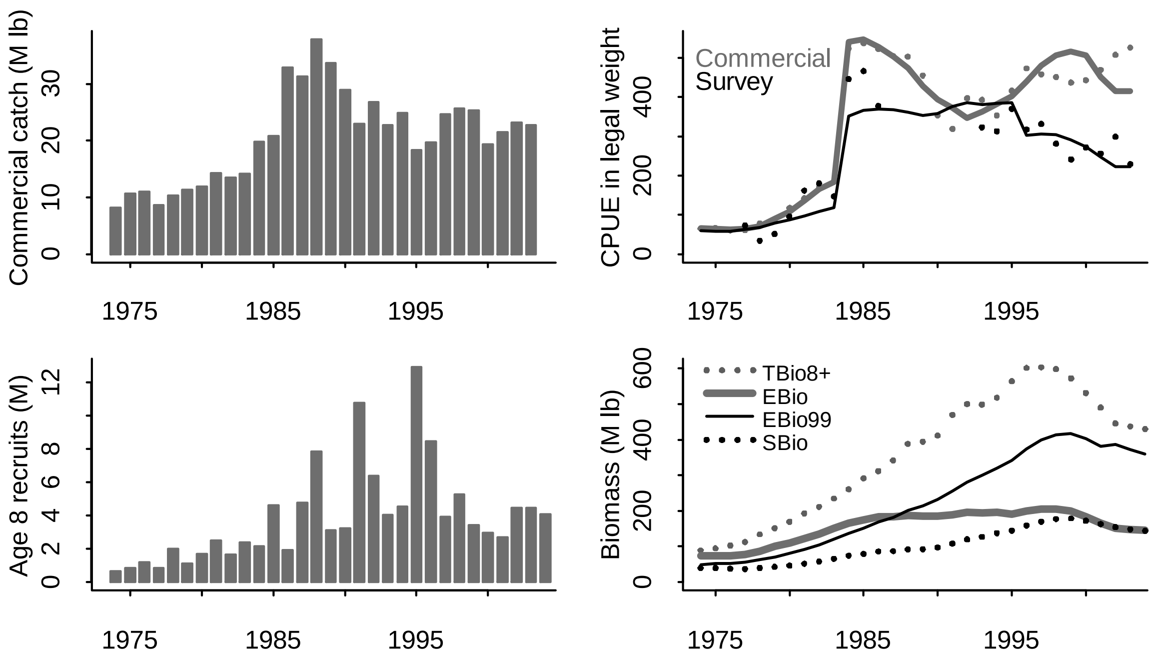

Figure 8c. Features of the Area 3A assessment. (See Figure 10a legend for details.)

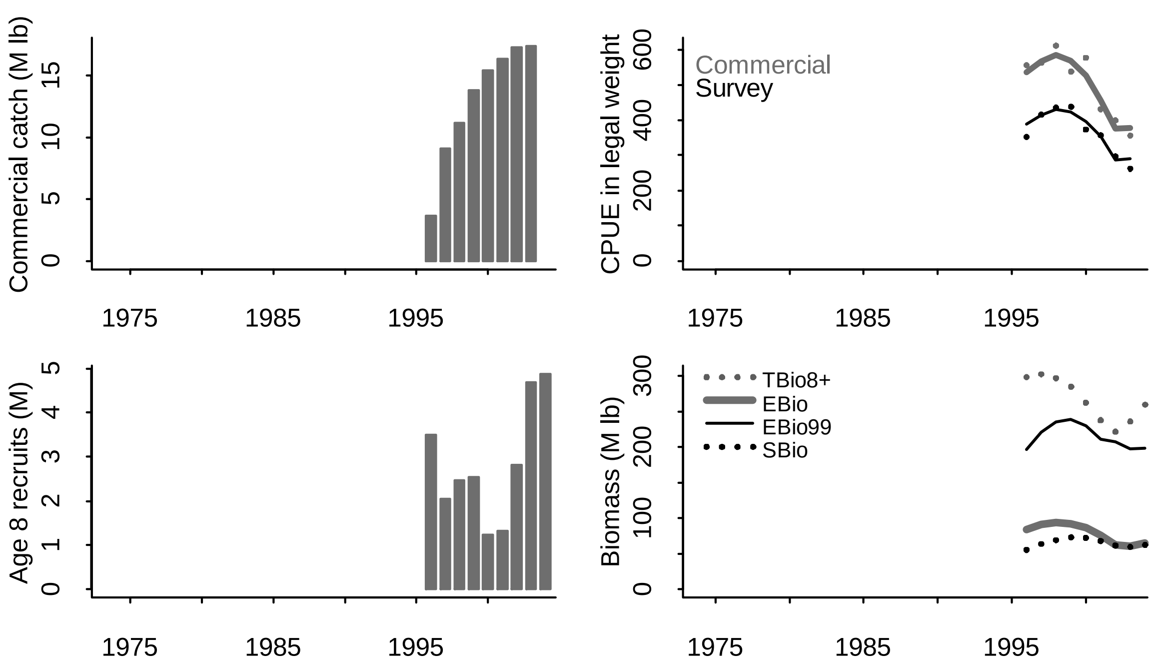

Figure 8d. Features of the Area 3B assessment.

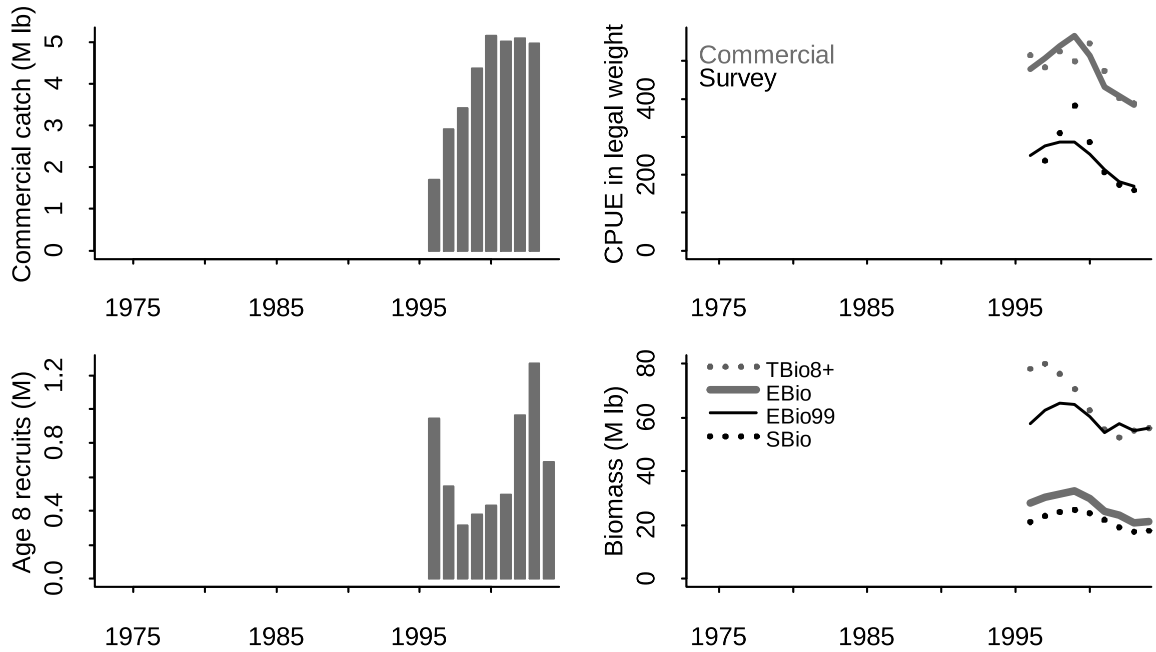

Figure 8e. Features of the Area 4A assessment. (See Figure 10a legend for details.)

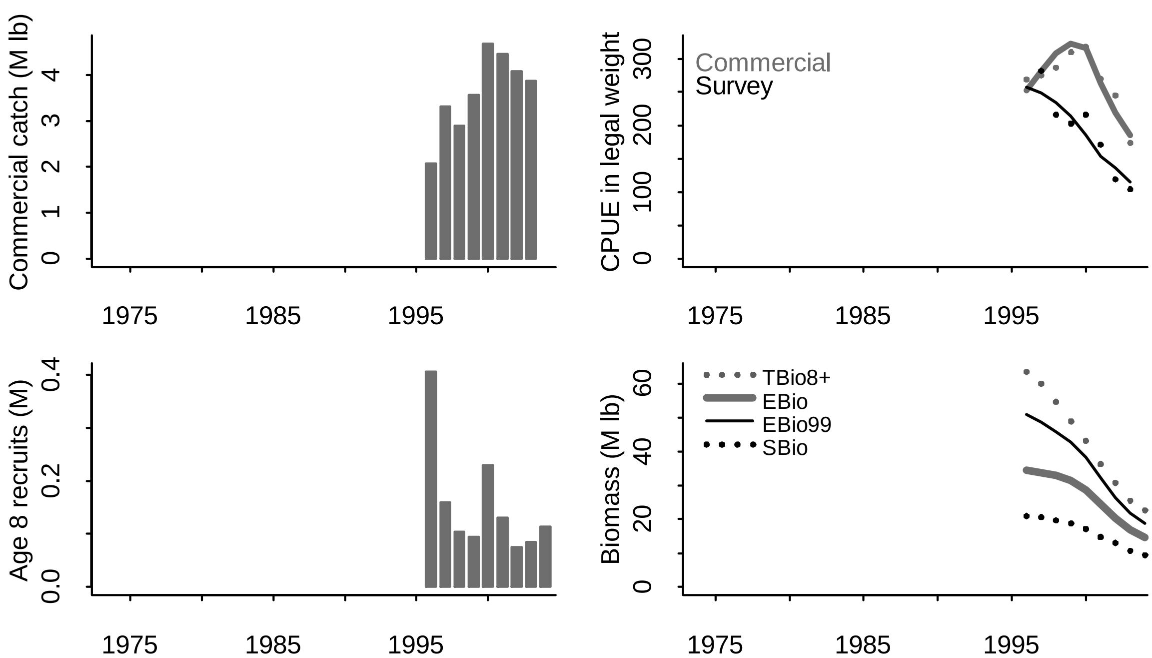

Figure 8f. Features of the Area 4B assessment.

Appendix A. Selected fishery and survey data summaries.

Table A1. Commercial catch (million pounds, net weight). Figures include IPHC research catches. Sport catch in Areas 2A and 2B is *not* included in this table.

	2A	2B	2C	3A	3B	4	4A	4B	4C	4D	4E	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
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	0.26	5.44	6.38	14.14	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	11.22	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	0.11	69.47
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	33.74	7.84	---	1.02	2.65	0.57	0.67	0.01	66.95
1990	0.32	8.57	9.73	28.85	8.69	---	2.50	1.33	0.53	1.00	0.06	61.60
1991	0.36	7.19	8.69	22.93	11.93	---	2.26	1.51	0.68	1.44	0.10	57.08
1992	0.44	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	0.72	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	9.54	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	13.84	---	4.37	3.57	1.76	1.89	0.26	74.31
2000	0.48	10.81	8.44	19.27	15.41	---	5.16	4.69	1.74	1.93	0.35	68.29
2001	0.68	10.29	8.40	21.54	16.34	---	5.01	4.47	1.65	1.84	0.48	70.70
2002	0.85	12.07	8.60	23.13	17.31	---	5.09	4.08	1.21	1.75	0.56	74.66
2003	0.82	11.74	8.45	22.68	17.41	---	4.97	3.87	0.93	1.91	0.41	73.19

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

	2A	2B	2C	3A	3B	4	4A	4B	4CDE	Total
1974	0.252	0.900	0.371	4.477	2.816	1.892	---	---	---	10.708
1975	0.252	0.902	0.451	2.610	1.661	1.097	---	---	---	6.973
1976	0.252	0.941	0.503	2.741	1.944	1.181	---	---	---	7.562
1977	0.254	0.725	0.407	3.366	1.544	1.976	---	---	---	8.272
1978	0.253	0.551	0.213	2.441	1.308	3.400	---	---	---	8.166
1979	0.253	0.694	0.638	4.488	0.688	3.446	---	---	---	10.207
1980	0.253	0.514	0.418	4.927	0.870	5.713	---	---	---	12.695
1981	0.252	0.533	0.403	3.989	1.096	4.369	---	---	---	10.642
1982	0.252	0.299	0.199	3.197	1.683	2.944	---	---	---	8.574
1983	0.253	0.291	0.200	2.083	1.218	2.472	---	---	---	6.517
1984	0.252	0.516	0.211	1.508	0.919	2.291	---	---	---	5.697
1985	0.252	0.548	0.201	0.797	0.341	2.246	---	---	---	4.385
1986	0.253	0.558	0.202	0.674	0.197	2.617	---	---	---	4.501
1987	0.253	0.793	0.202	1.588	0.396	2.674	---	---	---	5.906
1988	0.253	0.773	0.202	2.126	0.042	3.273	---	---	---	6.669
1989	0.253	0.720	0.202	1.805	0.437	1.944	---	---	---	5.361
1990	0.253	1.029	0.674	2.633	1.215	---	0.625	0.335	2.385	9.149
1991	0.253	1.221	0.546	3.126	1.035	---	0.731	0.236	2.237	9.385
1992	0.276	1.017	0.574	2.644	1.116	---	0.724	0.655	1.937	8.943
1993	0.276	0.651	0.333	1.919	0.466	---	0.140	0.479	1.407	5.671
1994	0.276	0.571	0.396	2.352	0.848	---	1.197	0.536	1.820	7.996
1995	0.381	0.705	0.219	1.460	0.825	---	1.087	0.149	2.116	6.942
1996	0.473	0.166	0.233	1.403	0.960	---	0.594	0.459	2.991	7.279
1997	0.473	0.109	0.240	1.549	0.729	---	0.844	0.198	2.964	7.106
1998	0.834	0.117	0.238	1.471	0.731	---	1.193	0.327	2.725	7.636
1999	0.761	0.107	0.230	1.283	0.743	---	0.909	0.336	2.642	7.011
2000	0.634	0.128	0.254	1.286	0.646	---	0.808	0.580	2.279	6.615
2001	0.645	0.149	0.184	1.617	0.632	---	0.574	0.387	2.900	7.088
2002	0.286	0.152	0.166	1.073	0.719	---	0.534	0.196	2.735	5.861
2003	0.286	0.154	0.167	1.364	0.584	---	0.499	0.184	2.558	5.796

Table A3. Commercial CPUE (net pounds per skate).

Values before 1984 are raw J-hook catch rates, with no hook correction. 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	4A	4B	4C	4D	4E
J-hook CPUE:										
1974	59	64	57	65	57	---	---	---	---	---
1975	59	68	53	66	68	---	---	---	---	---
1976	33	53	42	60	65	---	---	---	---	---
1977	83	61	45	61	73	---	---	---	---	---
1978	39	63	56	78	53	---	---	---	---	---
1979	50	48	80	86	37	---	---	---	---	---
1980	37	65	79	118	113	---	---	---	---	---
1981	33	67	145	142	160	158	99	110	---	---
1982	22	68	167	170	217	103	---	91	---	---
1983	---	---	---	---	---	---	---	---	---	---
C-hook CPUE:										
1984	63	148	314	524	475	366	161	---	197	---
1985	62	147	370	537	602	333	234	---	330	---
1986	60	120	302	522	515	265	---	427	239	---
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	209	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	257	851	---
1994	93	215	207	353	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	483	275	335	671	---
1998	194	232	236	451	611	525	287	287	627	---
1999	---	213	199	437	538	500	310	270	535	---
2000	263	229	186	443	577	547	318	223	556	---
2001	169	226	196	469	431	474	270	203	511	---
2002	181	222	244	507	399	402	245	148	503	---
2003	183	240	240	526	356	388	174	100	443	---

Table A4. 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. 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; J-hook values are raw J-hook catch rates.

	2A	2B	2C	3A	3B	4A	4B	4C	4D	4E
J-hook surveys:										
1974	---	---	---	---	---	---	---	---	---	---
1975	---	---	---	---	---	---	---	---	---	---
1976	---	---	---	---	---	---	---	---	---	---
1977	---	15	---	73	---	---	---	---	---	---
1978	---	21	---	34	---	---	---	---	---	---
1979	---	---	---	51	---	---	---	---	---	---
1980	---	28	---	95	---	---	---	---	---	---
1981	---	18	---	162	---	---	---	---	---	---
1982	---	21	145	180	---	---	---	---	---	---
1983	---	20	142	147	---	---	---	---	---	---
1984	---	28	---	217	---	---	---	---	---	---
C-hook surveys:										
1984	---	64	260	446	---	---	---	---	---	---
1985	---	47	260	466	---	---	---	---	---	---
1986	---	42	283	377	---	---	---	---	---	---
1987	---	---	---	---	---	---	---	---	---	---
1988	---	---	---	---	---	---	---	---	---	---
1989	---	---	---	---	---	---	---	---	---	---
1990	---	---	---	---	---	---	---	---	---	---
1991	---	---	---	---	---	---	---	---	---	---
1992	---	---	---	---	---	---	---	---	---	---
1993	---	105	---	323	---	---	---	---	---	---
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	435	310	216	---	---	---
1999	37	95	204	241	438	382	203	---	---	---
2000	---	104	233	272	373	286	216	---	213	---
2001	41	117	237	256	357	207	171	---	197	---
2002	33	107	261	299	297	174	119	---	257	---
2003	22	85	223	229	262	159	104	---	195	---

Staff regulatory proposals: 2004

Bruce M. Leaman and Heather L. Gilroy

In making catch limit recommendations for 2004, staff has considered the results of the analytic assessment, changes in the commercial and survey indices used to monitor the stock, the implications of separate male and female assessments, and an appropriate harvest strategy. Consideration of all of these elements and the latter two in particular, lead us to recommend caution in setting catch limits for 2004.

Commercial catch rates in 2003 improved or were stable with those of 2002 in Areas 2A through 3A, with a notable increase in Area 3A. Those in the west, Areas 3B and 4, continued their decline of recent years. In all of these western areas, commercial CPUE has been declining since 2000 and in the case of Areas 4C and 4D, for longer periods. The coherence of CPUE changes in these latter two areas is consistent with the staff's view that Areas 4C/D/E comprise a single stock management unit. However, with the exception of Area 4C, the commercial CPUE in regulatory sub-areas of Area 4 is near the long-term average value.

In contrast, the IPHC setline survey CPUE values decreased in 2003 in all regulatory areas. The declines in Areas 2C and 3A are from higher CPUE values seen in 2002, and are now similar to the CPUE observed in 2001. Western area survey CPUE values continued to show declines similar to the commercial CPUE values.

The major changes in the stock assessment for 2003 are the development of a sex-specific model for the stock which uses a length-specific selectivity, allowance for bias and variance in age estimation, and the first analytical estimates of abundance for Areas 3B, 4A, and 4B (Clark and Hare 2004). Previously, the sexes have been combined in the IPHC stock assessment but the change in halibut growth rates over the past decade and the consequent effect on the selectivity of fish by age has prompted the staff to separate the sexes for assessment. While recruitment estimates for Areas 2B, 2C, and 3A are higher than previous estimates, the estimates of exploitable biomass are lower because we are using updated length-specific commercial selectivities that show the lower selectivities associated with lower growth rates over the past decade. This results in fewer fish being fully recruited to the fishing gear, especially males in Area 3A. The new analytical estimates of exploitable biomass in Areas 3B, 4A, and 4B are substantially lower than the previous survey-based estimates.

Catch limit recommendations

The analytic stock assessment has been conducted on a sex-specific basis for the first time. Our recommendations have been developed in consideration of the sex-specific differences in selectivity from previous estimates. In addition, the Conditional Constant Catch (CCC) policy, outlined by Hare et al. (2004) is used in making recommendations to the Commission for use in the management of the Pacific halibut stock. The CCC policy uses a ceiling harvest rate and a ceiling (or cap) on total removals as a means to stabilize harvest over longer periods. The lower selectivities used in this year's assessment will likely require an upward revision of the existing 20% Constant Exploitation Yield (CEY) harvest rate but this analysis is not yet complete. In the interim, the yield estimates have been calculated using a 25% harvest rate in Areas 2 and 3, but we maintain the 20% harvest rate in Area 4 because of uncertainty about the underlying productivity of stocks in this region.

The staff recommendations totaling 73.78 million pounds are presented in Table 1. The Area 2A recommendation includes all removals (commercial, treaty Indian, sport) allocated by the Pacific Fishery Management Council's Catch Sharing Plan. For the first time, the Area 2B catch limit recommendation includes totals for the commercial and sport fisheries. The Department of Fisheries, Canada will allocate the adopted catch limit between the sport and commercial fisheries.

The Area 3A estimated exploitable biomass for 2003 increased considerably over the previous year but we believe some caution is required before the CEY based on this estimate should be adopted. Accordingly, we are recommending that the catch limit for Area 3A be increased by only 50 percent of the potential increase. The stock assessment indicates lower biomass in Area 3B and we recommend using the setline CEY based on this estimate.

We are concerned that the productivity of the Bering Sea halibut is less than that of the Gulf of Alaska and more southerly areas. In addition, the data set providing the exploitable biomass estimate is of relatively short duration, and we have seen a sequence of years with declining CPUE for these areas. Accordingly, we recommend continuation of a 20% exploitation rate for this area until either the results of a recent tagging experiment or continued application of the analytic model indicate a higher rate is appropriate. The historical record of recommended catch limits, catches and CPUE values by regulatory area, from 1999-2003 are included in Table 2.

Future directions

The full implementation of the sex-specific assessment is not yet complete and there are several aspects of the assessment that require additional work. In addition, we wish to continue our examination of the CCC harvest policy in light of the results of the sex-specific assessment. The change in growth rates in the central region of the stock and the associated change in selectivity to longline gear requires that we re-examine the suitability of our current minimum commercial size limit. While increased yield per recruit could be achieved with a lower size limit, primarily from the harvest of a higher fraction of males, there are potential negative impacts on mortality of immature females and the possibility of highgrading by harvesters. This requires an examination of spawning contributions of recruiting females and the use of a variety of minimum size limits. Lastly, the PIT tagging experiment undertaken in 2003 will provide a valuable anchor on the validity of our assessment model, through an independent estimate of biomass and exploitation rates. Estimates using recoveries from the PIT tagging program are expected to begin in 2004 and be refined in subsequent years as tags continue to be recovered from the approximately 44,000 tags applied in 2003.

Fishing periods

As in past years, the staff recommends March 15 to November 15 opening and closing dates for the quota share fishing season. This recommendation is a compromise between minimizing interceptions of migrating fish and providing opportunity for market presence of fresh wild fish. The Area 2A fishery should also occur within this period.

Elsewhere in this volume, the staff reports on the joint industry-agency working group report on extension of the existing halibut season. While the staff would prefer to minimize the issues created by the interception of migrating fish during fishing outside of the existing season, we recognize the desire for longer market presence of wild fish by the industry. Leaman et al. (2002) concluded that conservation for the halibut stock as a whole would not be compromised by an extended fishing season. The annual stock assessment would continue to guarantee conservative harvest for the coastwide spawning stock. The essence of the concerns about winter fishing for halibut involving its biology is the potential shifts in biomass distribution that could occur as a result of interceptions of migrating fish. Interceptions will create differential exploitation rates among areas, since catch limits are set on a regulatory area basis. The magnitude of the changes would be proportional to the magnitude of the winter fisheries.

For the Area 2A directed commercial fishery, the staff recommends fishing periods similar to those in effect in 2003: A series of 10-hour periods, with fishing period limits to ensure that the catch limit is not exceeded. The size of the fishing period limits will be determined when more information on fleet participation is available.

The staff recommends a subsistence fishing season in Alaska of January 1 to December 31, in accordance with National Marine Fisheries Service regulations.

Catch sharing plans: Areas 2A and 4CDE

The Commission does not make allocative decisions within regulatory areas or among different user groups. However, for Areas 2A and 4CDE the staff recommends that the Commission endorse the catch sharing plans developed by the Pacific and North Pacific Fishery Management Councils for these areas, respectively.

Proposed changes to the IPHC regulations

Retention of tagged halibut

Current regulations allow the retention of halibut only by commercial harvesters. The Commission staff recommends allowing any person at any time to be able to retain a halibut that bears a Commission tag. The halibut would need to have the tag attached at the time of landing and it would be made available to the Commission or an authorized officer. Therefore, Section 20 of the IPHC Regulations would apply to all fishing whereas it applies currently to commercial halibut fishing only. If this proposal is adopted, we also recommend that the sale of tagged halibut be restricted to legal-sized halibut caught by commercially licensed vessels. In addition, we recommend changing the regulation to define the tag as an external tag that was applied by IPHC or with IPHC permission.

Permit required to retain halibut for research purposes

The Commission staff recommends an addition to the regulations that would require individuals or organizations to obtain written permission from IPHC to collect and retain halibut for scientific, experimental, or educational projects. The Commission has given permission and worked with organizations in the past to complete research projects on halibut. In most cases, individuals do obtain a permit to allow them to possess halibut. We recommend a new regulation section that would be for halibut retained outside of the licensed user groups. It would state that it is unlawful to possess, transport, and retain halibut, except in accordance with the terms of a permit issued by the IPHC.

Request NMFS to change date-specific regulations

It was the consensus of the season extension work group that the Commission should request that NMFS restructure the current date-specific quota share regulations to instead reference a time relative to the season opening or closing dates when operational events (such as permit calculations and issuance) will occur, rather than on a specific date. The Commission staff agrees with this recommendation and believe it is appropriate even if the halibut season were not changed in the near future, as it would allow the Commission and NMFS flexibility in implementing alternate season dates. The halibut season (quota share) opening date is now partially restricted by the NMFS date-specific regulations.

Customary and traditional fishing in Alaska

At the request of the National Marine Fisheries Service, we recommend that IPHC regulations be changed to require that the data collected in the subsistence fishery remain confidential.

References

Clark, W. G. and Hare, S. H. 2004. Assessment of the Pacific halibut stock at the end of 2003. Int. Pac. Halibut Comm. Report of Assessment and Research Activities 2003: 171-200.

Hare, S. H., Clark, W. G., and Leaman, B. M. 2004. The conditional constant catch (CCC) harvest policy: Summary and estimated CCC yield for 2004. Int. Pac. Halibut Comm. 2004 Annual Meeting Handout (Bluebook): 51-62.

Leaman, B. M., Geerneart, T. O., Loher, T., and Clark, W. G. 2002. Further examination of biological issues concerning an extended commercial fishing season. Int. Pac. Halibut Comm. 2002 Annual Meeting Handout (Bluebook): 39-58.

Table 1. 2003 setline catch limits, 2004 estimated yields under the CCC harvest policy, 2003 other removals, and staff recommended catch limits for 2004, by IPHC regulatory area (million lbs, net weight).

Regulatory Area	2003 Catch Limit	2004 CCC Total Estimated Yield	Estimated Other Removals	2004 Setline Yield	2004 Recommended Setline Catch Limit
2A	1.31	1.69	0.30	1.39	**1.39** [1]
2B	11.75	13.00	0.47	12.53	**12.53** [2]
2C	8.50	12.00	2.97	9.03	**9.03**
3A	22.63	35.00	6.52	28.48	**25.56**
3B	17.13	16.25	0.65	15.60	**15.60**
4A	4.97	4.20	0.73	3.47	**3.47** [3]
4B	4.18	3.00	0.19	2.81	**2.81** [3]
4CDE[4]	4.45	5.96	2.57	3.39	**3.39** [3]
Total	74.92	91.10	14.40	76.70	**73.78**

[1] Catch limit for 2A includes commercial, sport, and treaty subsistence catch

[2] 2004 Catch limit for 2B includes commercial and sport catch

[3] Catch limits for Area 4 use 0.2 exploitation rate because of uncertainty about productivity

[4] Individual catch limits for Areas 4C, 4D, and 4E are determine by North Pacific Fishery Management Council catch sharing plan

Table 1. Estimated setline CEY, staff recommended catch limits, catch limits adopted by the Commission, catch, percent of catch limits taken, survey and commercial CPUE of Pacific halibut by IPHC regulatory area (in thousands of pounds, net weight), 1999-2003.

Regulatory	ESTIMATED SETLINE CEY					STAFF RECOMMENDATIONS				
Area	1999	2000	2001	2002	2003	1999	2000	2001	2002	2003
2A[1]	690	830	1,120[2]	1,310	1,290	690	830	1,140[2]	1,130	1,310
2B	11,210	7,850	10,510[2]	11,750	11,320	11,210	9,970	9,990[2]	11,750	11,750
2C	10,490	6,310	8,780	8,500	9,110	10,490	8,400	8,780	8,500	8,500
3A	24,670	11,940	21,890	24,140	34,220	24,670	18,310	21,890	22,630	22,630
3B	26,830	18,360	25,460	28,560	29,190	13,370	15,031	18,500	17,130	17,130
4A	8,420	6,420	9,820	11,960	11,220	4,240	4,970	4,970	4,970	4,970
4B	6,710	6,770	10,060	7,510	7,760	3,980	4,910	4,910	3,440	4,180
4CDE	9,800	4,130	7,630	11,810	13,820	4,130	4,130	4,450	4,450	4,450
Total	98,820	62,610	94,770	105,540	117,930	72,780	66,550	74,630	74,180	74,920

Regulatory	CATCH LIMITS[3]					CATCH[4]				
Area	1999	2000	2001	2002	2003	1999	2000	2001	2002	2003[5]
2A[1]	760	830	1,140	1,310	1,310	780	845	1,126	1,253	1,234
2B	12,100	10,600	10,510	11,750	11,750	12,214	10,630	10,207	11,987	11,681
2C	10,490	8,400	8,780	8,500	8,500	9,902	8,266	8,273	8,455	8,327
3A	24,670	18,310	21,890	22,630	22,630	24,310	18,166	21,100	22,614	22,282
3B	13,370	15,030	16,530	17,130	17,130	13,160	14,888	15,993	17,003	17,141
4A	4,240	4,970	4,970	4,970	4.970	4,220	4,960	4,915	5,002	4,895
4B	3,980	4,910	4,910	4,180	4,180	3,452	4,560	4,388	4,030	3,827
4CDE	4,450	4,450	4,450	4,450	4,450	3,917	3,951	3,926	3,458	3,195
Total	74,060	67,500	73,180	74,920	74,920	73,954	68,266	71,929	73,802	72,582

	PERCENT OF CATCH LIMIT TAKEN					AVERAGE SURVEY (S) AND COMMERCIAL (C) CPUE[6]									
Regulatory						1999		2000		2001		2002		2003	
Area	1999	2000	2001	2002	2003	S	C	S	C	S	C	S	C	S	C
2A[1]	103	102	99	96	94	37	NA	NA	263	41	169	33	181	22	183
2B	101	100	97	102	99	95	213	104	229	117	226	107	222	85	240
2C	94	98	94	99	98	204	199	233	186	237	196	261	244	223	240
3A	99	99	96	100	98	241	437	272	443	256	469	299	507	229	526
3B	98	99	97	99	100	438	538	373	577	357	431	297	399	262	356
4A	100	100	99	101	98	382	500	286	547	207	474	174	402	159	388
4B	87	93	89	96	92	203	310	216	318	171	270	119	245	104	174
4CDE	88	89	88	78	72	-	-	-	-	-	-	-	-	-	-

[1] Area 2A includes sport catch and treaty Indian catch

[2] With the lower series of Area 2B sport catch estimates (including .887 Mlb in 2001), Area 2AB exploitable biomass is 66.71. With 11% of the total in Area 2A, the 2001 setline CEY is 1.12 Mlb in 2A and 10.51 Mlb in 2B. With a sport catch estimate of 1.58 Mlb in 2001, the exploitable biomass for 2AB is 67.62 Mlb and the 2001 setline CEY is 1.14 Mlb in 2A and 9.99 Mlb in 2B

[3] Catch limits do not include additional pounds from underage/overage programs

[4] Catch does not include IPHC research catch

[5] 2003 data are preliminary

[6] lbs/skate: no Area 2A surveys in 1998 or 2002 and refer to Clark and Hare (2003) for Areas 4C and 4D CPUEs