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 $\geq$ 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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Clark, W. G. and Hare, S. R. 2002. Effects of climate and stock size on recruitment and growth of Pacific halibut. N. Am. J. Fish. Mgmt. 22: 852-862.

Clark, W. G. and Hare, S. R. 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. R. and Clark, W. G. 2003. Issues and tradeoffs in the implementation of a conditional constant catch harvest policy. Int. Pac. Halibut Comm. Report of Assessment and Research Activities 2002: 121-161.

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

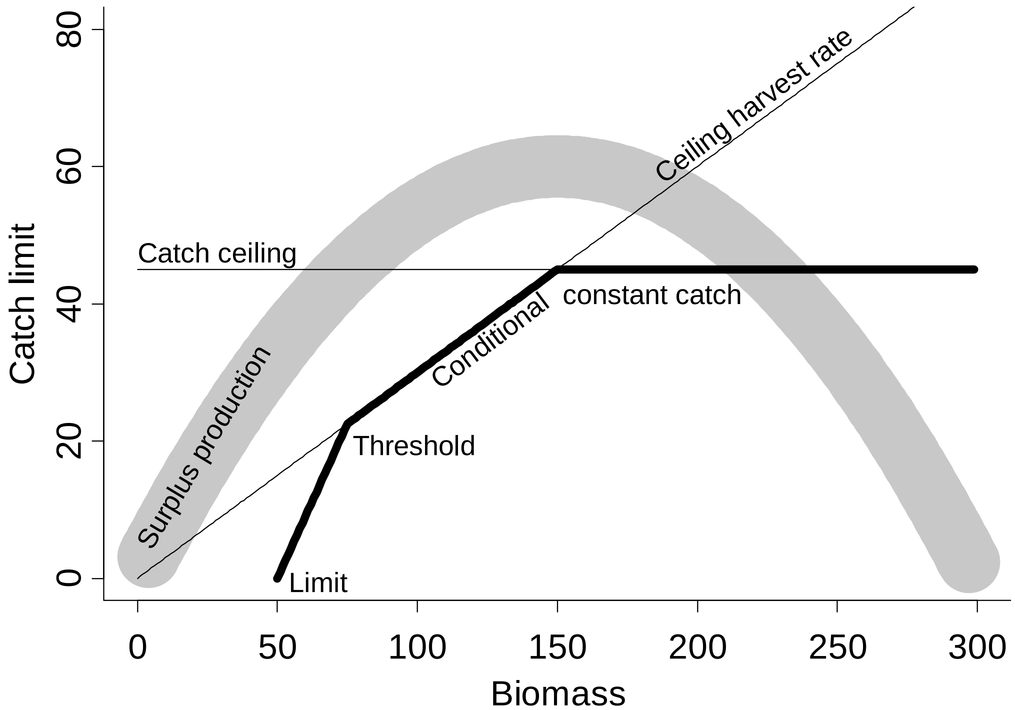

Figure 1. A graphic illustration of the conditional constant catch harvest policy in relation to biomass level and surplus production (modified from Clark and Hare, In Press).

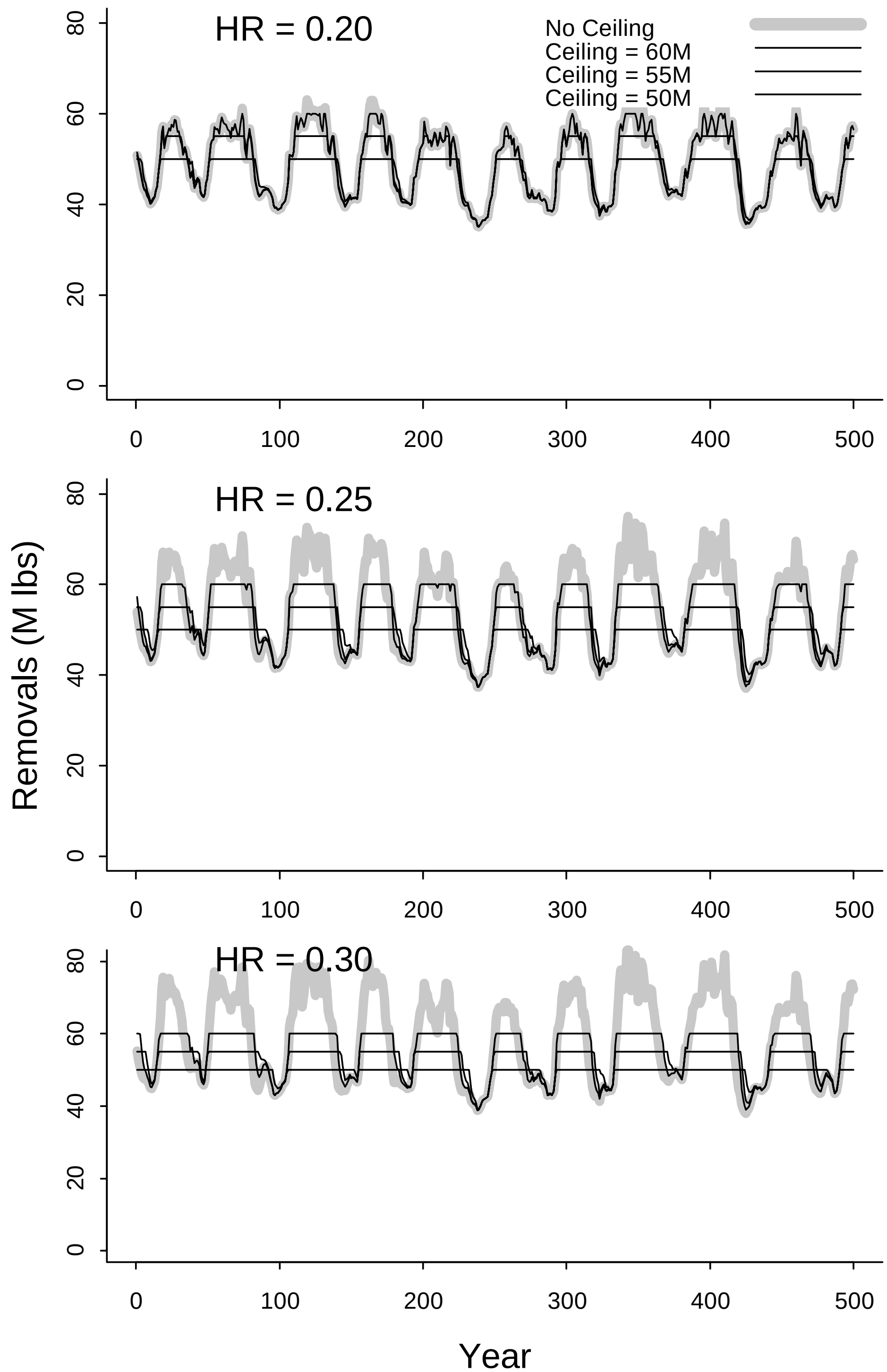

Figure 2. Yield trajectories under three different ceiling harvest rates and three different ceiling removal levels.