Questions and Significant Comments Arising at Apportionment Workshop – September 2008

Steven R. Hare, Ray A. Webster, Juan L. Valero, and Bruce M. Leaman

1. If the exploitation rates in Area 2, particularly Area 2B, have really been as high as 40-50% then how can we still have stock left to fish on?

Exploitation rate is removals divided by exploitable biomass. Exploitable biomass is a fraction (generally around 20-25%) of total resident biomass. It is quite incorrect to think that 40-50% of the halibut in Area 2 are being captured every year. This is particularly true of the younger aged fish (ages 6-11) as selectivity is quite low at those ages and quite a small fraction of resident fish ages 6-11 are taken annually. The catches in Area 2 have a much higher proportion of younger fish than the catches in Area 3 and 4. Fish of this age are growing relatively rapidly and their weight gain is the main addition annually to the surplus production and exploitable biomass in Area 2. Areas 3 and 4, which have a broader age spectrum, have a larger component of the exploitable biomass derived from older fish. The exploitable biomass in Area 2 is thus of a younger average age than in other areas and the high exploitation rate maintains the younger age distribution we see in the survey and commercial age compositions.

Figures 1 and 2 illustrate the relative levels of estimated exploitable and unexploitable biomass and numbers, and actual removals in Area 2B, both for the past five years as well as the detailed age and sex composition for 2007. All estimates are derived using relative survey catch rates among areas and the area/sex/age proportions are applied to the coastwide estimate of total numbers. Summing across just age groups 8 and older, exploitable biomass has ranged between 20 and 30% of total biomass during the past five years. For comparison purposes, similar graphs for Area 3A are provided in Figures 1 and 3.

Finally, while fishing is still occurring in Area 2, the catch rates have declined precipitously. The survey CPUE in Area 2B declined by 59% between 1997 and 2007; Area 2C survey CPUE declined by 66%. Put another way, the catch rates in Area 2 are just 30-40% of what they were a decade ago. The combination of sharply declining survey catch rates, and young age composition of the stock is not indicative of sustainable fishing and generally supports our estimates of too high harvest rates in Area 2.

2) The applicability of the coastwide survey data for biomass apportionment depends on catchability being equal, or nearly so, among all regulatory areas. Is this actually true? How can it be verified?

The assumption of equal catchability across regulatory areas is critical to use of the survey in apportioning biomass. Equal catchability implies that survey catch rates ("CPUE") will be similar in all areas given the same density of fish. Equivalently, it also implies that areas of lower density will have proportionally lower catch rates. As far as we have been able to statistically detect, this assumption appears to be reasonable. At the very least, it is the default assumption and we would need to demonstrate an actual and consistent difference in catchability among areas to weight certain areas differently. The best means of verifying consistent catchability among different areas is probably to conduct a large scale trawl/setline survey experiment using paired stations.

Figure 4 provides a new method of examining the catchability assumption. To prepare the figure, survey catch rates, in number of fish per survey unit of effort, were computed for males and female halibut ages 6 to 25. These catch rates were then weighted by bottom area to establish relative proportions by regulatory area for all ages and both sexes. This method uses no assessment model, it simply looks at survey derived relative catch rates. The catch rates are divided by selectivity at age, which differs by region according to relative size at age. There are several items of note in Figure 4. First, it can be seen that Area 2 (shaded blue in the figures) has around 20% of the youngest fish (ages 6-8). However, the share of older fish in Area 2 steadily declines with age (particularly among males) while the relative shares in Area 3 steadily increase. What these trends mean is that either: catchability differs **by age** among regulatory areas (i.e., that the relative share of older fish is similar among areas but older fish have a lower catchability in Area 2) or the catchability is similar among ages and there are fewer older fish in Area 2 due to increased mortality (presumably from fishing). While differential catchability on the whole is possible among regulatory areas, it is more difficult to postulate a viable difference based solely on age across areas.

We also note that the sablefish biomass apportionment is done in precisely the same manner as IPHC staff are proposing for halibut (with the exception that commercial CPUE is also part of the allocation calculation) – and there is no differential weighting by area for differences in catchability. In personal discussions with the sablefish assessment team, no reasons to suspect area differences in catchability were suggested.

3) NMFS survey data for Areas 3B and 3A were used to validate the assessment but not those from NMFS surveys in Areas 2C or 2A, nor those from DFO surveys in Area 2B. Why not?

A comparison of NMFS swept area estimates and IPHC abundance estimates for Area 2C is illustrated in Figure 5. In general, the IPHC estimates are higher, by a factor of about two, than the NMFS estimates. There are two points at very high abundance where the NMFS estimates are higher and these are the 2005 and 2007 estimates for 60-69 cm halibut. Given the unsuitability of much of Area 2C bottom area for trawling, it is highly likely that the NMFS trawl survey does not survey all halibut habitat. This would result in an underestimate of halibut numbers in the NMFS trawl survey. We will inquire as to the availability of trawl swept area estimates of halibut abundance in 2A and 2B and make the same comparison, if possible at the Annual Meeting

4) The fishery in various regulatory areas catches different proportions of the available catch limit prior to the median date of the IPHC survey, yet the IPHC does not account for these differences. What is the basis for not requiring some correction to the IPHC survey CPUE index based on those removals? If the fishery has an effect on the biomass, why doesn't it have an effect on the IPHC survey? Does the assessment of this impact incorporate all removals prior to the median date (both directed and incidental)? Should we scale survey CPUE by the proportion of the annual removals taken before the survey?

In most regulatory areas, the commercial catch has little or no effect on commercial CPUE within a fishing season (Webster and Clark, 2008, Figures 3-7). The obvious exception is Area 2B, where commercial CPUE shows an initial decline each year with increasing cumulative commercial catch. A smaller decline is also apparent in some years in Area 2C.

To apply a correction to survey CPUE based on proportion of catch taken prior to each year's survey, you would need information on the relationship between survey CPUE and this proportion in each regulatory area. The proportions themselves should not be used as correction factors, as this would require making unsupportable assumptions about the strength of the relationship between survey CPUE and proportion of catch taken prior to median survey date. Data since 1998 show no apparent relationship between survey CPUE and proportion of commercial catch in any regulatory area (Webster and Clark, 2008, Figure 1). However, in most areas, survey CPUE is highly variable from year to year, and the proportions are in quite a narrow range, making it very difficult to determine if a relationship exists, and impossible to devise a sensible correction factor. There is a greater range of proportions for some statistical areas within each regulatory area, and so we looked at whether, for any regulatory area, there is a clear pattern in the relationships between statistical area survey CPUE and proportion of commercial catch taken prior to the median survey date for a statistical area. It is difficult to discern consistent patterns in any regulatory area, with each containing some statistical areas which show signs of a negative relationship and those that show an apparent positive relationship of survey CPUE with proportion commercial catch taken before median survey date (Figure 6).

Other removals, such as sport, bycatch and personal use cannot be included in these analyses because we do not have data on these removals by date.

In summary, there are no clear relationships between survey CPUE and proportion of commercial catch taken prior to the median survey date. The high variability in survey CPUE and often narrow range of the proportions mean we cannot conclude that there is no effect of catch taken prior to median survey date on survey CPUE, but if there is an effect, we cannot quantify it with sufficient precision to use it as basis for calculating correction factors for survey CPUE.

Webster, R. A., and Clark, W. G. 2008. Questions about fishery-survey interactions. Int. Pac. Halibut Comm. Report of Assessment and Research Activities 2007: 229-243.

5) Some believe the commercial fishing in the vicinity of the survey stations affects CPUE. IPHC says they see no evidence of it, but is the method of determining an effect sensitive enough to detect an effect? Can you run some tests to assess the sensitivity of your tests and what effect would removals have?

One of the ways we looked at the effect of commercial catch on survey CPUE was to plot station CPUE against commercial catch taken within a certain number of days prior to the set and within a specified distance. If commercial catch close in time and space to the survey set had a negative effect on station CPUE, then we would expect to see decreasing CPUE with increasing catch. To see how sensitive such plots are to a relationship between station CPUE and commercial catch, we simulated data that mimics observed data (in terms of mean and variance) assuming relationships of varying strengths. A detailed summary for Area 2C is available on request; results for other areas were almost identical. Our conclusion is that if a relationship is not strong enough to be detected visually in such plots, the effect on survey CPUE will be extremely small (a reduction of 2% or less). The reason for this is that relatively few survey stations have any commercial catch taken nearby (we looked at catches taken within 5 days prior to and 5 nmi of the set), and most of the remainder have relatively little nearby catch. This means that survey CPUE is very robust even under simulated strong negative effects of commercial catch.

6) We use the estimates of F from PIT tagging in the tag recovery model but not in the assessment; why not?

Tag recoveries were very low in almost all regulatory areas, and with natural mortality fixed at 0.15 in all areas, this leads to estimates of *F* (commercial fishing mortality) from tag-recovery modelling that are lower, sometimes much lower, than we think is credible. Although we still do not fully understand why, it is very likely the tag-recovery estimates of *F* are inaccurate, and for this reason they should not be used in the stock assessment modelling.

The reverse question has also been posed: if we don't believe the *F* values from the PIT tag modelling, can we run the models with the *F*s from the stock assessment, and how will that affect migration estimates? To examine this question we fixed *Fs* so that their relative magnitude among areas reflects the relative magnitude of the stock assessment values. The most striking result is that estimates of migration from Area 4A are much higher under this model. However, the model fits poorly, as forcing Area 4A to have higher relative *F* leads to fitted tag-recoveries that are much higher than those observed for this area. We do not think there is much merit to fitting models that constrain the *F*s in such a way. Estimated migration rates are effectively annual out-of-release-area recovery rates corrected for differences in tag-recovery probabilities among areas. Whatever the cause of the low tag-recovery rates, they are still what we observe, and it is appropriate when estimating migration to fit models that approximate well the observed tag-recovery probabilities. The question is not if these observed recoveries are correct (they are what they are), but rather if they're not caused by low *F*s as the model says, what is causing them?

7) The survey apportionment is unfair and we don't support it.

The survey apportionment method is the most objective, consistent and standardized method available to us to partition the biomass. There are legitimate questions about potential regional differences in catchability but nothing that we've found to date has caused us to question it as the most scientifically defensible method of accurately apportioning coastwide biomass. It is also important to understand that the apportionment process addresses biological stock management goals, not social equity. Economic impacts are clearly a consequence of the assessment and application of a harvest policy.

8) Releases of PIT tags in Area 2A coincided with changes in the regulated distribution of the commercial fisheries, with major halibut grounds closed due to bycatch concerns for other species, especially rockfishes. This should affect the recoveries of tags.

The Area 2A non-trawl RCAs cover an extensive portion of the halibut habitat and include the majority of the IPHC setline survey stations, at which tags were released in 2003. The closures, however, apply only until the end of August. This means that all tagged fish still have the potential to be captured by the commercial fleet for at least part of the fishing season. If overall harvest is reduced because of the closures, then that would lead to fewer recoveries of tagged fish, and corresponding decreases in estimates of rates of commercial fishing mortality (if we had sufficient data to attempt to estimate these). In general, changes in fishing mortality are something the tagging study is designed to measure, although with few releases in Area 2A, this would be difficult even if recovery rates were comparable to northern areas.

9) Movement patterns from PIT recoveries reflect 'artificial' regulatory area boundaries. What do the data indicate if they are partitioned into minor statistical areas?

The question here seems to be whether "migration" is simply a back and forth movement of fish across the boundaries between regulatory areas. The raw recovery data show that Area 4A and 3B releases are recovered in statistical areas throughout areas to the east, with no apparent concentration of recoveries on the boundaries of these two areas with their neighbours. The only cases where there appears to be more recoveries near the boundary are 3A releases recovered in 3B, and 2C releases recovered in 2B.

Further, if migration was simply due to boundary movements between neighbouring areas, we would expect net migration to be close to zero. The tag-recovery models produce direct estimates of emigration only: to estimate immigration rates, and hence net migration, we need to know the relative population sizes of each regulatory area. Assuming that tag-release numbers in 2003 are proportional to population size, we estimate large annual rates of net migration into 2B (+18%) and out of 4A (-13%), with net migration rates for other areas ranging from -5% to +4%.

10) Will additional PIT tagging resolve uncertainty around migration estimates?

Additional PIT tagging will not be considered until we understand why recovery rates of tags have been so low in most regulatory areas. However, if there are more data, you will get more precise estimates, and for the purpose of estimating migration rates, future studies should have a greater proportion of tags released in areas such as Area 4 and Area 2A. The primary purpose of the 2003/2004 experiment was to estimate exploitation rates, hence population size, rather than migration rates, so the experimental design was optimized for that purpose.

11) How do recovery data from surveys compare with those from commercial fisheries?

There are relatively few survey recoveries (81 in 2006 and 52 in 2007), but we can see both similarities and differences (Tables 1-4). As with commercial recoveries, in both years combined, there have been very few recoveries in Area 4 (3 in total, and none in Area 4B). Unlike commercial recoveries, few recoveries have been made outside of the area of release – just three, or 2% of the total, compared with around 16% to date for commercial recoveries. This is likely to be an artifact of revisiting release sites on the survey. Fish that return to a survey site are more likely to be recovered than those that have moved somewhere else, which is more likely to be a location between stations than another station.

12. Should IPHC apply differential mortality estimates to tagged fish based on depth of capture during tagging?

It has also been suggested that migration rates could also be made a function of depth strata on release. These are things we can explore in this year's tag-recovery modeling.

13. Do estimates of migration rates from the tag-recapture model include tagging mortality?

Tag-induced mortality was assumed to be "negligible" (i.e., fixed at zero) in the model, based on the results of holding tank studies. A working value of 2.5% has been suggested, and adding this into the model has the same effect as increasing natural mortality or tag loss rate. That is, provided it's the same for all areas, estimates of commercial fishing mortality will be affected, but migration estimates will not be significantly affected. Migration estimates depend on the relative amounts of mortality in each area, something barely affected by changing a parameter that is the same for each area. To check this, we fitted a model with a 2.5% annual tag-induced mortality rate, and as expected, while the *F*s changed, changes in migration rate estimates were miniscule.

14. The high bycatch in the Bering Sea is affecting recoveries of PIT tags.

Most of the bycatch in the Bering Sea occurs on the flats and is comprised mainly of small fish, fish smaller than those generally caught and tagged on our setline survey (e.g., 80% of the halibut captured in the 2007 NMFS trawl survey of the Bering Sea were < 55 cm). Further, with the exception of Area 4D, almost all PIT tagging was done "downstream' of where the majority of trawl bycatch is taken. These two factors make it unlikely that many PIT tags were taken in the bycatch.

Also, legal-sized bycatch is accounted for in the tag-recovery modelling as part of non-commercial removals. For Bering Sea bycatch to be a cause of low tag-recoveries in the commercial catch in Area 4 (rather than reduced commercial catch overall), tagged fish would need to have been preferentially selected by bycatch over untagged fish, something that is hard to imagine occurring.

15. Is the decline in recruitment in Area 2 caused by the increase in harvest of halibut in Areas 4 and 3? How can that be demonstrated?

Actually there is no indication of a decline in recruitment (as numbers of 8 year old halibut) in Area 2 for the last 10 years. Figure 7 shows the numbers of 8 year old halibut based on survey catch rates and bottom area for each regulatory area (top) and aggregated areas (bottom) for years 1998 to 2008. Estimates are corrected for differences in selectivity due to regional differences in size at age. The most recent recruitment estimates (2005 to 2008) include fish that have not recruited fully to the survey and therefore their estimates are less precise than those for earlier years. Even excluding those most recent recruitment estimates, the overall trend for all regulatory areas is of an increase or at least a stable recruitment level since 1998 (Figure 7).

16. The 'arithmetic' slide showing effects of undetected migrations was not easily understood.

This slide will be redesigned for all future presentations. The main point of the slide was that emigration had the same effect on estimating population size as an increase in natural mortality while immigration has the same effect as a decrease in natural mortality. It is well known, and easily demonstrated, that the natural mortality rate has the effect of scaling a population number upwards or downwards depending on its magnitude. A lower rate than that assumed inflates numbers (as occurs in Area 2) while a higher rate than assumed decreases estimates (as in Area 4).

17. Does a mismatch of the timing of migration and the timing of the survey create biases?

The survey occurs at midyear, when abundance is approximately at its average value for the year. By basing apportionment on a midyear apportionment, an equal rate of instantaneous fishing mortality among regulatory areas is achieved. The mathematical details supporting a mid-year based apportionment are available in a paper titled "Effect of migration on achievement of proportional harvest under a system of survey apportionment of total catch" by William G. Clark and can found on pages 217-219 of the 2007 IPHC Report of Assessment and Research Activities.

18. Don’t ratchet up harvest in ‘source’ areas for migration – is cutting off migration to ‘destination’ areas.

In order to answer this question we need to understand the combined impacts of fishing and migration on the dynamics of halibut across IPHC regulatory areas.

There is increasing evidence indicating that western areas have historically been exploited at lower harvest rates than areas in the eastern part of the stock. Average harvest rates estimated from the coast-wide assessment from 2001 to 2007 range from 0.15 (4A) to 0.17 (3B) in the west part of the stock and from 0.31 (2A) to 0.54 (2B) in the eastern part of the stock. The effect that different harvest rates in western areas may have on eastern areas (given the general pattern of eastern migration) can be illustrated with one of the widgets presented at the workshop. The widget simulates halibut population dynamics for areas 4A to 2A under different migration and fishing rates. For more details on the widget and underlying model please refer to the widget tutorial and presentation by Valero during the Apportionment Workshop.

Figures 8 to 12 show run results of 5 relevant scenarios to answer this question. All 5 scenarios assume a migration pattern similar to the estimated from PIT analysis. The “unfished conditions” scenario is shown in Figure 8. Simulated spawning biomass distribution is shown in the top panel, expected and observed (for the 2007 IPHC Survey) percentage of halibut older than 20yr in the survey are shown in the bottom left panel, and realized harvest rate estimated from the coastwide assessment is shown in the bottom right panel. Figure 9 represents the expected results under uniform harvest rates (0.2) across regulatory areas. Under this scenario the spawning biomass distribution is barely altered (top panel), with changes of less than 3% with respect to the unfished scenario. The percentage of simulated halibut older than 20yr decreases in all areas (as expected under exploitation) but the overall distribution pattern is similar to unfished conditions with older halibut in the western part of the stock (bottom left panel). However, the observed distribution of halibut older than 20yr (older halibut in the west than in the east) is dramatically different than that simulated under a balanced harvest rate (older halibut in the west); suggesting this scenario does not adequately capture observed conditions. Scenarios with unbalanced exploitation rates that are similar to those estimated by the coastwide model (Figure 10, bottom right panel) capture the differential distribution of older halibut (Figure 10, bottom left panel) and indicate a decrease in spawning biomass contribution for eastern areas (Figure 10, top panel).

Increasing harvest rates up to the target rate (0.2) in the western areas decreases the percentage of older fish in the western areas but have no noticeable effect either on the percentage of older fish (Figure 11, bottom left panel) or the low contribution of spawning biomass in eastern areas (Figure 11, top panel) if their exploitation rate stay at the levels estimated by the coastwide assessment (Figure 11, bottom right panel).

Conversely, decreasing exploitation rates to 0 (no fishing) in western areas has no noticeable effect in the percentage of older fish in eastern areas if they if their exploitation rates stay at the high historical levels (Figure 12, bottom panels). If anything, the relative spawning biomass contribution of eastern areas decreases given that unexploited western areas would increase their spawning biomass contribution.

In summary, the widget simulations suggest that varying exploitation rates in the western areas have little effect on the dynamics of eastern areas if exploitation rates in the east remain as high as estimated by the coastwide assessment. Uniform (balanced) exploitation rates across the distribution of the stock do not alter the relative distribution of halibut biomass under migration patterns and exploitation rates on the order of what is expected for the halibut stock and its fishery.

19. Show that survey data reflect local abundance.

A survey, by design, reflects local abundance of fish multiplied by their selectivity (which is determined by the length of the fish). It uses the same standardized gear and bait at each station and presents the only consistent measure of abundance across areas that is available. If local abundance is mainly comprised of smaller fish, i.e., smaller than the legal size limit, the survey will produce a low estimate of exploitable biomass. Harvests are set on the basis of exploitable fish, not small fish, so the survey is the appropriate apportionment method.

20. There is a mismatch between survey CPUE and commercial CPUE among areas, i.e., they don't track the same and they differ in ratio – is that evidence of catchability differences and why should the ratio be different?

The commercial fleet and the survey fish in very different ways and one would not expect the indices to have the same catch rate nor necessarily identical trends. The survey fishes the same locations with the same amount of gear every year and measures how the grand average within each regulatory area changes over time. The commercial fleet may or may not fish the same grounds but will constantly move to find the highest concentration of fish. Thus the commercial index is likely to show less decrease when overall biomass declines, a situation termed "hyperstability" in the fisheries literature. There is no means of identifying catchability differences among areas from the relative survey and commercial catch rates. What the difference in magnitude between the two may illustrate is the extent to which commercial fishing is tightly clustered in some regulatory areas.

21. How does the IPHC account for terrain differences and gear differences among areas?

The IPHC does not account for terrain differences. The design of the survey factors all forms of habitat into its method of calculating the CPUE index. Commercial CPUE is computed from fixed hook gear in all areas, though in Areas 2A and 2B snap hook gear is also included. Catch rates in the commercial fleet are adjusted for hook spacing.

22. The IPHC did some historical experimental comparisons of catchability differences between Area 3 and Area 2. Those studies indicated catchability differences, which the IPHC accepted; why are differences among areas now being rejected?

The IPHC used a catchability correction between Areas 2B and 2C/3A/3B during the mid 1980s to mid 1990s in fitting assessment models. The correction ranged from 1.0 (no correction) to 1.5 for Area 2B and 0.75 for Areas 2C/3A/3B. This practice was discontinued as more elaborate models were developed that allowed for freely varying catchability coefficients. The two studies that report on the trawl/setline catchability experiments are both replete with discussion of the very large variances (in part due to small sample sizes) in estimation of regional catchability differences. The experiments were restricted to trawlable grounds, only fish in the size range 82-99 cm were used (larger fish outswam the trawls), and there was no means of insuring that trawl catchability between the different areas was constant. For all these reasons, the conclusion that different catchabilities existed was always couched in general and highly-qualified terms. In addition, the experiments were conducted in the mid 1980s, a time when dogfish were very prevalent in Area 2B and the experimental data reflect such. Nowadays, the catch rate of dogfish is actually higher in 3A than in 2B. The presence of dogfish was generally cited as the cause of the catchability difference. As the difference in density of dogfish has since disappeared, it would make no sense to apply very uncertain results from experiments conducted 20 years ago to the situation today. That said, the time is right to revisit the question of whether a regional difference in catchability can be quantified by an updated trawl/setline study.

23. The biggest flaw in survey apportionment is that it doesn't account for migration.

This question was addressed in the answer to Question 17.

24. Use a different survey pattern in Area 2A because the grid pattern doesn't match bottom area distribution.

An analysis of station bottom depth and actual bottom depth distribution initially showed that Area 2A had a few too many shallow stations and too few deep stations. However, reanalysis of the data (summing station depths into correctly sized bins) eliminates most of the difference in the two distributions and does not indicate that a correction to the survey CPUE should be made.

25. Show that your tests of potential effects of commercial fishing on survey data are sensitive enough to detect real differences and show the impact of those differences.

This is addressed in the answer to Question 5.

26. Were the data previously presented just catch or did they include all removals?

All data presented as catches were total removals with the exception of one slide that illustrated historical commercial catches from 1895-present. The apportionment shares method that referenced historical catches in fact used total removals from each area to calculate the share.

27. Let's use a 15-yr average of commercial catch distribution by area as the basis for apportionment. Will that address stock management needs?

Figure 13 shows total CEY (Constant Exploitation Yield), Catch Limit Recommendations and Realized Harvest Rates resulting from the suggested apportionment based on a 15 year average of commercial catch distribution among Halibut regulatory areas. Figure 14 summarizes the effect of alternative apportionment methods including the 15 year average on Realized Harvest Rates.

The use of any form of catch history has the dual characteristics of both reflecting whatever annual catch limits were at the time and incorporating no feedback for changes in the stock. In the case of simply reflecting catch limits, those data will have built into them any shortcomings of the stock assessments at the time. This is particularly important when thinking of catch data as an apportionment tool for a coastwide biomass estimate because the catches in question were assigned on the basis of the closed-area assessments, which we now know to have been in error because of continuing movement of fish among areas. It was the conclusion of the 2007 Assessment Workshop and the external peer review that we cannot use a closed-area assessment for the stock, which was accepted by the Commission. Therefore, these catch limits cannot be expected to reflect true stock biomass distribution.

The lack of feedback in using a fixed average catch distribution is significant because such an apportionment will never change, in spite of any changes in the distribution of exploitable biomass. That those changes have, and will, occur is amply demonstrated by both the catch history by area and the area-specific biological characteristics of the stock, which are not dependent on any estimation or model-based process. Any improvements to individual areas resulting from decreases in current exploitation rates will never be reflected in fixed catch-averaging.

28. Use a blend of survey and commercial data in the apportionment index.

This point was also raised during the 2007 IPHC Stock Assessment Workshop and it was addressed in its Final Report, page 17, Question 22:

http://www.iphc.washington.edu/halcom/meetings/workshop2007/SAW07Reportfinal.pdf

In most fisheries the use of CPUE (survey or commercial) as an index for abundance has traditionally assumed a proportional relationship to abundance. However, that relationship is not always proportional and CPUE can decline faster than abundance (hyper-depletion) or slower than abundance (hyper-stability). Commercial CPUE indices are likely to be hyper-stable, that is: they tend to remain at stable values even when abundance drops. Some of the reasons behind commercial CPUE hyper-stability are the ability of fishermen to obtain relatively high CPUE even when abundance is declining by distributing their effort to productive areas, and post-fishing redistribution of fish resulting in concentration of fish in areas preferred by fishers. Commercial CPUE is also likely to be biased due to changes in gear, technology and fishers' behavior. Some of the major world fishery collapses (from forage fish to marine mammals) have been attributed to hyper-stability of commercial CPUE and its use as an index of abundance. In contrast to commercial CPUE, survey CPUE is a better index of abundance by being highly standardized and consistent both in spatial coverage and time of the year, gear and overall sampling methodology. Mixing commercial and survey CPUE will incorporate the potential biases of commercial CPUE into the resultant apportionment index. In theory, this could be addressed by giving different weights to each CPUE index. However, it would likely be difficult to find a consistent and objective way to assign weights between CPUE indices.

29. Can the IPHC demonstrate the benefits to coastwide and regulatory area management?

We take this question to mean one of two things: 1) the benefits of coastwide vs. closed-area assessments, because under either assessment scenario the Commission continues to enact regulatory area management, i.e., catch limits are set by individual regulatory areas; or 2) should we use the same exploitation rate in every regulatory area?

The first question of coastwide vs. closed-area assessment was the topic of the 2007 workshop and our external peer review, reported here:

http://www.iphc.washington.edu/halcom/meetings/workshop2007/wrkshp2007.htm

As a result of staff reports and the external peer review, the Commission accepted the need for a coastwide assessment framework at the 2008 Annual Meeting. Accordingly, and given the inability to assess exploitable biomass accurately using closed-area assessments, the staff therefore uses this coastwide assessment approach. The errors resulting from incorrectly using the closed-area approach were detailed at the 2007 workshop.

The second question is a question of basic biology. The two scenarios are: using a common exploitation rate, or using individual area-specific exploitation rates. We have shown in previous analyses that the Bering Sea Regulatory Areas constitute an area of lower productivity and are using a target harvest rate of 0.15, with all Areas from 4A eastwards using a target harvest rate of 0.2. It is fair to question whether we need to use a constant exploitation rate within each of these two production areas. It is clear from all previous tagging studies that there is substantial movement of fish for annual reproductive activities, with a general movement toward the central Gulf of Alaska. The relative contribution of the individual regulatory areas to the coastwide spawning biomass is far from equivalent and reflects the spawning biomass in each area. What is of great concern in a biological sense is that the composition of the spawning biomass in each area differs not just in the magnitude of that spawning biomass, but also in its composition (Figure 15). As a result of very high recent exploitation rates in Area 2, the spawning biomass is composed almost exclusively of fish < 20 yr old, and there is a large difference in reproductive capacity between the spawning biomasses in Areas 2 and 3. Over the past several years, removals from Area 2 have been around 32% of the coastwide removals, but Area 2 contributes just 20% of the female spawning biomass. This truncated age composition in Area 2 means that the reproductive value (the per unit spawning contribution over the fish's lifetime in the exploitable stock) of recruiting fish in this Area is substantially below that of recruiting fish in Area 3 (or Area 4).

Why is this disparity important? Halibut have evolved in response to a specific set of environmental challenges that has resulted in selection for its mode of lifetime reproductive contribution. This means that the long-term distribution of halibut biomass is dependent upon, among other things, a common contribution in terms of the reproductive value of fish from all areas. Persistence of the halibut stocks in individual areas is therefore a function of their reproductive contribution. The high exploitation rates in Area 2 relative to other areas have substantially altered the reproductive contribution from Area 2, both in terms of historical contribution and also that which would occur in the absence of exploitation. To ignore this change, is to ignore the necessity for the reproductive characteristics that have evolved within the halibut population. We do not know with certainty whether the reproductive contribution from a given regulatory area has a direct bearing on the reproductive success in recruitment to that area. However, basic biological principles argue that we should maintain the relative contributions to the reproductive output of the stock. If we do not do so, we are undertaking a substantial gamble that these evolved characteristics of the halibut population have no meaning in its persistence. The Precautionary Approach to fisheries management requires that we respect these biological principles in our management strategy and the Commission's harvest policy enacts that approach.

30. Migration widget uses constant recruitment pattern; simulate something more realistic.

The Migration-Fishing widget presented at the Apportionment Workshop assumes that recruitment does not change during the simulated model run (100 years). Area specific recruitment was based on the area specific average recruitment estimates for the 1995-2005 period derived from closed-area assessments. This was only a first approximation and we are currently working with more realistic recruitment scenarios that will be presented at upcoming meetings.

31. Can the IPHC show the potential mid-term impact of estimates of the projected strong incoming year-classes?

Average recruitment for the 1988 to 1997 year classes is estimated to be around 12.5 million eight year olds. Estimates of recruitment numbers for the 1999 and 2000 year classes are around 31.5 million eight year old halibut. In Figure 16, the expected contribution of these different levels of recruitment is illustrated. From an average recruitment of 12.5 million halibut, average annual yield at a harvest rate of 0.20 would be approximately 5.4 million pounds over 10 years with catch peaking when the fish are 13 years of age (5 years from present). From an average recruitment of 31.5 million halibut, average annual yield over a ten year horizon (at a harvest rate of 0.20) would be 13.5 million pounds, again peaking at age 13

32. Hook competition not equal across areas but the IPHC is ignoring it.

This is equivalent to a differential catchability argument among regulatory areas. We did make an analysis of hook competition (see pages 211-215 in the 2007 RARA) and found little difference in hook competition – in terms of baits still remaining – for Areas 2B through 4A. There is some evidence of increased hook competition in 2A and decreased hook competition in Areas 4B and 4CDE. Adjusting CPUE on the basis of this study remains an option but the differences are relatively minor.

33. The PIT tag data show almost no movement between Area 3A and 2C – that can't be true.

It isn't true. We presented estimates of annual emigration rates from the tag-recovery modelling that showed a rate of emigration from Area 3A to Area 2C that, to the nearest 1%, was zero. That figure does not tell the full story. The estimated emigration rate from Area 3A to 2C is actually 0.4% (SD=0.1%). While this seems very small, Area 3A has a much larger population than Area 2C and the number of fish moving into 2C from 3A is a much larger proportion of the Area 2C population size than it is of 3A population. The tag-recovery model estimated an annual migration rate of 3% from 2C into 3A. Assuming that tag-release numbers are proportional to population size (see Question 9 above), we get an estimate of annual immigration into 2C from 3A that is around 2%, not large, but not zero either. The model estimate of annual migration from 3A to 2B is also 0.4%, implying that 3A makes a similar contribution to migration into 2B.

34. The ages on the slide of average survey age and %> 20 y old don't match data on p.517 of 2007 RARA. Why not?

The slight mismatch between the slides in the presentation and the data on p. 517 of the RARA is mainly due to the display of combined sex age data in the presentation while the RARA listed data segregated by sex. A very small source of difference comes from an updating of ages following quality control of ages that is done after initially data are collected for the RARA.

35. Is there information on survey catchability from survey recoveries of PIT tags?

In the PIT tag study, all halibut caught on the first three skates of the 2003 setline survey were tagged and released, resulting in tagging rates that were proportional to survey catch for each area. If catchability is the same in each regulatory area, this design should also lead to releases that are proportional to area abundance. If the equal catchability assumption holds, then we can expect survey tag recoveries per scanned fish to be approximately equal among areas. A lower rate of recoveries would be evidence of lower survey catchability in the release year, while a higher rate would imply higher catchability.

Taken at face value, the combined 2006-07 survey recovery rates imply higher survey catchability in Area 2B, and lower catchability in Areas 4A and 3A (Table 5). However, the rates are not precisely estimated, and we cannot rule out other factors affecting these values, for example, greater site fidelity of tagged fish in some areas than others.   Nevertheless, if the concern is that survey CPUE apportionment is unfair on Area 2 because catchability is lower in that area, these data provide no evidence to support that concern.

NOTE: The following figures make extensive use of color, which is not conveyed well in black and white. Full-color figures can be viewed here:

http://www.iphc.washington.edu/halcom/meetings/workshop2008/summary/qncomm.pdf

Table 1. Survey recoveries in 2006 of PIT tags released in 2003, by release and recovery area.

Release Area (2003)	Recovery Area (2006)						Total
	4D	4A	3B	3A	2C	2B	
4D	1						1
4A							0
3B			16	2			18
3A				12			12
2C					6		6
2B						6	6
Total	1	0	16	14	6	6	43

Table 1. Survey recoveries in 2006 of PIT tags released in 2004, by release and recovery area.

Release Area (2004)	Recovery Area (2006)						Total
	4D	4A	3B	3A	2C	2B	
3A				34			34
2B						4	4
Total	0	0	0	34	0	4	38

Table 2. Survey recoveries in 2007 of PIT tags released in 2003, by release and recovery area.

Release Area (2003)	Recovery Area (2007)						Total
	4D	4A	3B	3A	2C	2B	
4D							0
4A		2		1			3
3B			11				11
3A				7			7
2C					1		1
2B						5	5
Total	0	2	11	8	1	5	27

Table 3. Survey recoveries in 2007 of PIT tags released in 2004, by release and recovery area.

Release Area (2004)	Recovery Area (2007)						Total
	4D	4A	3B	3A	2C	2B	
3A				24			24
2B						1	1
Total	0	0	0	24	0	1	25

Table 5. Setline survey recovery rates of 2003 releases per 10 000 fish scanned calculated from combined 2006 and 2007 scanning data

Catch area	Legal halibut scanned (10 000s)	Tag recoveries	Recoveries per 10 000 scanned (SD)
4D	1 561	1	6 (6)
4A	4 404	2	5 (3)
3B	25 107	27	11 (2)
3A	42 818	22	5 (1)
2C	7 314	7	10 (4)
2B	4 627	11	24 (7)
Coastwide	90 974	70	8 (1)

List of Figures

Figure 12. Widget screenshot for Scenario 5, “No fishing in Western areas”.

Figure 13. Widget screenshot illustrating Total CEY (Constant Exploitation Yield), Catch Limit Recommendation and Realized Harvest Rate resulting from an apportionment based on a 15 year average of commercial catch distribution among Halibut regulatory areas.

Figure 14. Widget screenshot summarizing the effect of alternative apportionment methods on Realized Harvest Rates among Halibut regulatory areas.

Figure 15. Characteristics of halibut female spawning biomass. Top plots shows estimated distribution of spawning biomass by regulatory area, as estimated from survey catches of female halibut. Bottom plots shows average age of spawning females by regulatory area. The thick line in the bottom plot is the coastwide average age.

Figure 16. Illustration of the relative contributions to exploitable biomass and yield for two different levels of recruitment. The top panel shows the decline in numbers at age. The middle panel shows expected annual contribution to exploitable biomass at age and the bottom panel shows expected contribution to catch (yield). Age is synonymous with year (e.g., 8 or 2008) and both trajectories assume an annual harvest rate of 0.20.

2B 3A

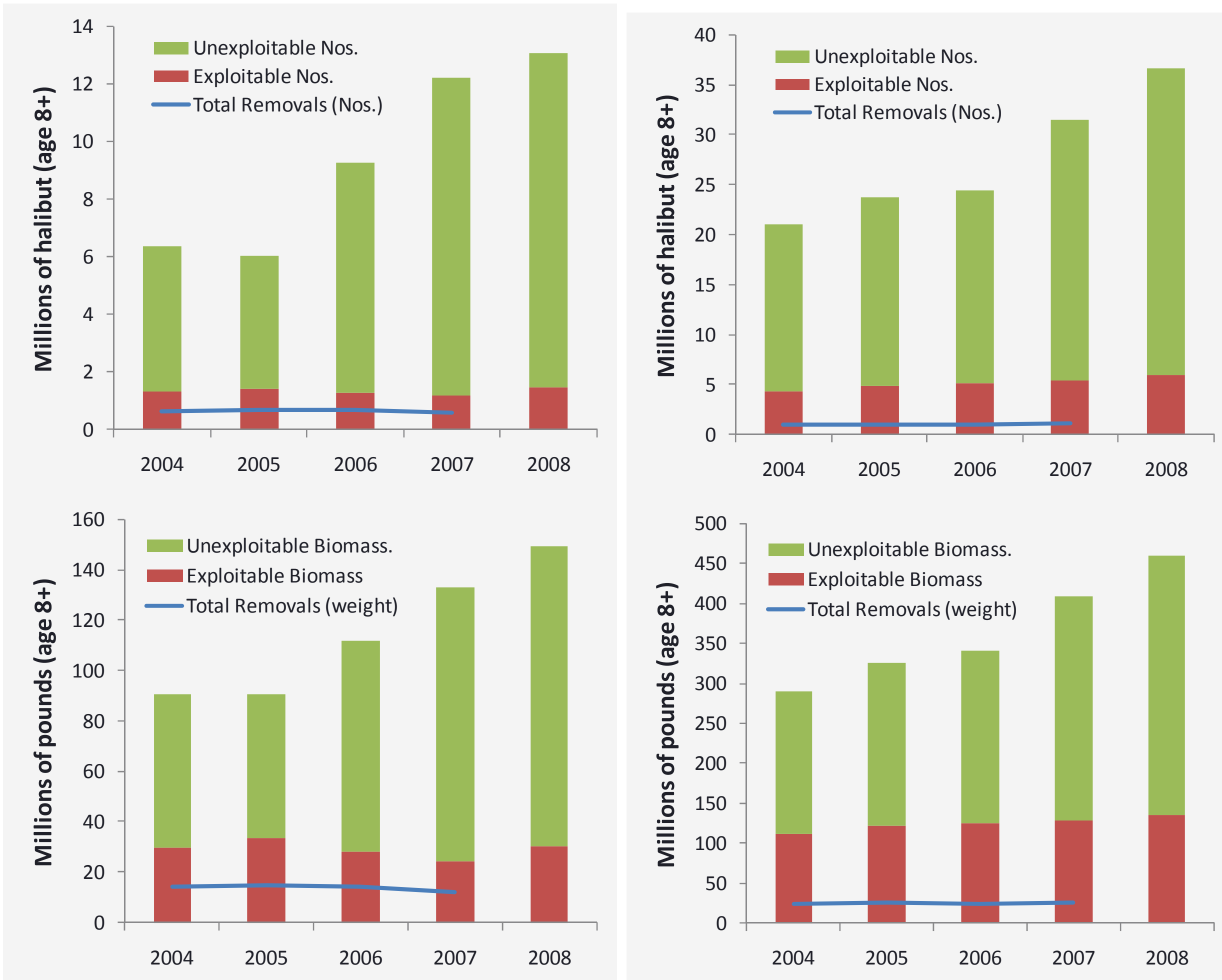


Figure 1. Estimates of halibut numbers (top plots) and weight (bottom plots) in Area 2B (on the left) and 3A (on the right) for 2004-2008. The plots show estimated numbers and weight of exploitable halibut, unexploitable halibut and actual removals for 2007. The biomass only counts fish aged 8 and older thus the unexploitable biomass and numbers are understated (there is almost no commercial catch of fish younger than 8).

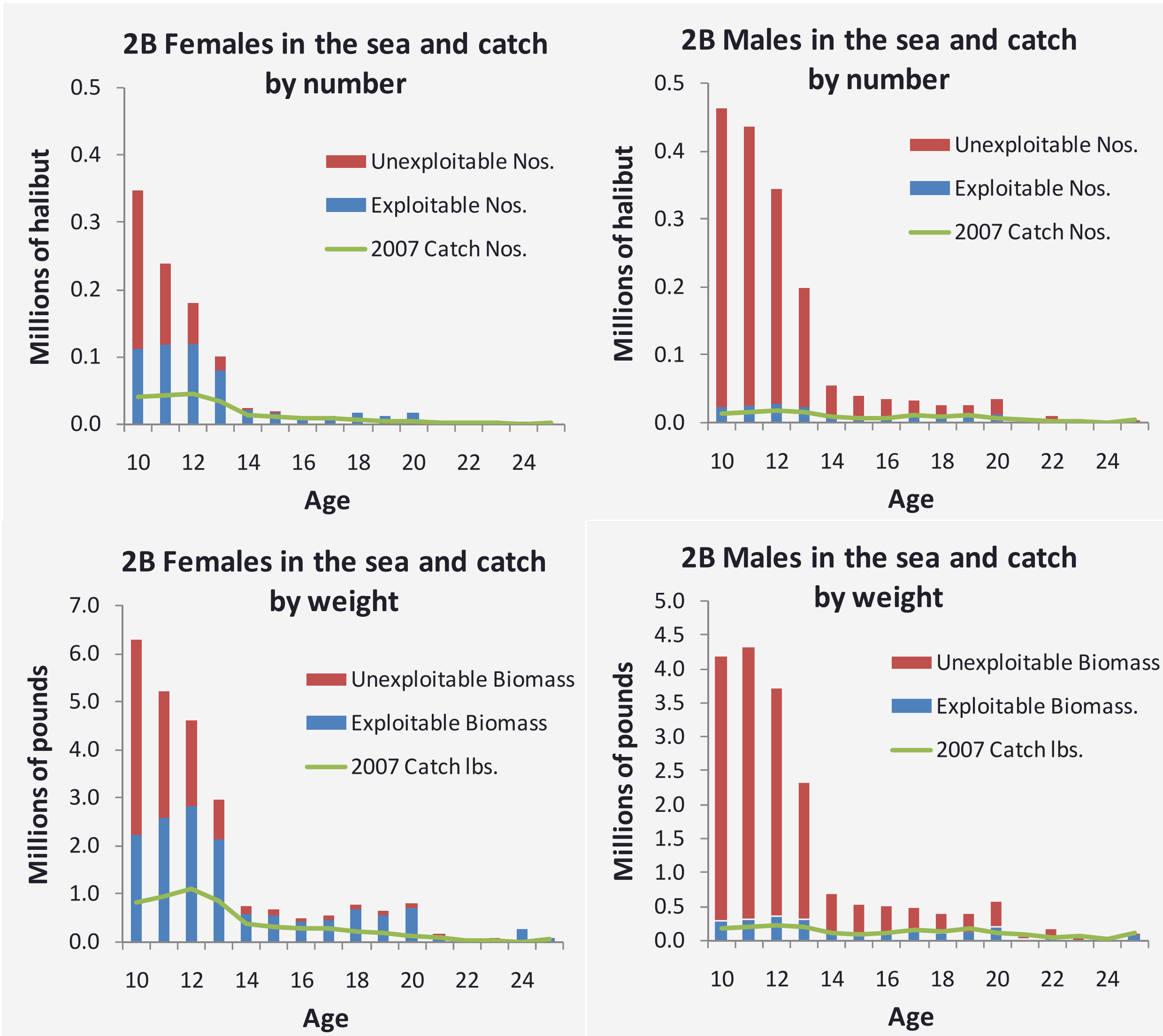


Figure 2. Breakdown of estimated exploitable and unexploitable numbers and biomass and actual removals of halibut by age and sex in Area 2B in 2007. Numbers are shown only for ages 10+ as inclusion of ages 8 and 9 would make values for older ages almost imperceptible. For comparison, the estimated number of age 8 females is approximately. 2.7 million, compared to an estimated total of 0.63 10 year olds.

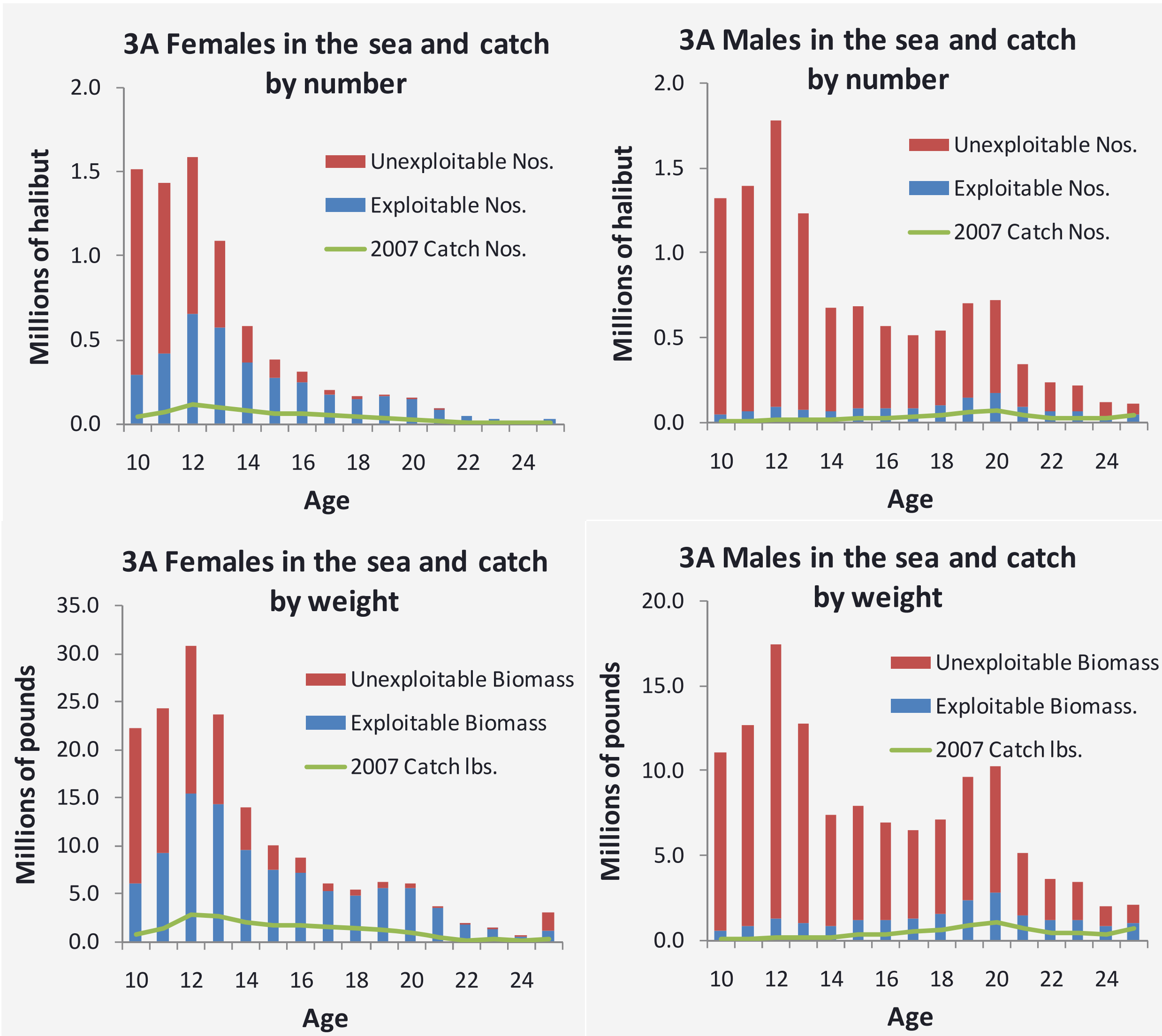
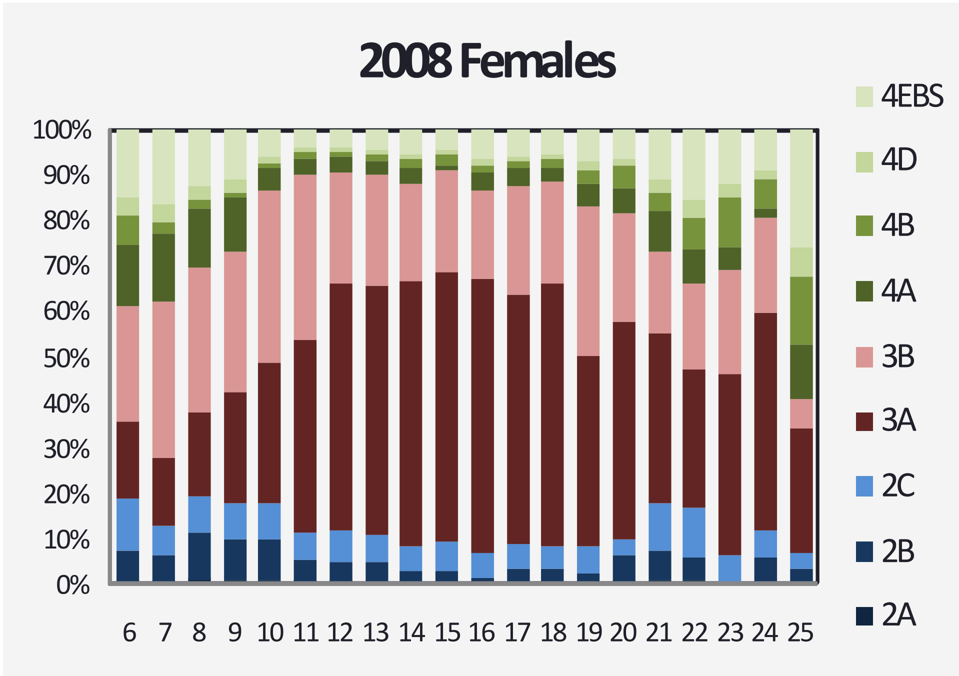


Figure 3. Breakdown of estimated exploitable and unexploitable numbers and biomass and actual removals of halibut by age and sex in Area 3A in 2007. Numbers are shown only for ages 10+ as inclusion of ages 8 and 9 would make values for older ages almost imperceptible. For comparison, the estimated number of age 8 females is approximately. 4.3 million, compared to an estimated total of 1.51 10 year olds.



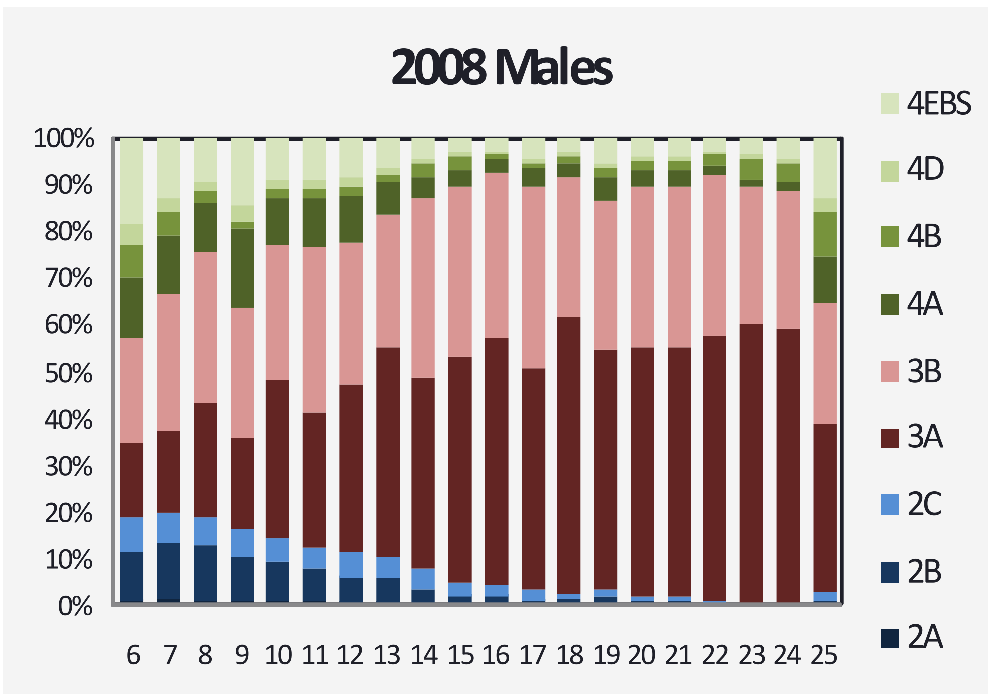


Figure 4. Estimated relative distribution of halibut ages 6 to 25 (which is a plus group) among IPHC Regulatory Areas. Estimates are derived from area weighted catch rates, corrected for differences in selectivity due to regional differences in size at age, on the IPHC setline survey and are not derived from a model.

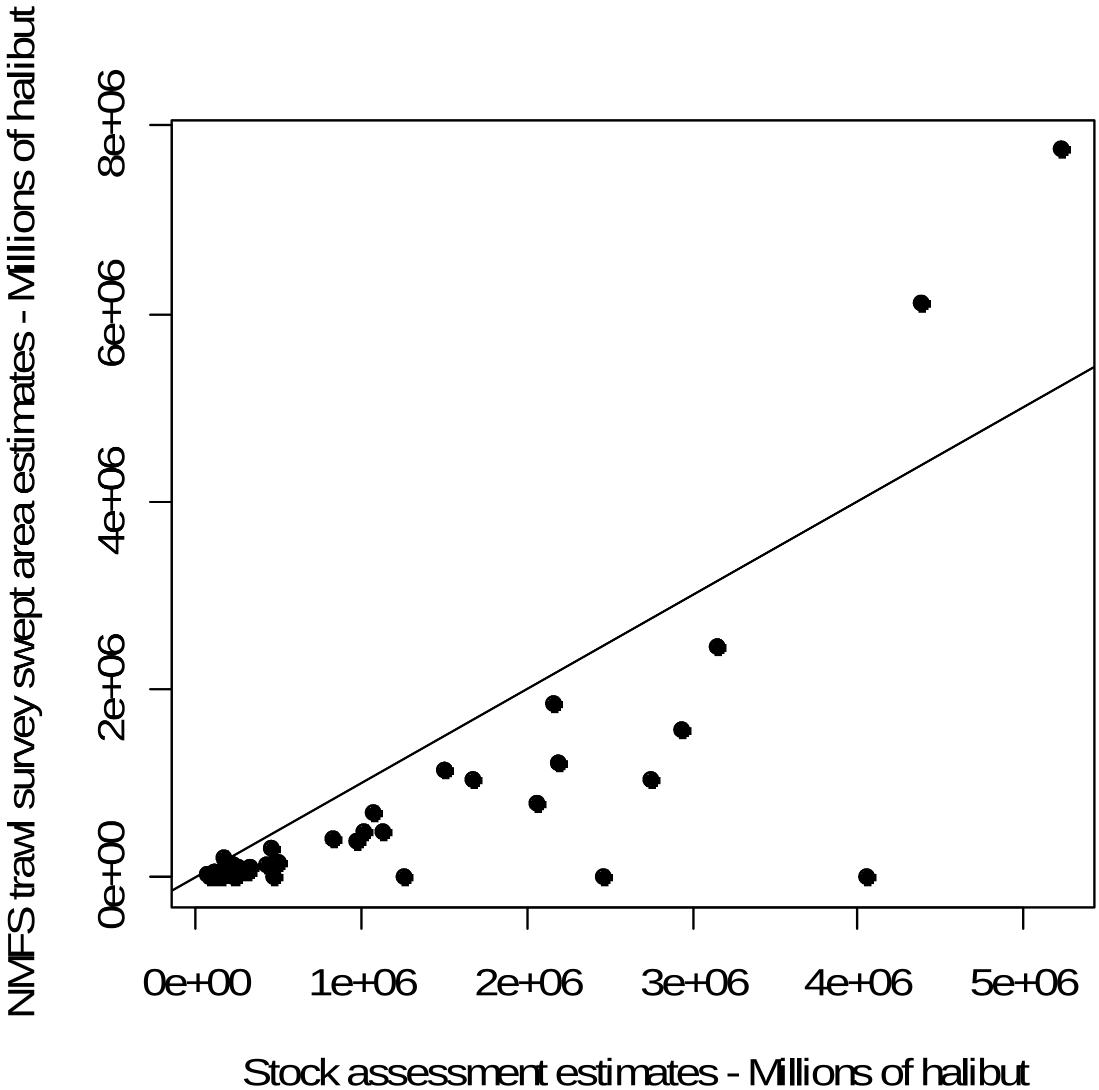


Figure 5. Comparison of population estimates between the IPHC stock assessment and NMFS trawl survey swept area estimates for regulatory area 2C. Each dot represents one year's estimate of fish in a 10 cm group (60, 70, 80, 90, 100, 110, 120+). A 1:1 line is illustrated for reference.

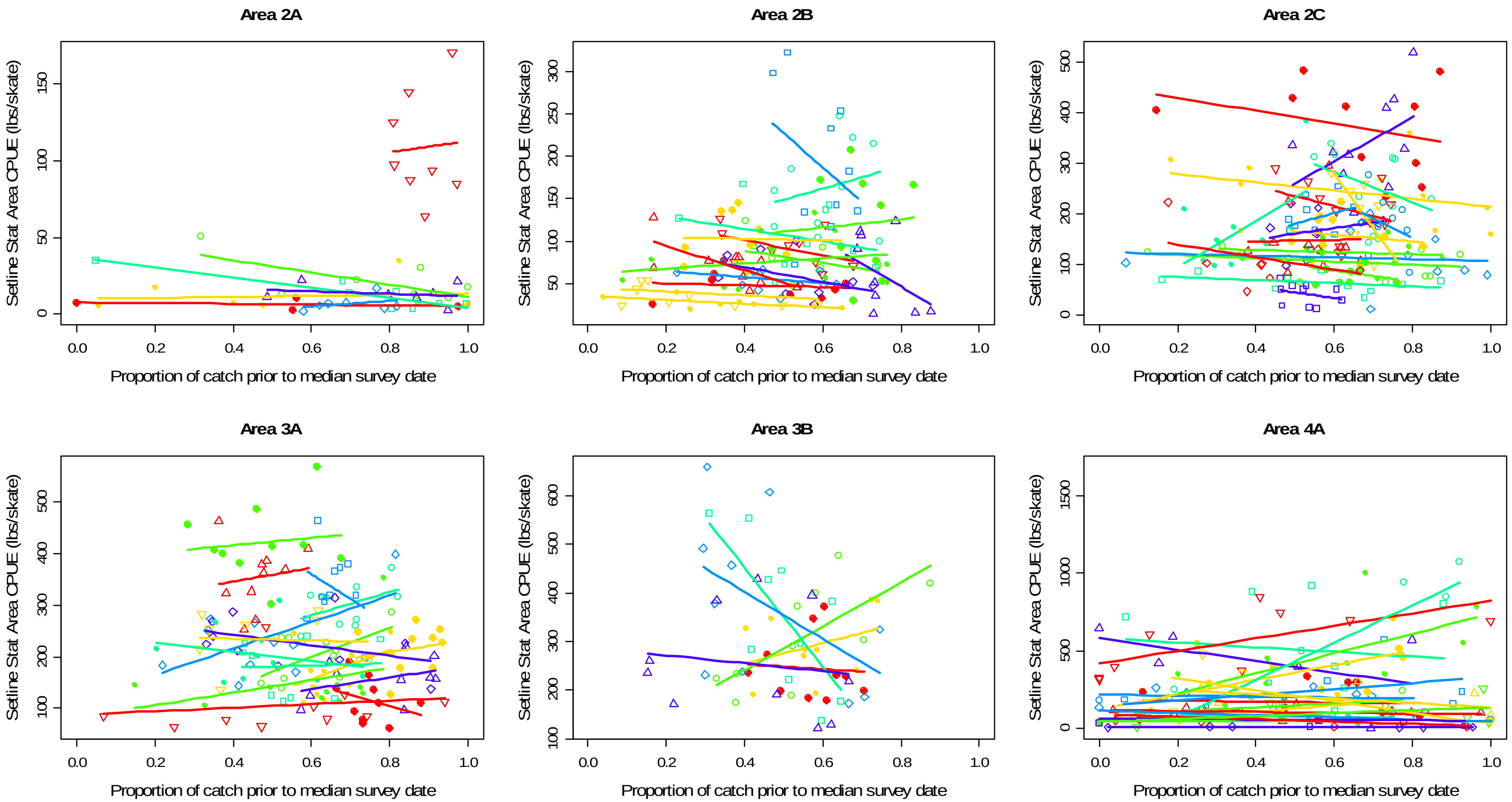
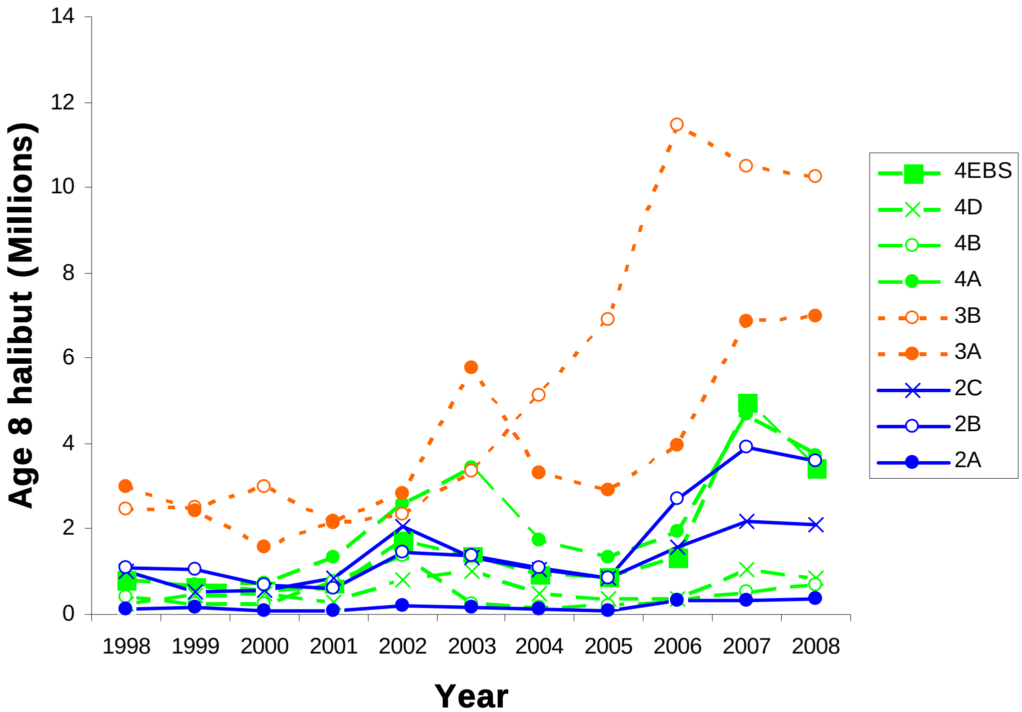


Figure 6. Relationship between survey CPUE at a statistical area and proportion of commercial catch taken in that area prior to its median survey date. Each point represents the CPUE for one statistical area in one year (1998-07). The lines are estimated linear regression lines for each statistical area. Data for different statistical areas are distinguished by colours and symbols.



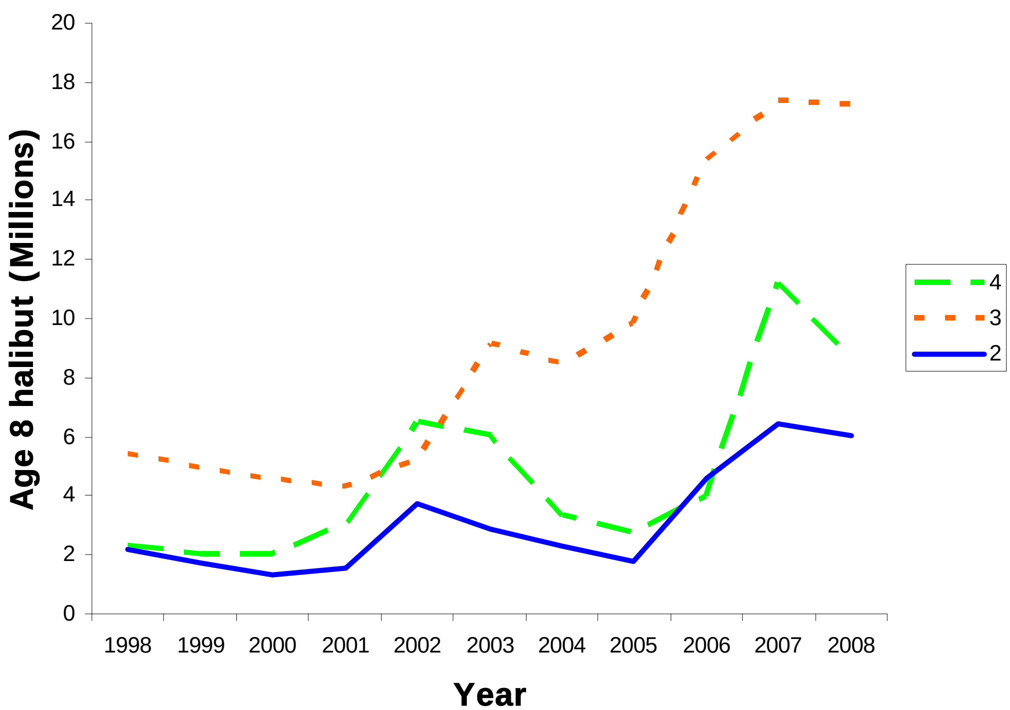


Figure 7. Halibut recruitment as numbers of 8 year olds for each regulatory area (top) and aggregated area (bottom) for years 1998 to 2008. Recruitment was calculated from survey catch rates and bottom area, corrected for differences in selectivity due to regional differences in size at age.

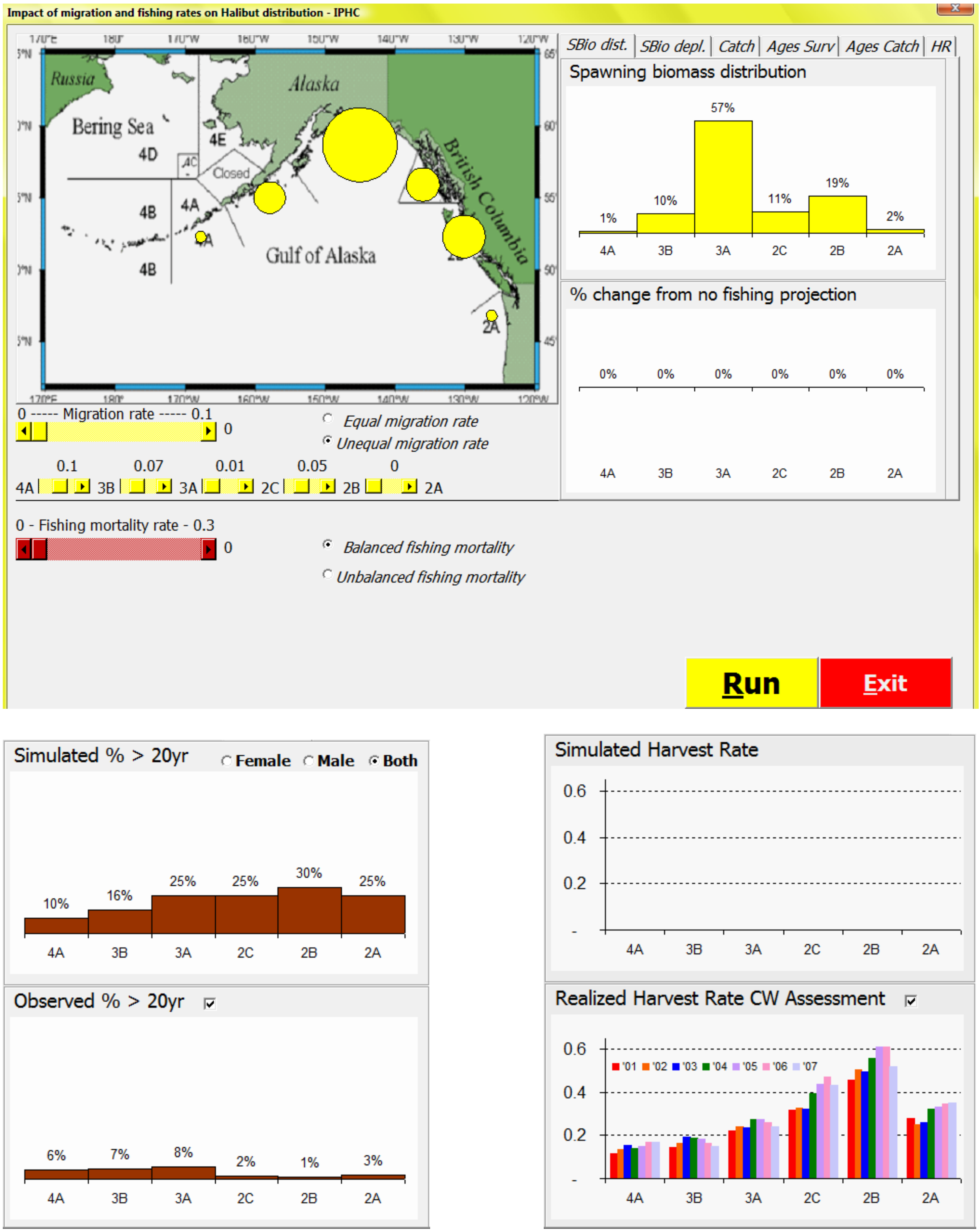


Figure 8. Widget screenshot for Scenario 1, "Unfished conditions"

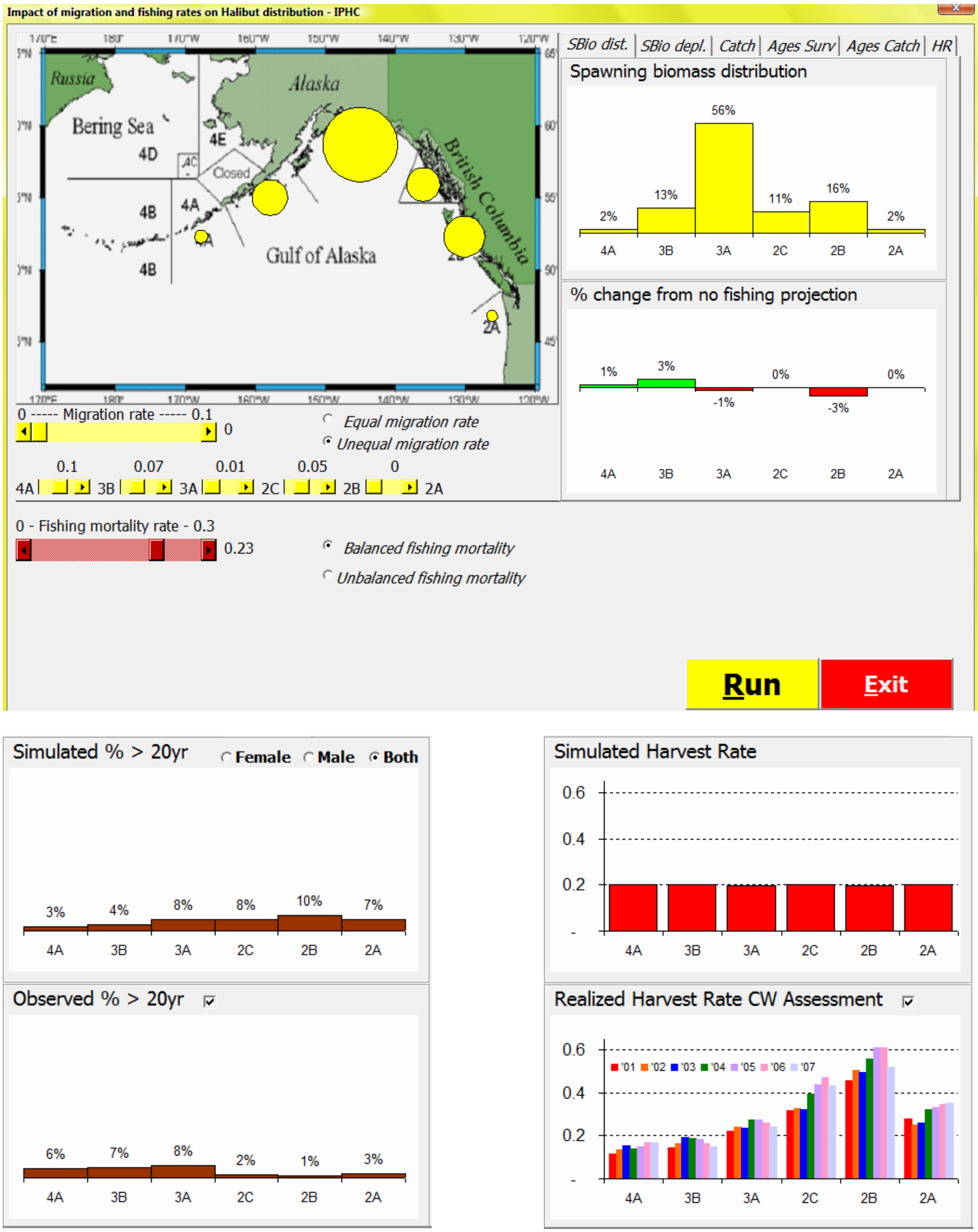


Figure 9. Widget screenshot for Scenario 2, “Proportional harvest rate”

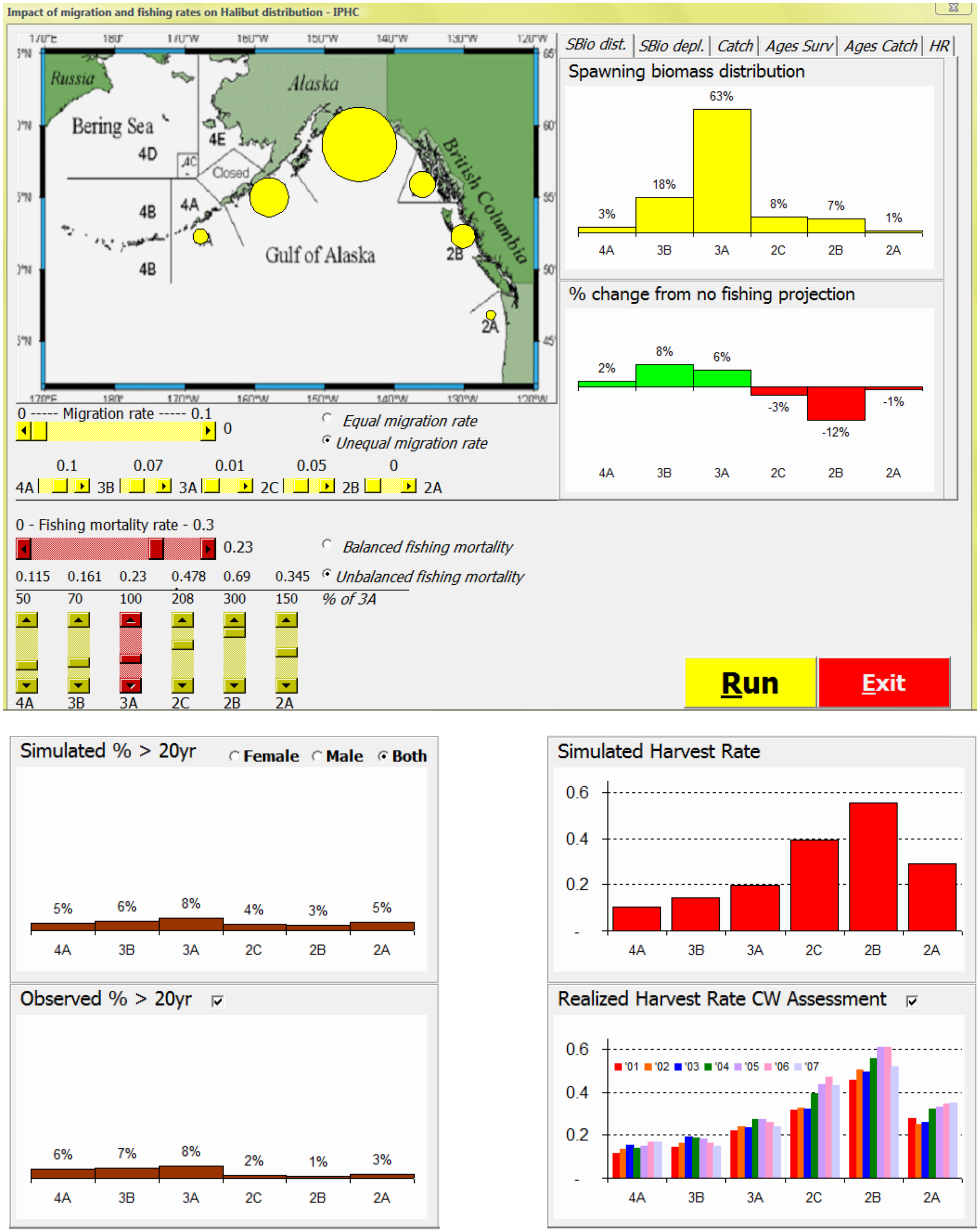


Figure 10. Widget screenshot for Scenario 3, "Historical realized harvest rates"

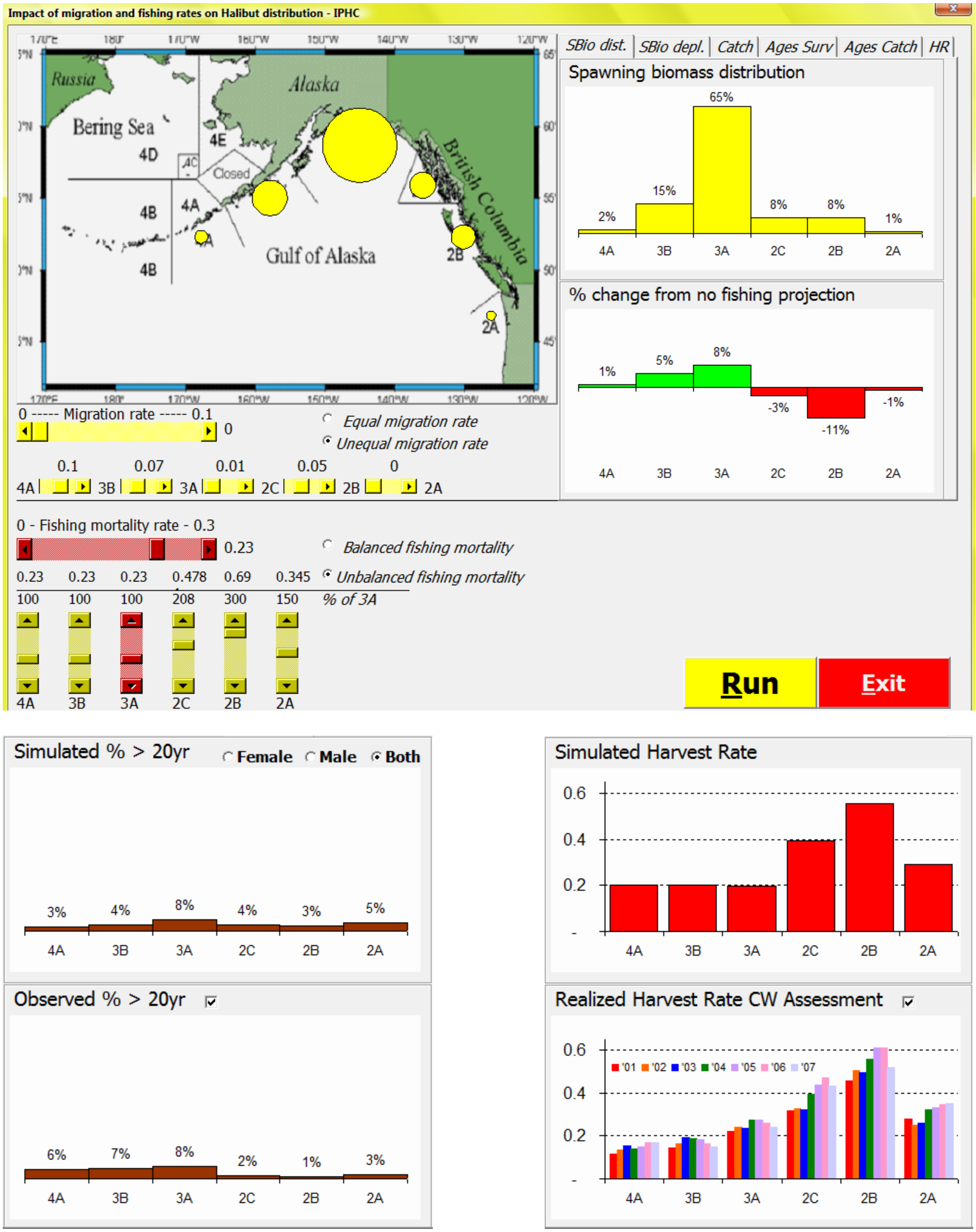


Figure 11. Widget screenshot for Scenario 4, "Target harvest rate in Western areas"

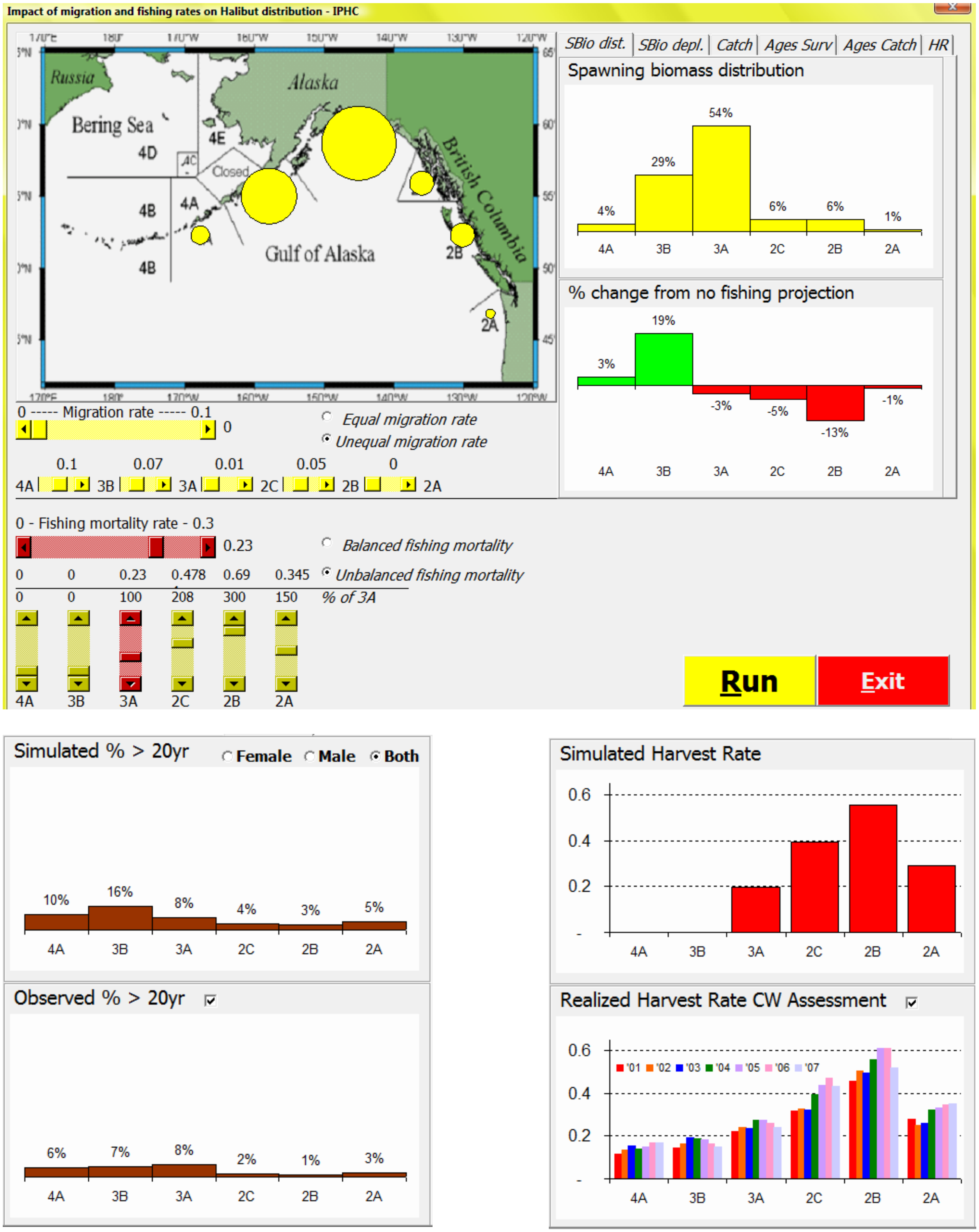


Figure 12. Widget screenshot for Scenario 5, "No fishing in Western areas"

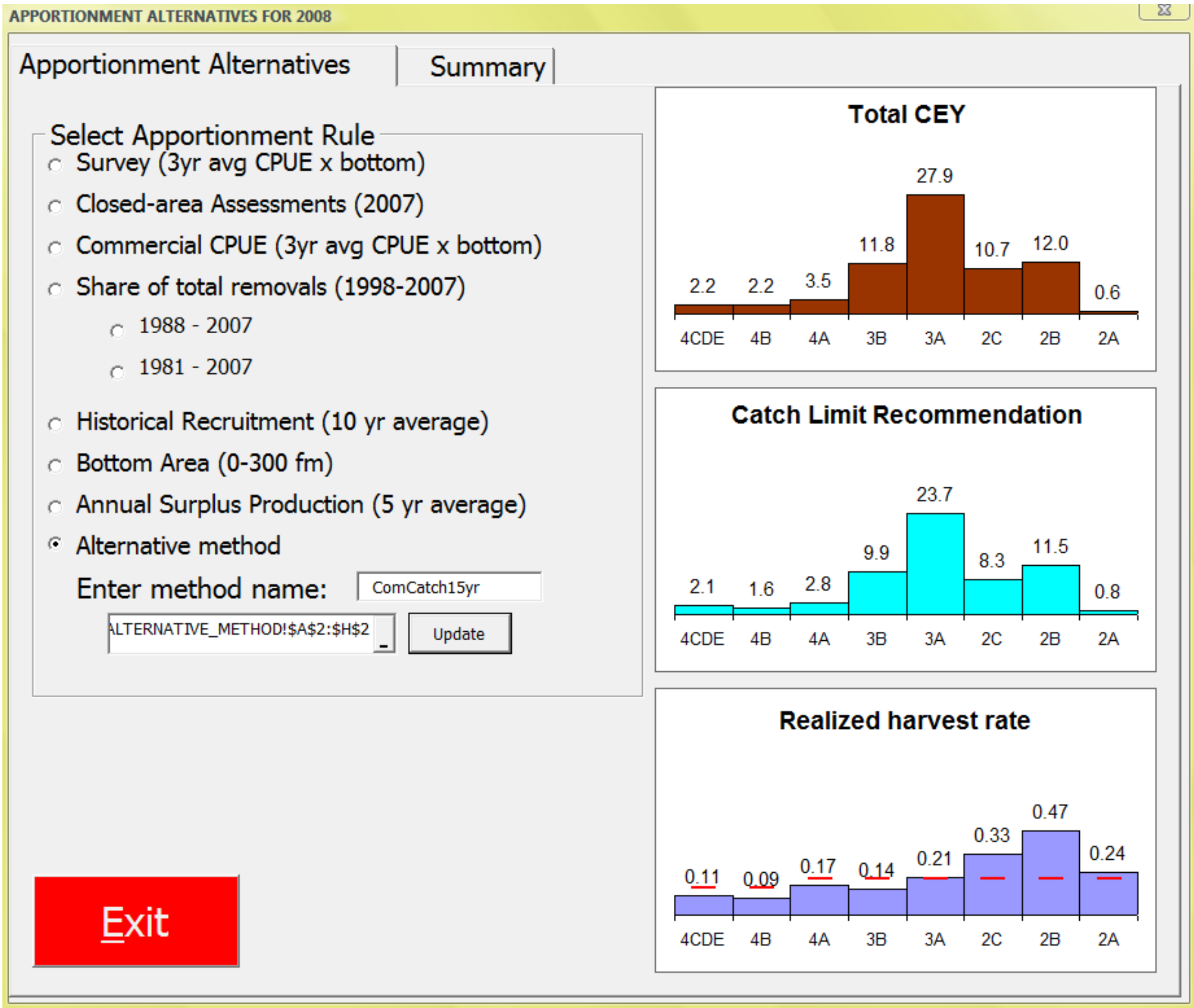


Figure 13. Widget screenshot illustrating Total CEY (Constant Exploitation Yield), Catch Limit Recommendation and Realized Harvest Rate resulting from an apportionment based on a 15 year average of commercial catch distribution among Halibut regulatory areas.

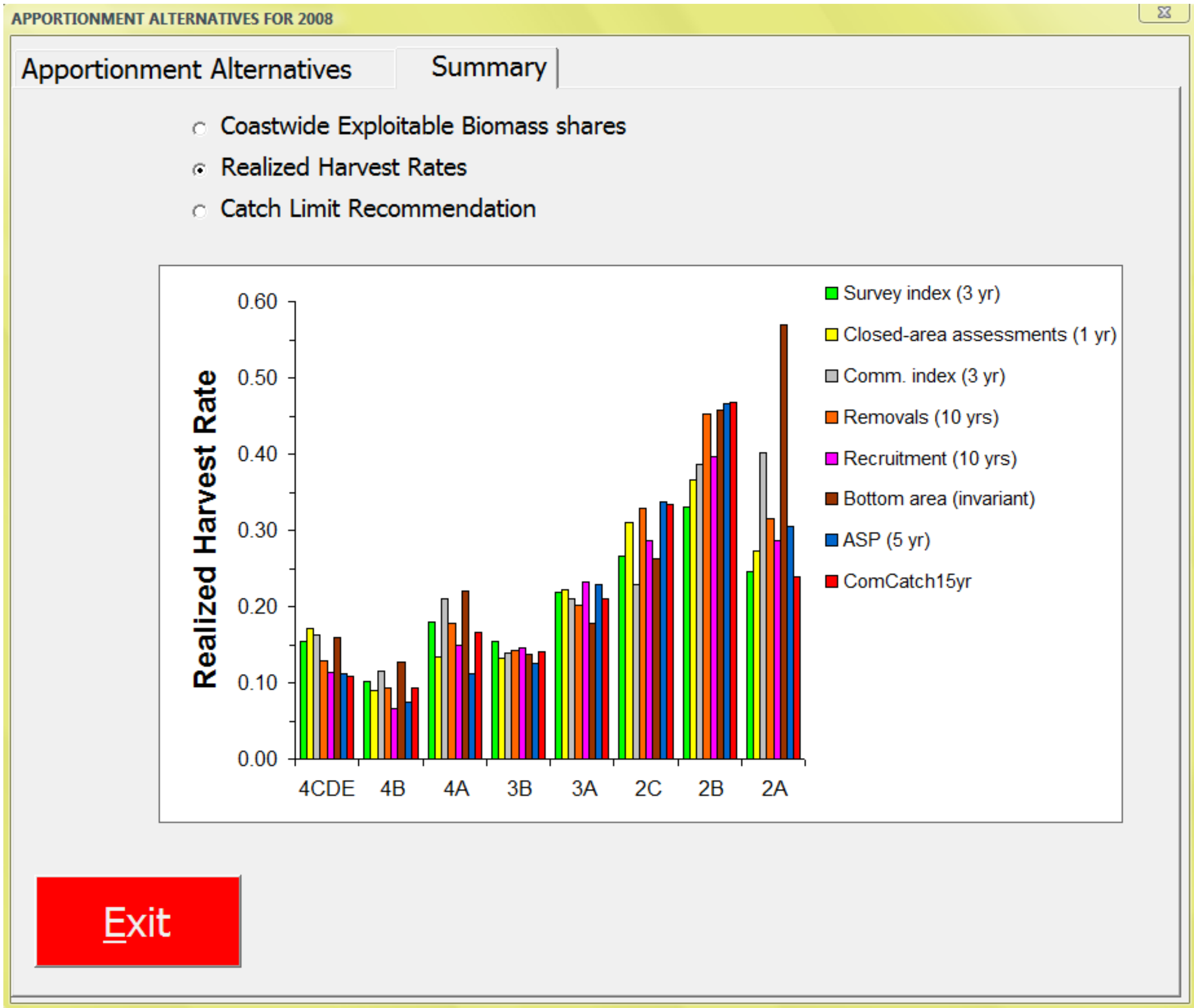
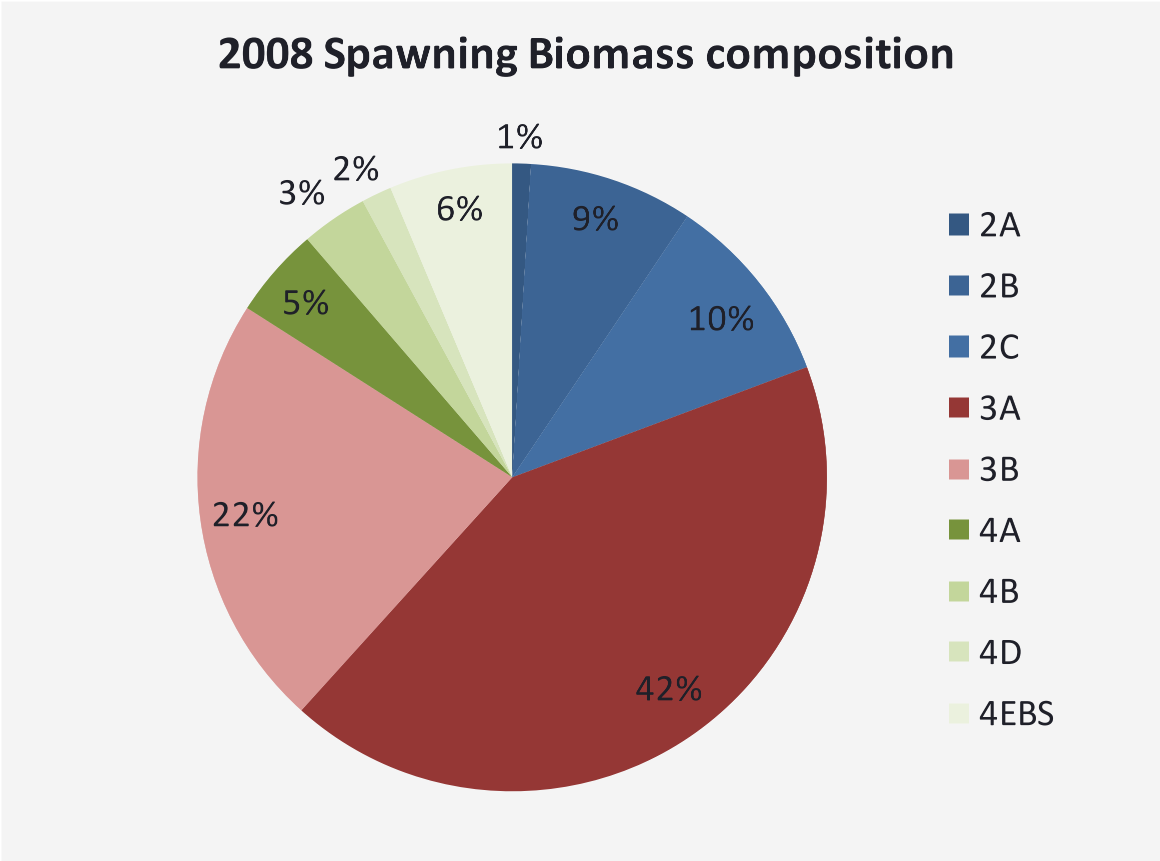


Figure 14. Widget screenshot summarizing the effect of alternative apportionment methods on Realized Harvest Rates among Halibut regulatory areas.



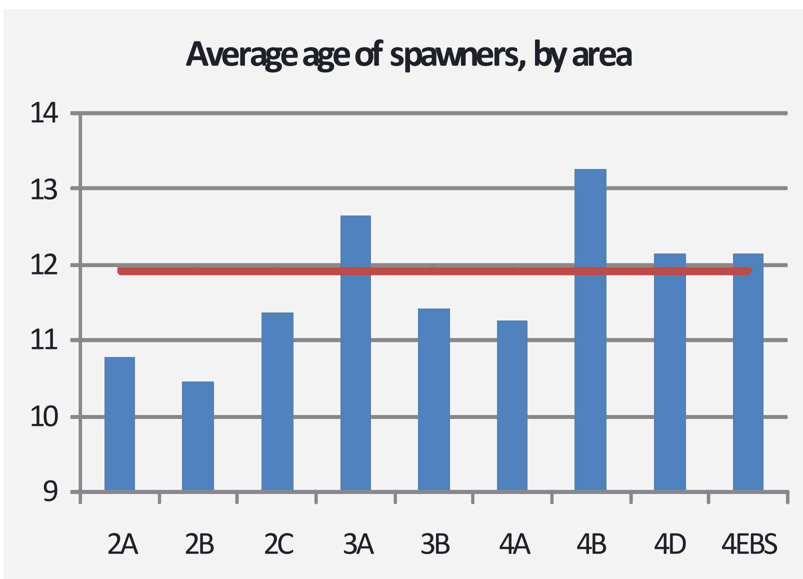


Figure 15. Characteristics of halibut female spawning biomass. Top plots shows estimated distribution of spawning biomass by regulatory area, as estimated from survey catches of female halibut. Bottom plots shows average age of spawning females by regulatory area. The thick line in the bottom plot is the coastwide average age.

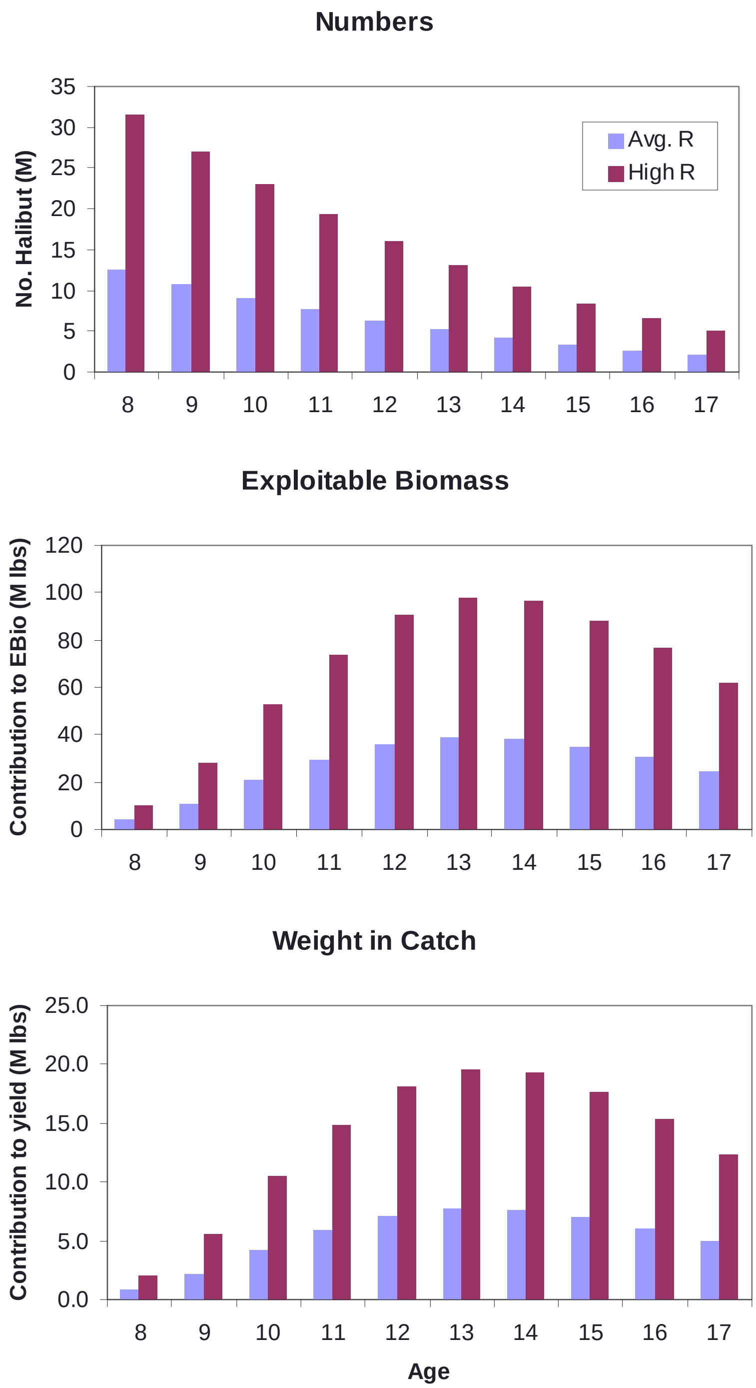


Figure 16. Illustration of the relative contributions to exploitable biomass and yield for two different levels of recruitment. The top panel shows the decline in numbers at age. The middle panel shows expected annual contribution to exploitable biomass at age and the bottom panel shows expected contribution to catch (yield). Age is synonymous with year (e.g., 8 or 2008) and both trajectories assume an annual harvest rate of 0.20.