Setline survey-based apportionment estimates

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Abstract

Setline survey weight per unit effort (WPUE) of halibut is used to estimate how the coastwide stock is distributed among regulatory areas. We describe revisions to the calculation of the survey WPUE time series made in 2014, and review the survey timing and hook competition standardisations, and three-year smoothing, that are applied to WPUE for apportioning the stock. The effects of adjustments to the WPUE index made by these standardisations are described, along with the effect on apportionment of the use of data from deep water habitat in computing WPUE. Apportionment estimates at the beginning of 2015 indicate that Areas 2A, 2B, 2C, and 4CDE are at or near the highest proportions of the coastwide stock estimated since 2000. In contrast, Areas 3B, 4A, and 4B currently comprise much less of the stock than in previous years.

Introduction

Since 2007, the IPHC has used the setline survey mean weight per unit effort (WPUE) index of density for O32 halibut (fish greater than 32 inches in length) weighted by bottom area to estimate the distribution of the stock among regulatory areas, a process known as apportionment. This method was reviewed by the IPHC’s Scientific Review Board (SRB) in 2013 (Cox et al. 2014). Two adjustments to the raw WPUE index are made in order to account for important factors known to influence survey catch rates of halibut. Adjustments for survey timing and hook competition are intended to improve standardisation of the WPUE index by accounting for differences among regulatory areas in the timing of the survey relative to the fishery, and in the degree of competition with halibut for baits.

In this report, we briefly describe the two adjustments we make to the survey index, and the three-year reverse weighting applied to produce the WPUE index used for apportionment. The effects of these modifications to the raw index are shown, and the resulting estimates of the proportion of stock in each area are presented. We also discuss the effect on apportionment of survey expansions in Areas 2A and 4A in 2014, and the use of data (IPHC setline survey and sablefish longline survey data) to estimate WPUE in deep waters (Webster et al. 2015).

Revisions in 2014

The computer code for processing setline survey data to calculate WPUE and NPUE indices was completely rewritten in 2014. The following revisions replace quantities that were previously fixed in the code, with calculations from data from IPHC database files, allowing estimates to be updated if any changes are made to the raw data, and making it clear within the code how estimates are derived:

- Correction factors for historical survey expansions are now calculated from the raw data for Areas 2B, 3A, and 4A. Previously these were fixed quantities, the derivation of which was unclear in some cases. Estimates of these correction factors use years up to 2006, so that they reflect spatial patterns of density within each area in the years closest to those
gaps in survey coverage that the adjustments correct for.

- Separate correction factors are now calculated for O32 WPUE and NPUE, and total WPUE and NPUE. Previously, correction factors were calculated only from O32 WPUE data and applied to all WPUE and NPUE indices.
- Estimates from Area 2A stratified surveys in 1995 and 1997 are recalculated from the raw data instead of coded as fixed quantities.
- Missing values in the Area 4D Edge time series (1998 and 1999) are now estimated using linear interpolation, consistent with what has been done for Area 2A. The previous approach was to use values from neighbouring regulatory areas for missing values in the times series of Area 4CDE component areas.
- Survey data from Area 4C in 1997 is used for first time: only stations within current Area 4IC boundaries are included for consistency with data from 2006 onwards.
- Missing values in the Area 4IC and 4ID time series from 1997-2005 are estimated after multiplying the mean ratio of total Area 4CDE values to 4CDE without 4IC and 4ID from 2006-2014, by 4CDE values without 4IC and 4ID from 1997-2005. This approach is consistent with how ratios are used to calculate correction factors for incomplete coverage in other areas, and replaces the use of values of neighbouring areas for missing values in Areas 4IC and 4ID.

As most of the revisions described above apply to historical data, they have no effect on the current apportionment estimates, although they can affect our understanding of the historical distribution of the stock. Other changes and updates that directly affect current and recent WPUE and NPUE indices and, therefore, this year’s apportionment calculations are as follows:

- Area 4N (northern Bering Sea) data updated to include new Norton Sound survey data from 2014.
- Bottom area for Area 2A revised to include area from 39-40°N covered by the 2014 setline survey, giving a new bottom area estimate of 17,507 nmi².
- Data from deep and shallow survey stations (outside of standard 20-275 fm survey depth range) included in calculation of indices and adjustment factors for Areas 2A and 4A.
- For Area 2A, coastal gaps, Puget Sound (Salish Sea), and N California adjustment factors all updated using new data.
- Use of sablefish longline survey data to create indices for halibut density for 275-400 fm.

The final three items on the above list are discussed in more detail in Webster et al. (2015).

**Survey timing standardisation**

The amount of commercial catch taken prior to the IPHC setline survey varies with both regulatory area and time (Webster 2009). In areas where removals are greater early in the season, expected survey WPUE will be lower on average than in areas where removals occur later in the fishing season. Concern about the effect of removals on survey WPUE is particularly strong in Area 2A, where typically over 80% of the removals are taken prior to the mean survey date, much higher than all other areas (Webster 2009, Webster and Hare 2010). The current approach, detailed in Webster and Hare (2010), is to standardise WPUE to its expected value if 50% of all O32 removals had been taken prior to the mean date of the setline survey in each area. All data inputs for calculating the timing standardisation have been updated in 2014.
Hook competition standardisation

The fraction of baits that remain on the survey gear on retrieval within each regulatory area is used to compute an adjustment factor for hook competition (Clark 2008, Webster et al. 2011). If a smaller than average proportion of baits are returned, an area’s WPUE index is adjusted upwards because higher competition for baits in that area would likely have had a negative effective on the halibut catch and therefore on that area’s WPUE. Conversely, an area with more than the average rate of baits returned will have its WPUE index adjusted downwards. This approach is intended to avoid the situation where differences in abundance of non-target species among regulatory areas would create bias in the observed WPUE index of density. Methods for calculating the hook competition adjustments followed those used in previous years (Clark 2008, Webster and Stewart 2013).

Three-year weighting

In addition to the two adjustments, WPUE for apportionment is also smoothed using a 75:20:5 reverse weighted averaging of the current and previous two year’s adjusted WPUE values for each area derived from a Kalman filter-type analysis of survey data (Webster 2011). This weighting is intended to improve precision of the WPUE estimates, without introducing significant bias from including past observations.

Apportionment results

Current (2015) and revised historical apportionment estimates of stock distribution are presented in Table 1, while 2015 estimates are also shown in Figure 1. Compared to the revised estimates for the start of 2014, the proportions in most areas are estimated to have changed relatively little. Only two areas have a change of greater than 1% of the coastwide stock: Area 3B, down 1.5%, and Area 4CDE, up 1.1%. The current O32 halibut biomass is estimated to be roughly divided into thirds: one-third in Area 2 (2A, 2B, and 2C), one-third in Area 3A, and one-third in Areas 3B-4CDE (Table 1, Fig. 1). This distribution represents a very pronounced change from historical values: we estimate that in 2000, roughly two-thirds of the stock was distributed in Areas 3B-4CDE, and only 12.4% in Area 2. In the intervening 15 years, each of Areas 3B-4B have shown a declining trend in their proportion of the coastwide stock, while the Bering Sea (4CDE) has remained relatively constant, with a slight increase at the end of the series (Table 1, Fig. 2). The biggest change has been the increasing percentage of the stock estimated to be distributed in Area 2, particularly over the last five years. These trends reflect survey WPUE indices in areas Areas 3B-4B that declined more rapidly than in the central and southern Gulf of Alaska, and recent increases in WPUE in Area 2.

Figure 3 compares the 2015 apportionment estimates with the estimates for 2014 calculated from the 2013 apportionment process (Webster and Stewart 2014). For most areas, this comparison agrees closely with the comparison in Table 1 described above, and therefore reflects trends in the underlying WPUE indices. Where it does not, this is due to the inclusion of data for deep water (275-400 fm) regions in the WPUE index for the first time, and to the survey expansion in Area 4A in 2014. Thus, the higher WPUE found on expansion stations in Area 4A this year (Webster et al. 2015), including in deep water, has contributed to the 1% increase in its estimated share of the coastwide stock from the estimate generated last year (5.7% to 6.7%). Area 2A is also affected by
the deep water expansion, with the estimated 0.2% decrease in its share of the stock due to zero survey catch in deep water in 2014 and its relatively high proportion of stations in deep water compared to other areas. The expansion of the survey to include stations between to 39°N and 40°N in Area 2A this year had negligible effect on apportionment, as no halibut were caught on these new expansion stations: the increase in bottom area for Area 2A was cancelled out by the decrease in mean WPUE over the whole area due to zero catch on the stations within this region.

Estimates of the percentage of O32 removals taken prior to the mean survey date are shown in Figure 4. Area 2A again had a high proportion of removals taken prior to the mean survey date in 2014, and the survey timing standardisation only has an appreciable effect on the WPUE index in this area (Fig. 5). Rates of bait returns were highest in Area 4B (Fig. 6), implying that competition with halibut for the baits is lowest in this area. Areas 2A, 3A, and the Area 4 island regions (4IC and 4ID) all showed declines in returned baits, while other areas were either stable (Area 2C) or had decreases in the proportion of hooks returning with bait. These data led to the calculation of positive adjustments due to competition in Areas 2A, 3A, and 3B, a negative adjustment in Area 4B, and little to no adjustment in other areas (Fig. 7).

The effects of the timing and hook competition standardisations, and the three-year weighted averaging, on WPUE for each area are shown in Figure 8. In recent years, the most notable effects of the two standardisations have been to adjust the index upwards in Area 2A, and downwards in Area 4B. The adjusted, three-year weighted averaged WPUE values in Figure 6 are weighted by bottom area in the 0-400 fathom range to produce the survey biomass index for each area used in estimating the apportionment values in Table 1.
References


Table 1. Estimated percentages of the coastwide stock in each regulatory area by year. Values were calculated using the adjusted O32 WPUE with the three year weighted averaging described in the text. In some years, row totals do not sum exactly to 100% because of rounding.

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<th>Year</th>
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<th>2B</th>
<th>2C</th>
<th>3A</th>
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Figure 1. Estimated O32 apportionment percentages for 2015 based on setline survey WPUE.
Figure 2. Estimated trends in O32 apportionment percentages over the last 16 years (estimates for 2000-2015).
Figure 3. Comparison of apportionment estimates of stock distribution calculated for the beginning of 2014 and 2015. The 2014 values are those estimated during the 2013 apportionment process, and differ from the revised values in Table 1.
Figure 4. Estimated percentage of O32 halibut removals taken prior to the mean setline survey date, by area and year. Includes commercial catch, wastage, sport catch in Areas 2A, 2B, 2C, and 3A, bycatch, personal use, and survey and other research catch.
Figure 5. Survey timing adjustment factors that are applied to setline survey WPUE for apportionment, by area and year.
Figure 6. Percentage of setline survey hooks returned with baits by area and year. Area 4S is the southern portion of the eastern Bering Sea, surveyed in 2006 only, while Areas 4ID and 4IC are the island portions (St Matthew, Pribilofs) of Areas 4D and 4C respectively. Here Area 4D means the Area 4CDE Edge.
Figure 7. Hook competition adjustment factors that are applied to setline survey WPUE for apportionment.
Figure 8. Comparison of survey WPUE without adjustments (Raw WPUE), with both timing and hook competition adjustments applied (Adj WPUE), and with adjustments and a 75:20:5 weighting of the three most recent years’ values (Adj with KF).