Estimating Effort from Instantaneous Counts: A Comparison of Analysis Approaches Using 2010 Victoria Area Recreational Survey Data

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by

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We performed a preliminary examination, using the 2010 Victoria area recreational creel survey data, to determine if more precise estimates of catch, CPE, and effort could be obtained by stratifying the data beyond the methods currently used. We focused our analysis on calculating activity profiles, which are then used to estimate daily effort from effort counts obtained from aerial surveys. Current methods generate activity profiles that are based on relatively coarse-scale geographical gradients. In the Victoria area this means using interview data across all surveyed access sites to develop activity profiles. We explored the possibility of stratifying the current interview data to generate more sub-area specific activity profiles in three ways. First, we generated activity profiles based on interview data from only landing sites specific to the subarea of interest. Second, we generated activity profiles based on interview data information based on targeted subarea fished. Third, we generated activity profiles based on species targeted by a particular fishing party. We evaluate approaches using effort and the catch of the most desired species in the area – chinook salmon (*Onchorhynchus tshawytscha*) and halibut (*Hippoglossus stenolepsis*). The results indicate that utilizing any of the three methods proposed in this study generally do not improve the precision of the catch and effort estimates relative to the current method. This is despite the relatively large interview sample sizes associated with this area. This study suggests that despite the coarse-scale geographical range over which activity profiles are generated, there is no consistent increase in precision by stratifying the data according to landing sites specific to subareas. Furthermore, incorporating information from fishing party interviews such as the targeted subarea and targeted species did not improve precision of catch or effort estimates. Thus, our results suggest that incorporating this information into current analysis methods will not lead to better estimates of catch and effort. However, we highlight additional areas where analysis methodology should be further reviewed.

RÉSUMÉ

Ma, B.O., Pickard, D.C., and O'Brien, D.S. 2012. Estimating effort from instantaneous counts: A comparison of analysis approaches using 2010 Victoria area recreational survey data. Can. Manuscr. Rep. Fish. Aquat. Sci. 3005: vii + 44 p.

Nous avons effectué un examen préliminaire à l'aide des données de l'enquête par interrogation des pêcheurs menée dans la région de Victoria en 2010 afin de déterminer s'il était possible d'obtenir des estimations plus précises des prises, des prises par unité d'effort et des efforts grâce à la répartition des données au-delà des méthodes actuellement utilisées. Notre analyse était axée sur le calcul des profils d'activités, qui permettent d'estimer les efforts de pêche quotidiens à partir des efforts observés au moyen de relevés aériens. Les méthodes actuelles génèrent des profils d'activités basés sur des gradients géographiques dont l'échelle est relativement grossière. Dans la région de Victoria, cela signifie l'utilisation de données d'entrevue dans l'ensemble des sites d'accès recensés pour élaborer des profils d'activités. Nous avons étudié la possibilité de répartir les données d'entrevue actuelles pour créer des profils d'activités propres aux sous-zones. Nous avons tout d'abord créé des profils d'activités basés sur les données d'entrevues menées uniquement aux sites d'atterrissage propres à la sous-zone d'intérêt. Nous avons ensuite créé des profils d'activités basés sur les données d'entrevue concernant la sous-zone de pêche ciblée. Par la suite, nous avons créé des profils d'activités basés sur les espèces ciblées par un groupe de pêcheur précis. Nous avons évalué les approches en utilisant les efforts et les prises des espèces les plus recherchées dans la zone, c'est-à-dire le saumon quinnat (*Oncorhynchus tshawytscha*) et le flétan (*Hippoglossus stenolepsis)*. Les résultats indiquent que l'utilisation d'une des trois méthodes proposées dans la présente étude n'améliorait généralement pas la précision des estimations sur les prises et les efforts par rapport à la méthode actuelle, et ce, malgré la taille relativement grande de l'échantillon des entrevues liées à cette zone. La présente étude suggère que malgré l'aire de répartition imprécise utilisée pour créer les profils d'activités, la répartition des données selon les sites d'atterrissage propres à une sous-zone ne mène pas à l'augmentation constante de la précision. De plus, l'inclusion des renseignements tirés des entrevues menées auprès de groupes de pêcheurs, y compris la sous-zone et les espèces ciblées, ne permet pas d'améliorer la précision des estimations sur les prises et les efforts. Par conséquent, nos résultats suggèrent que l'inclusion de ces renseignements dans les méthodes d'analyse actuelles ne mènera pas à l'amélioration des estimations sur les prises et les efforts. Cependant, nous soulignons d'autres zones où il faudrait mener un examen plus approfondi de la méthode d'analyse.

1.0 INTRODUCTION

Recreational fisheries in the Victoria – Sooke area have and continue to be very active. In 2011 an estimated 32,600 boat days of effort were deployed in the area and there was an average of 33,900 boat days recreational fishing effort per year over the most recent five years. This recreational fishery is one of the largest in the South Coast Region, representing about 18% of all South Coast recreational fishing effort (Pacific Fishery Management Areas 11 through 29). The most sought after fishes in the Victoria-Sooke area are chinook salmon (*Onchorhynchus tshawytscha*) and halibut (*Hippoglossus stenolepsis*). Fisheries and Oceans Canada (DFO) uses recreational creel survey data, i.e. data on the catch and effort from the recreational fishery, for a variety of management and monitoring purposes including providing estimates for domestic and international assessment and management purposes, measuring the success of management measures, and population health through adipose clip information and genetic samples. Thus, the accuracy and precision of estimates of catch and effort in the area is important.

Recently there has been concern that the methods used by DFO are overestimating the impact of the recreational fisheries on fish populations in the Victoria area. Of particular interest is the current DFO method for estimating fishing effort, specifically the methods used to expand relatively instantaneous aerial survey counts to daily effort (i.e., activity profiles). Activity profiles are defined as the pattern of fishing activity over hourly time blocks within a day. This information is generated from fishing time information collected through interviews of returning anglers. Activity profiles are used to generate estimates of daily effort from aerial survey counts, and when combined with catch per effort (CPE) data, are used to calculate catch. Past studies in the Strait of Georgia have examined the effect of sampling effort (aerial surveys and/or landing site interviews) on estimate precision (English et al. 1986, 2002, Korman et al. 2005). Unlike these other studies we examine the potential to improve precision of effort estimates by including existing but currently unutilized information from interview data in activity profile calculations. In theory activity profiles are specific to a subarea on a specific day type (weekday or weekend) in a specific month. There are five subareas in the Victoria area; however, current methods generate a single activity profile (for each day type – weekday or weekend) for the entire Victoria area. Furthermore, DFO collects per fishing party interview data (by boat trip) that is not utilized by current methods, including information on the targeted subarea and the targeted species. This information could potentially be useful in developing more precise estimates of effort and catch.

The analysis presented here examines the current methodologies used to estimate catch, CPE, and effort using 2010 recreational creel survey data from the Victoria area. The relatively large amount of interview data in the Victoria area makes it a good case study for other areas where surveys are conducted. Specifically, we explore three approaches for potentially increasing the precision of activity profiles:

1) *Based on close proximity access sites* – subarea-specific activity profiles were based on how close the geographic location of the access sites were relative to the subarea of interest
2) *Based on target subarea* – subarea-specific activity profiles were based on subarea fished as reported during fishing party interviews
3) *Based on target species* – activity profiles based on the targeted species reported during fishing party interviews.

The performance of the different methods of generating activity profiles is evaluated on the bias and precision, measured as standard error, relative to the current analysis methodology. We focus our analysis on the two major species of interest in the area – chinook salmon and halibut.

2.0 METHODS

2.1 DESCRIPTION OF THE VICTORIA AREA RECREATIONAL FISHERY

Recreational fisheries in the Victoria Area are focused in the Canadian waters of Juan de Fuca Strait (JdF) south of Vancouver Island. The fishery is most active between Sheringham Point in the West and Cadboro Point to the East. The fishery is shoreline focused for salmon and focuses further offshore for halibut. Halibut fisheries are. Salmon fisheries target primarily chinook year-round, but also coho, sockeye and other salmon species during return migrations. The halibut fishery is most commonly associated with the relatively shallow Constance Bank South of Victoria and has occurred from March to December in the past. In 2011 and 2012 there were conservation related closures of the recreational halibut fishery in early September. There is also a strong fishery for other groundfish, particularly rockfishes, and invertebrates in the area. The Victoria Area recreational fishery is one of the largest in the South Coast of British Columbia with nearly 35,000 recreational fishing boat trips per year on average over the past five years.

The Victoria Area recreational fishery is divided into five creel-subareas for recreational catch estimate purposes: 19B, 19C, 19D, 19E, and 20D that include portions of Haro Strait and JdF (Figure 1). Within this area, interview data are collected from different boat-access sites, which are typically marinas or boat launches. Interview data was collected from six access sites spread across the five creel-subareas: Cattle Point (103), Pedder Bay (104), Sidney (106), Flemming (108), Sunny Shores (114) and Becher Bay (1101) (Figure 1).

2.2 DESCRIPTION OF CURRENT ESTIMATE METHODS

We provide a description of the methods used to generate catch, effort, and catch per effort (CPE) statistics which are derived from English et al. (2002) in Appendix 1. In Appendix 1, we also note and correct problems with the method descriptions provided by English et al. (2002). Figure 2 provides a schematic of the methods used to estimate three variables: catch, effort and CPE. Variable estimation is derived from two sources of information: (1) interview data from access sites, and (2) aerial surveys. Interview data are used to directly estimate the CPE for each day type, subarea, and species. It is also used to generate daily patterns in fishing activity (i.e., activity profile) after correcting for the number of days of a particular day type an access site was sampled and the number of fishing trips sampled in a specific month. The activity profile is the corrected portion of the total fishing effort actively engaged in fishing during each time block of the day. Aerial surveys provide near-instantaneous counts of boats fishing, which when combined with the estimate of the proportion of boats fishing taken from the activity profiles, is used to estimate effort as the total number of boats fishing in a given subarea on that day (see Appendix 1).

Using the methods provided in Appendix 1 we computed estimates of catch, effort and CPE in an independent implementation of the analysis routine developed for this study in program R: A Language and Environment for Statistical Computing (R Development Core Team 2012). We compared these independently calculated estimates to those generated from the current DFO analysis package. There were small differences between the results generated by our R-based analysis and the DFO analysis package. The cause for these differences is unknown but can be traced back to differences in the calculation of activity profiles. For this study, differences in activity profiles between our derivation and the activity profile from the current DFO analysis package will only become important in how they interact with aerial survey data; i.e., only the activity profile ($\hat{A}_{dgjt'}$) specific to the time of the aerial survey (t') is important in estimating effort. During the time of the aerial surveys across the months our estimates of activity profiles, and thus effort, were generally lower than the estimates generated by the current DFO analysis package. There was a negative bias in 11 of 14 combinations of month and day type with average bias across all months and day types of -6.2% (Appendix 2). To accurately compare the approaches proposed in this study we use our derivation of the methods as a baseline to compare against to determine if there were improvements in the precision of catch and/or effort estimates. Further analysis is required to determine why these discrepancies in generated activity profiles between the two implementations of the same methods differ.

2.3 APPROACH 1 – ACTIVITY PROFILES BASED ON CLOSE PROXIMITY ACCESS SITES

We use the existing equations to generate the subarea specific activity profiles, where the group of landing sites *g* represents access sites with similar activity patterns. We use two (sub) approaches:

1. *Approach* 1*a* – Access sites specific only to the subarea of interest
2. *Approach* 1*b* – Access sites from the subarea of interest and adjacent subareas with the Victoria area

The group of landing sites *g* used for Approach 1*a* and Approach 1*b* are found in Table 1. These definitions of *g* are used in equations A6 and A7 to calculate new activity profiles, which lead to changes in catch, effort, and CPE. The remainder of the methods used for these approaches are the same as those found in Appendix 1.

2.4 APPROACH 2 – ACTIVITY PROFILES BASED ON TARGET SUBAREA

Subarea-specific activity profiles were developed based on the targeted subarea taken from interview data. The current method is tied to access-site specific interview data; the method proposed here is *not* tied to access site data. Instead, activity profiles are generated across all landing sites and tied to the areas fished by interviewed fishing parties. The outcome of this approach still leads to subarea-specific activity profiles. However, the current methods have landing site-specific corrections to interview data where the analysis expands for all possible stints at each site ($W1_{dij}$) and for all boats that landed in each work block for a given landing site ($W2_{dijk}$). The second correction ($W2_{dijk}$) corrects for boats that were missed due to oversaturation of interview staff during periods where high volumes of boats returned to the access site. $W1$ can be modified such that it accounts for the number of days that there were interviews in a specific *subarea* (not landing site); the $W2$ expansion, however, cannot be calculated because the boats missed is tied to the access site. Because $W2$ values could not be calculated for Approach 2, we chose to evaluate this method against an *unadjusted* method (i.e., the current method without $W1$ and $W2$ calculations). Therefore, the updated $W1$ and $W2$ equations are $W1' = 1$ and $W2' = 1$. The differences between the current and unadjusted methods are discussed in Appendix 3.

In Approach 2 the equations for the estimate of the fishing activity in time block t ($\hat{A}_{dgjt}$) and activity profile ($P_{dg\sigma t}$) are modified to include the targeted subarea (σ) as an index such that the subscripts for the two variables are $\hat{T}_{dgj\sigma}$ and $\hat{A}_{dgj\sigma t}$ (see Appendix 1). The remaining equations (aside from $W1$ and $W2$ calculations discussed above) remain unchanged from the current methods.

We compared the precision of the unadjusted method and Method 2 using the standard errors across all months and subareas of the Victoria area.

2.5 APPROACH 3 – ACTIVITY PROFILES BASED ON TARGET SPECIES

Activity profiles were developed based on the target species of each fishing party determined through interview data. We only used the two most desired species in this area: halibut and chinook salmon. Thus, we generated two activity profiles for each day type for each of the five subareas leading to twenty activity profiles within the Victoria area. Each activity profile used the interview data across all of the landing sites in the area.

Similar to Approach 2, a problem with Approach 3 was that the expansion for all boats that landed within the work block ($W2_{dijk}$) was landing site specific. Although the target species information can be determined on a landing site basis, dividing interview data between two target species (and ignoring other targeted species such as sockeye salmon) within a landing site makes it difficult to calculate the 'boats missed' information. Without understanding the 'boats missed' information outside of the context of landing sites we were required to use the unadjusted method to compare against our results to determine if precision was increased.

2.6 DESCRIPTION OF COMPARISON APPROACHES

We calculated the estimates and standard errors of effort, CPE and catch using the methods outlined in Appendix 1. To determine whether Approaches 1, 2 and 3 lead to increased precision in estimates we compared our results against the current methods using three measures – effort, catch of all chinook salmon, and catch of halibut. For ease of interpretation we did not include the subcategories of catch for chinook (e.g., adipose-fin-clipped individuals). The measures were evaluated in terms of the value and the standard error associated with the value. For effort and catch estimates, we assumed estimates were normally distributed and used 95% confidence intervals to evaluate whether the new approaches differed from the current methods for each combination of year and month. Estimates where 95% confidence intervals did not overlap were considered different. For estimates of precision, we compared the standard error of the new approaches compared to the current methods at two intervals: a 10% increase in precision and a 25% increase in precision. For instance, if the new method resulted in a 15% drop in standard error relative to the results of the current method, this was deemed a 'true' increase in precision at the 10% threshold but not the 25% threshold. We specifically addressed chinook salmon catch estimates in subarea 20D because there is a large chinook fishery in this area, and halibut catch estimates in 19D because there is a large halibut fishery in this subarea at Constance Bank. We used the program R: A Language and Environment for Statistical Computing (R Development Core Team 2012) to perform our analyses.

3.0 RESULTS

3.1 APPROACH 1 – ACTIVITY PROFILES BASED ON CLOSE PROXIMITY ACCESS SITES

The results indicated that stratifying the data set according to landing sites in or close to the subarea of interest did not lead to a systematic difference in estimates and precision for effort (Figure 3 and Figure 4), catch of chinook salmon (Figure 5 and Figure 6), or catch of halibut (Figure 7 and Figure 8). Of the 35 comparisons, we found only 2 estimates of effort were significantly higher than current estimates (i.e., had higher means with non-overlapping confidence intervals) for Approach 1a. However, no estimates of catch were considered significantly different from those calculated using current methods. For Approach 1b, there were no estimates of catch or effort that were significantly different from current methods. In subarea 20D, we note that there is generally a slight reduction in chinook salmon catch estimates with the exception of August 2010 (Figures 5 and 6). This is reflected in the increased precision of the estimates, with the exception of August 2010 again. For halibut catch in subarea 19D we note a decrease in halibut catch estimates (Figure 7) and increased precision (Figure 8), but these differences were not consistent across all months. We saw no clear trend in the change in precision of estimates (Table 2 and Table 3). For instance, increased precision was found in 20% of the effort estimates; however, this was counterbalanced by 43% of samples with decreased precision.

3.2 APPROACH 2 – ACTIVITY PROFILES BASED ON TARGET SUBAREA

When activity profiles were based on the targeted subarea of each fishing party, there was no consistent bias in effort (Figure 9) or increase in precision (Figure 10) compared to the unadjusted methods. Catch of chinook salmon (Figures 11 and 12) and halibut (Figures 13 and 14) also did not yield consistent increases in precision or bias in the estimates and often led to decreases in precision and higher estimates of catch. Of the 35 samples, we found only 2 estimates of effort were significantly higher than DFO estimates (i.e., had higher means with non-overlapping confidence intervals). No estimates of catch were considered significantly different from DFO methods. For subarea 20D, the largest chinook fishery, we did not see a clear trend in difference in catch of chinook salmon estimates (Figure 11) or precision (Figure 12). For subarea 19D, the largest halibut fishery, we did not see a clear trend in the difference between halibut estimates (Figure 13) or precision (Figure 14). We found no clear trend in the proportion of subarea-months that had increased or decreased precision compared to the current methods (Table 2 and Table 3).

3.3 APPROACH 3 – ACTIVITY PROFILES BASED ON TARGET SPECIES

For the analysis on activity profiles based on the targeted species of each fishing party, we focused on two target species – chinook salmon and halibut. For each of the target species, the comparison should be restricted to effort and the catch of that species only. In other words, we do not assess the chinook salmon catch data using the activity profiles calculated with halibut as the target species, and we do not assess the halibut catch data using activity profiles calculated with chinook salmon as the target species. However, we provide information on both target species for completeness. Of the 35 comparisons, no estimates of effort or catch were considered significantly different from unadjusted methods (i.e., all samples had overlapping confidence intervals). For chinook salmon, there was no consistent trend in the estimate of effort (Figures 9 and 10) or catch of salmon (Figures 11 and 12). There were a large proportion of subarea-months that had a negative bias in effort and higher precision for estimates of effort when using the activity profiles calculated only using halibut data (Figures 9 and 10). However, the increase in the precision of effort did not lead to a consistent trend in the catch of halibut (Figures 13 and 14). For subarea 20D, the largest chinook fishery, the estimates of catch for chinook was generally higher than unadjusted methods except in the month of the most abundant catch – August 2010. However, this was linked to a lower precision in the catch estimate for that month and most other months. We found no clear trend in the proportion of subarea-months above or below the unadjusted methods. The proportion of subarea-months with negative or positive biases in effort, catch of chinook, and catch of halibut are reported in Tables 3, 4, and 5 respectively. For subarea 19D, the largest halibut fishing area, we had lower estimates of halibut catch than estimated by the unadjusted methods for all months except August and September 2010 (Figure 13). This was coupled with a lower standard error (i.e. increased precision) in all months aside from August and September 2010 (Figure 14).

4.0 DISCUSSION

The Victoria area recreational fishery has been an economic driver in the Victoria area, and Fisheries and Oceans Canada (DFO) continues to monitor effort and catch primarily for domestic and international stock assessment and management purposes. For chinook salmon this is primarily to support estimates of stock specific exploitation rates for the pacific salmon treaty and for halibut it is biomass estimates to support international pacific halibut commission assessments.

Current methods generate activity profiles based on fishing party interview data for the entire Victoria area regardless of the geographic location of the landing sites where interviews took place and ignoring the targeted subarea and targeted species of each fishing party. Activity profiles provide an estimate of the proportion of boats fishing in each subarea during a unit of time, and this information coupled with the boats counted from aerial surveys leads to an estimate of effort. In this study we focused on generating finer scale activity profiles by examining three approaches –

1) *Based on close proximity access sites* – subarea-specific activity profiles were based on how close the geographic location of the access sites were relative to the subarea of interest
2) *Based on target subarea* – subarea-specific activity profiles were based on subarea fished as reported during fishing party interviews
3) *Based on target species* – activity profiles based on the targeted species reported during fishing party interviews.

We evaluate approaches using effort and the catch of the most desired species in the area – chinook salmon (*Onchorhynchus tshawytscha*) and halibut (*Hippoglossus stenolepsis*).

Our results suggest that generally there was no difference in the estimates and precision of the estimates when using finer scale landing site information, information on the targeted subarea, or information on the targeted species. Subsequently, our results suggest that incorporating these pieces of information into current estimate methods would not significantly impact the estimates of catch of chinook salmon and halibut. There was a large proportion of subarea-month data that had increased precision of estimates of effort when only using information from fishing parties that targeted halibut (Approach 3 – Halibut). This increase in precision should only be interpreted for halibut-specific information and should not be generalized to other species. Overall, this is a promising result that halibut specific information may have an increased precision in effort, but this result did not translate into a consistent difference in halibut catch when using this approach.

The differences between estimates exist only due to a few possible differences between approaches. The approaches differed from one another and from current methods in the calculation of activity profiles. Approach 1 – where sub-area specific activity profiles were generated from access sites in or near the subarea of interest, used the same equations as the current estimate methods (equations A6, A7 and A8) but used a subset of the group of landing sites (g) to generate the activity profile. Approaches 2 and 3, focusing on the target subarea and target species respectively, relied on modifications of existing methods to account for additional stratification of the data based on the target subarea (σ; equations A19 and A20) and target species (ρ; equations A21 and A22).

There are several caveats to our approach. First, for activity profiles generated based on target subareas (Approach 2) and target species (Approach 3) do not account for expansions for all days where interviews took place and for all boats landed, forcing us to compare the results from these approaches to unadjusted (i.e. unexpanded) current estimate methods. However, the effort calculations from the unadjusted current methods were generally lower than the current methods suggesting that comparing the activity profiles from the approaches here against unadjusted current methods is a conservative test of our approach. Second, we have not explored the effect of sample size on these methods. As English et al. (2002) point out, the precision of catch and effort estimates can be highly dependent on sample size. In these estimates, sample size must be considered at two levels – (1) as the number of interviews that occurred, and (2) the number of days that interviews took place (i.e. stints) within a month. Finally, there are some inconsistencies between our calculation of estimates based on our understanding of the current methods and the estimates provided to us from the DFO analysis algorithms. In general, of the activity profiles that were used in the calculations of effort, 11 of 14 estimates that we derived were lower than DFO estimates with an average across all months (7) and day types (2) of -6.2%. These differences are further documented in Appendix 2. These differences translated to generally lower estimates of effort and catch of chinook salmon and halibut (Figures A1-A6). Further, this suggests that there are undocumented nuances to the current DFO analysis tools that require further review.

In future examination of these approaches, we suggest that new methods for expanding across interview and boat data need to be developed that are not dependent on access site information. Further, we suggest a closer examination of the number of interviews and days when interviews took place and the effects these had on the estimates of catch and effort. For instance, species-specific activity profiles (Approach 3) are expanded across all effort as calculated from aerial surveys. This method could be refined by weighting the effort within a subarea based on the proportion of interviews targeting a particular species and then expand this effort in equivalent amounts. We did not explore changes to the variance components of the creel survey data - Korman et al. (2005) previously examined the analytical procedures for estimates and variance components of the creel survey data from the Strait of Georgia and demonstrated that a negative binomial distribution provided the best fit to the CPE data. However, this had little effect on the on confidence intervals except when sample size was small or the variance-to-mean ratio was very high. We also suggest expanding these methods to a longer time series, thereby increasing the dataset available to further investigate the effect of the approaches proposed in this study.

Finally, we suggest some alternate approaches to examining and partitioning the data beyond the scope of this study. Current estimate methods that do not consider target subareas consisted of boats targeting subareas outside of the Victoria – Sooke recreational fishery including 19A, 18B, 18D, 20C, 20B, and 17D. This suggests that (1) information for these other subareas may be missed by current estimation methods, and (2) the same may be true for the Victoria – Sooke recreational fishery. Therefore, additional information on interview data from other access sites outside the Victoria – Sooke area may improve precision. Additionally, it is worth exploring whether current methods omit interviews that target these subareas outside of the Victoria – Sooke area.

There are several ways that data could be further partitioned to improve precision. Data could be partitioned based on a high/low season stratification, whereby the changes in fishing effort may be seasonal. Effort for chinook salmon tends to be focused from June to August inclusive (‘high’ season), and less effort during September to May (‘low’ season). For halibut, high season is April to June. Data could also be partitioned into weekly or bi-weekly estimates. Current methods use the relatively coarse metric of monthly calculations of catch, CPE and effort. Given a closer examination of the number of interviews and aerial surveys, estimates calculated from smaller time steps could lead to more precision in those estimates. Finally, DFO collects data from interviews on the number of anglers per fishing party, but currently the effort from each boat is considered equally regardless of the number of anglers. Other factors, such as environmental factors such as wind may also have an effect on the amount of fishing effort, and are worth exploring.

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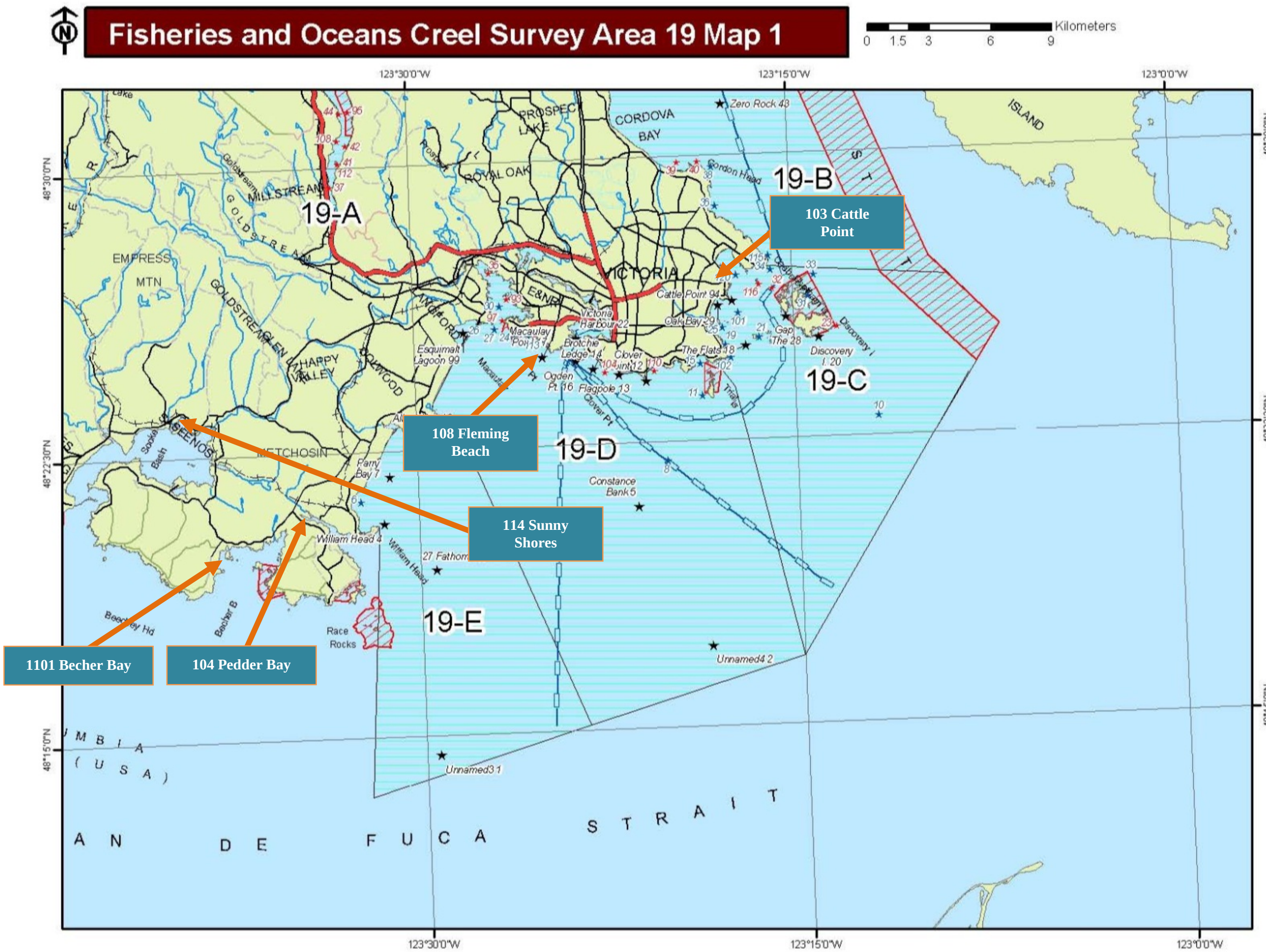
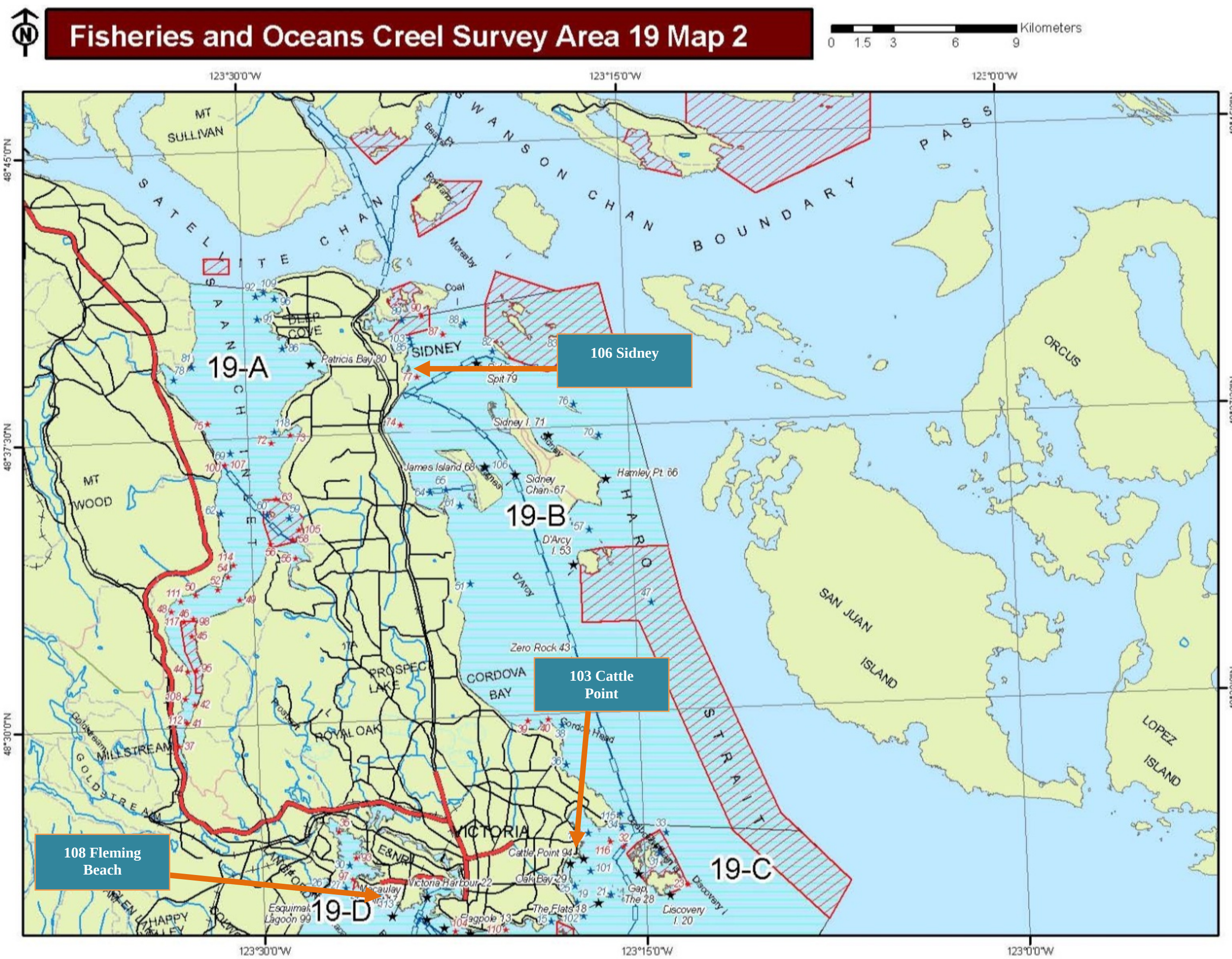
7.0 FIGURES

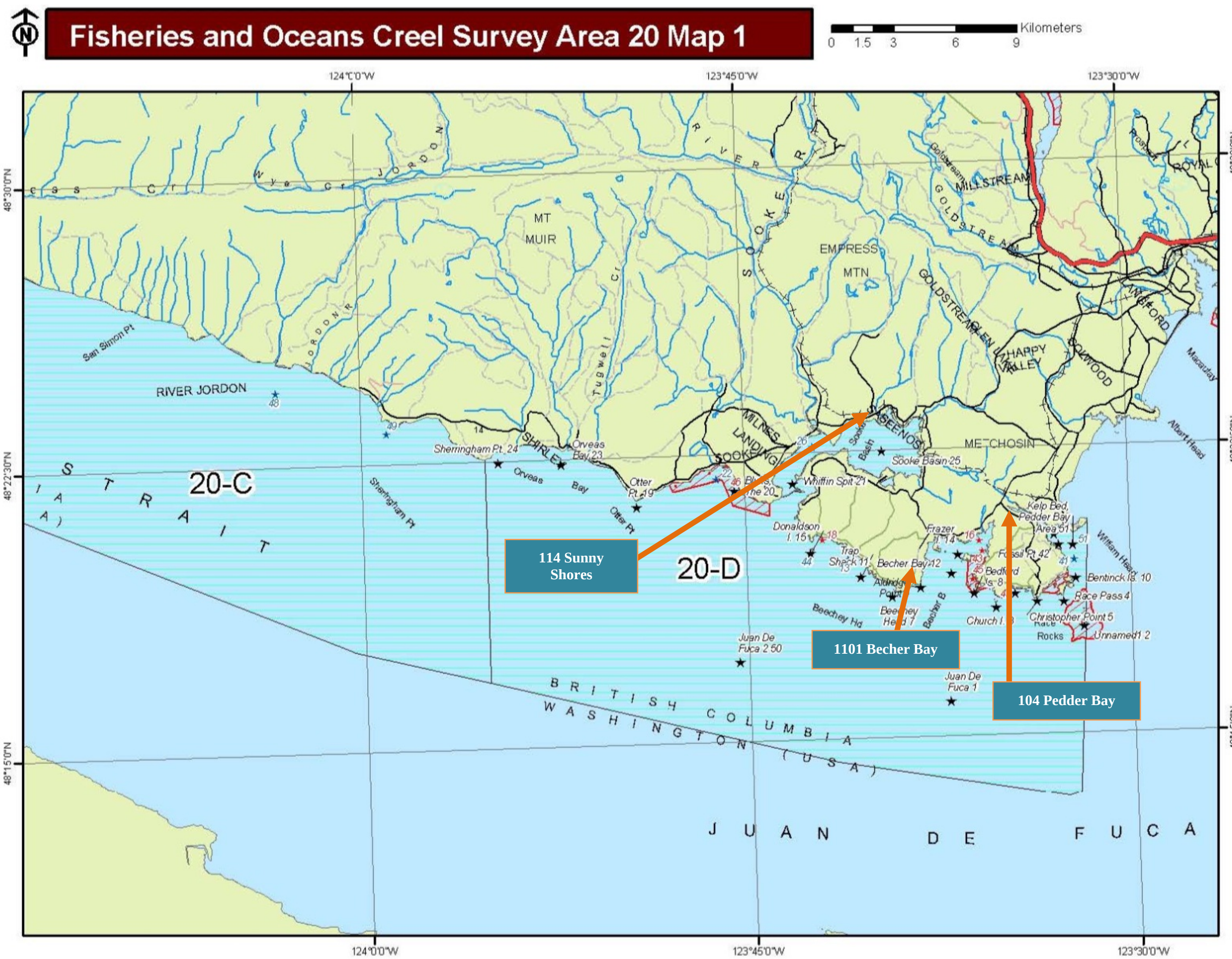


Fisheries and Oceans Creel Survey Area 19 Map 1
Kilometers
0 1.5 3 6 9
19-A
19-B
19-C
19-D
19-E
103 Cattle Point
108 Fleming Beach
114 Sunny Shores
1101 Becher Bay
104 Pedder Bay
VICTORIA
CORDOVA BAY
ROYAL OAK
METCHOSIN
Race Rocks
Unnamed4 2
Unnamed3 1
Constance Bank 5
S T R A I T
A N D E F U C A

A)


Fisheries and Oceans Creel Survey Area 19 Map 2
Kilometers
0 1.5 3 6 9
106 Sidney
103 Cattle Point
108 Fleming Beach
19-A
19-B
19-C
19-D
SIDNEY
VICTORIA
CORDOVA BAY
PROSPECT LAKE
ROYAL OAK
MT SULLIVAN
MT WOOD
MILLSTREAM
DEEP COVE
SAN JUAN ISLAND
ORCUS
LOPEZ ISLAND
SWANSON CHAN
BOUNDARY PASS
HARO STRAIT
SATELLITE CHAN
SAANICH INLET
Patricia Bay 80
Spit 79
Sidney I. 71
James Island 68
Sidney Chan. 67
Hamley Pt 66
D'Arcy I. 53
Zero Rock 43
Cattle Point 94
Oak Bay 29
The Flats 18
Victoria Harbour 22
Esquimalt Lagoon 99
Discovery I. 20
Gap The 28
123°30'0"W
123°15'0"W
123°0'0"W
48°45'0"N
48°37'30"N
48°30'0"N

B)



C)

Figure 1: Maps of the Victoria recreational fishing area. Panel A displays subareas 19B, C, D, and E; Panel B displays the northern most region of the subareas (subareas 19B, C, and D); Panel C displays area 20D. The recreational fishing access sites currently sampled are marked with orange arrows and blue background text boxes with the name and numbered ID of each access site listed.

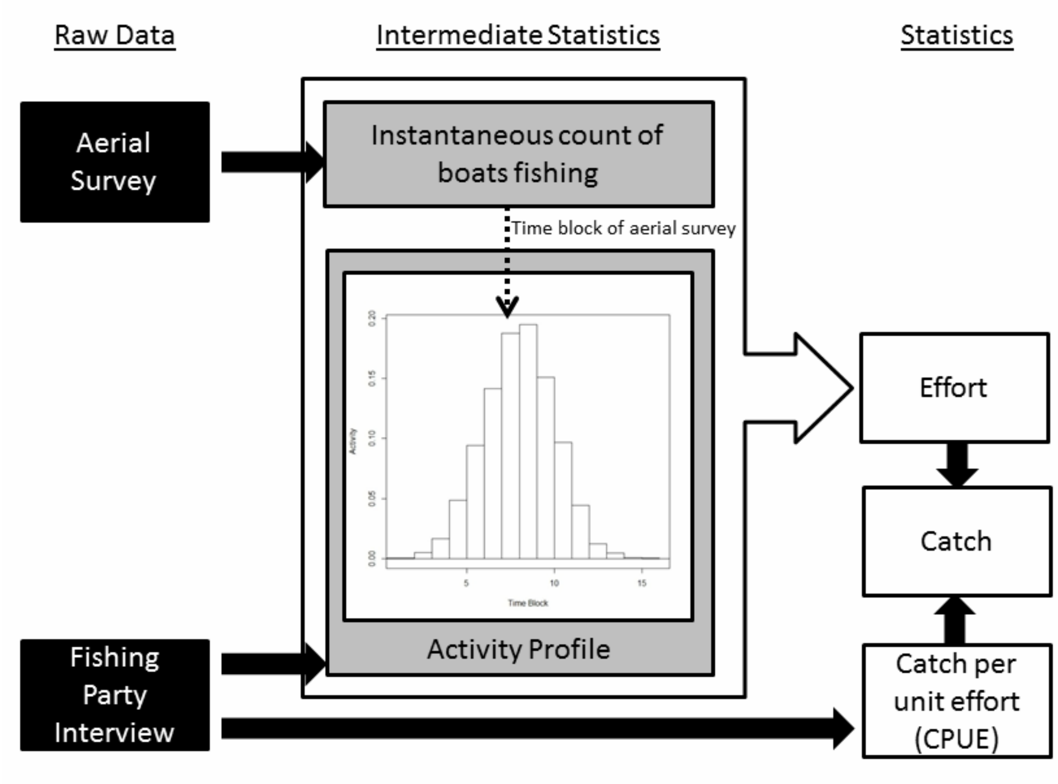


Figure 2: Simplified representation of the steps required to estimate catch, effort and CPE from interview and aerial survey data. The black boxes represent raw data; the grey boxes represent intermediate calculations; the white boxes represent the output variables of interest. Arrows are used to show the flow of information between boxes.

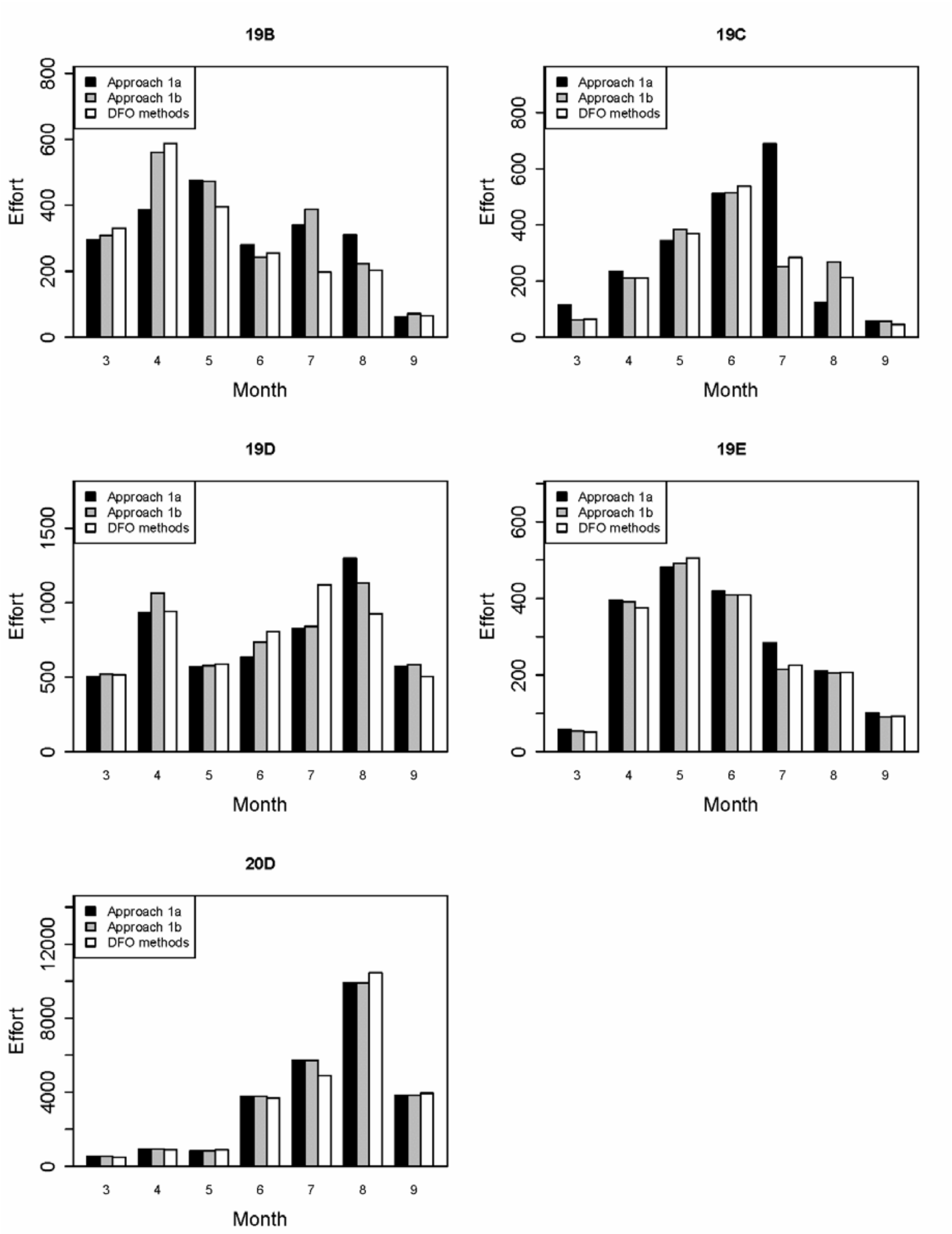


Figure 3: Comparison of the monthly estimates of effort per subarea for current methods against Approaches 1a, using only interview data from landing sites specific to the subarea of interest; and 1b, using interview data from landing sites in or adjacent to the subarea of interest.

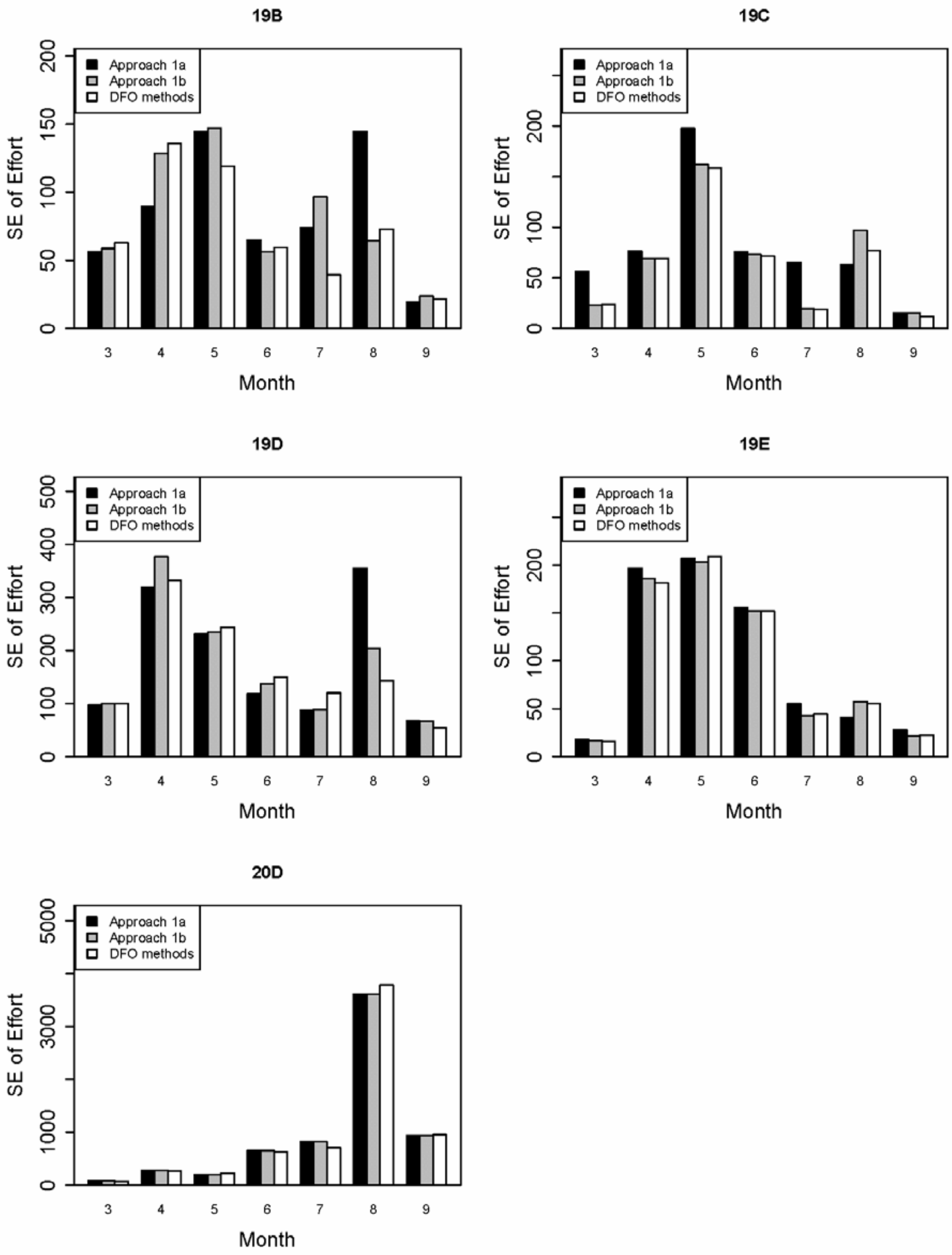


Figure 4: Comparison of the standard error of the monthly estimates of effort per subarea for current methods against Approaches 1a, using only interview data from landing sites specific to the subarea of interest; and 1b, using interview data from landing sites in or adjacent to the subarea of interest.

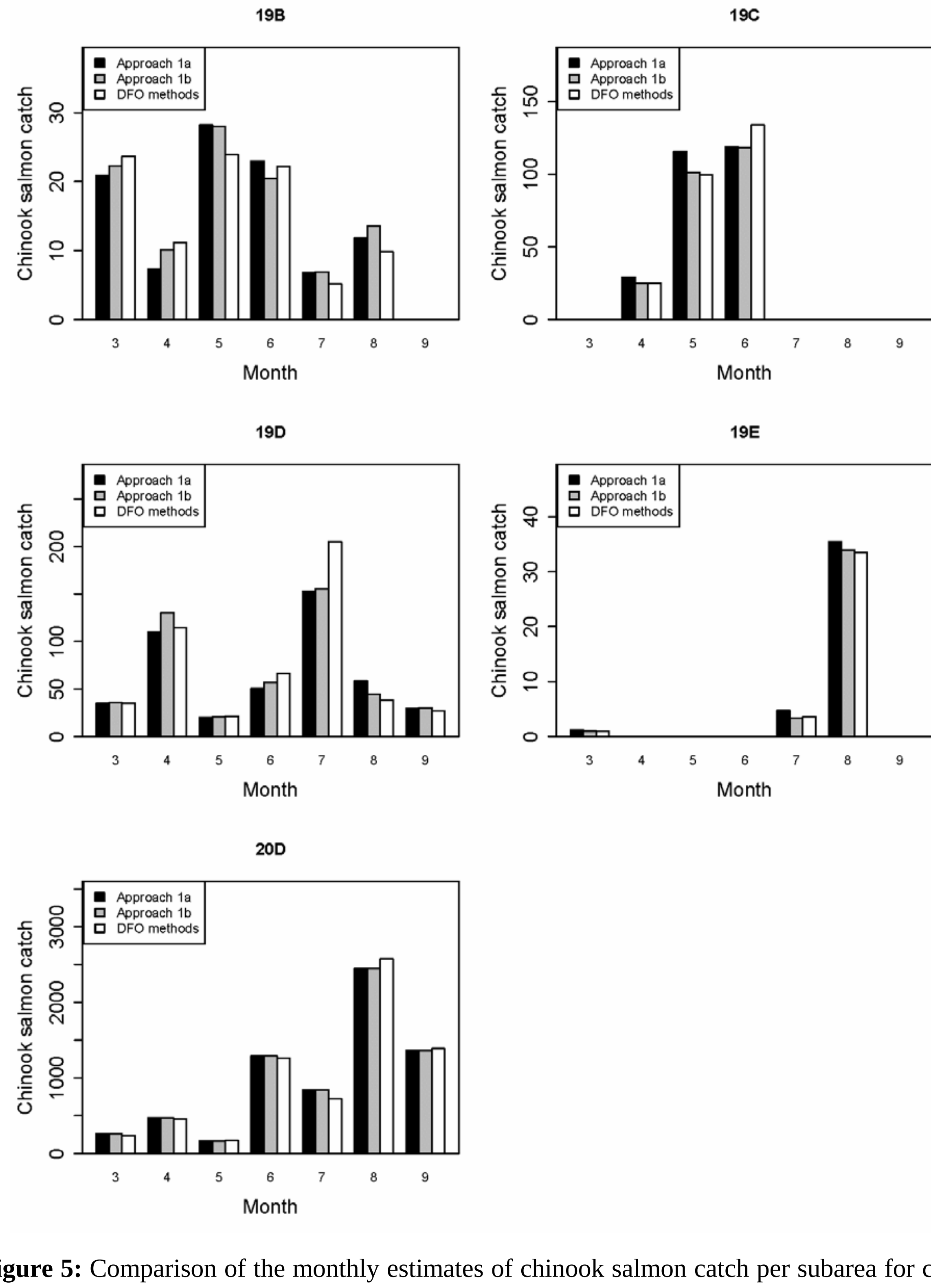


Figure 5: Comparison of the monthly estimates of chinook salmon catch per subarea for current methods against Approaches 1a, using only interview data from landing sites specific to the subarea of interest; and 1b, using interview data from landing sites in or adjacent to the subarea of interest. Bar plots with no entries represent subarea-months where no interview data had chinook salmon catches.

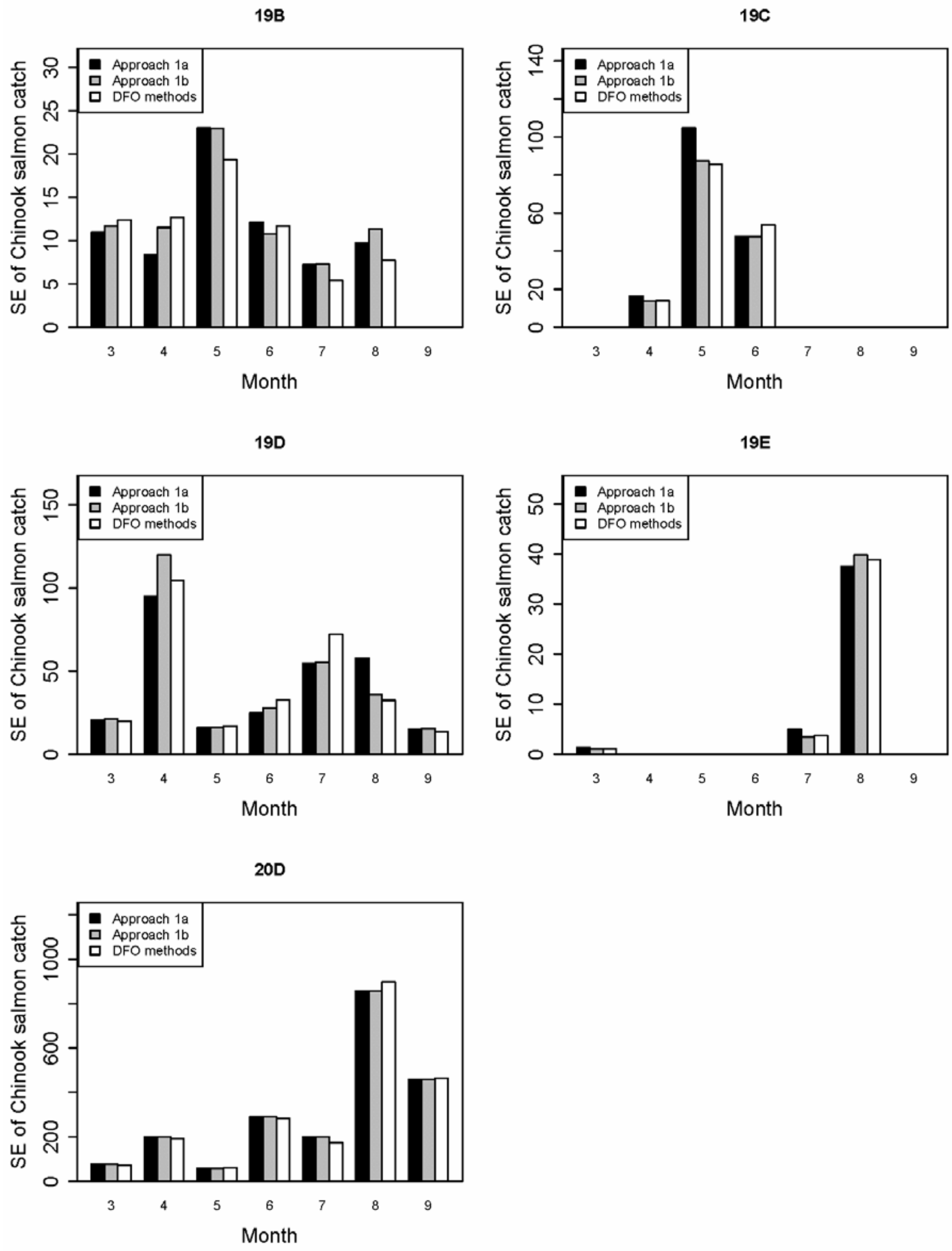


Figure 6: Comparison of the standard error of the monthly estimates of chinook salmon catch per subarea for current methods against Approaches 1a, using only interview data from landing sites specific to the subarea of interest; and 1b, using interview data from landing sites in or adjacent to the subarea of interest.

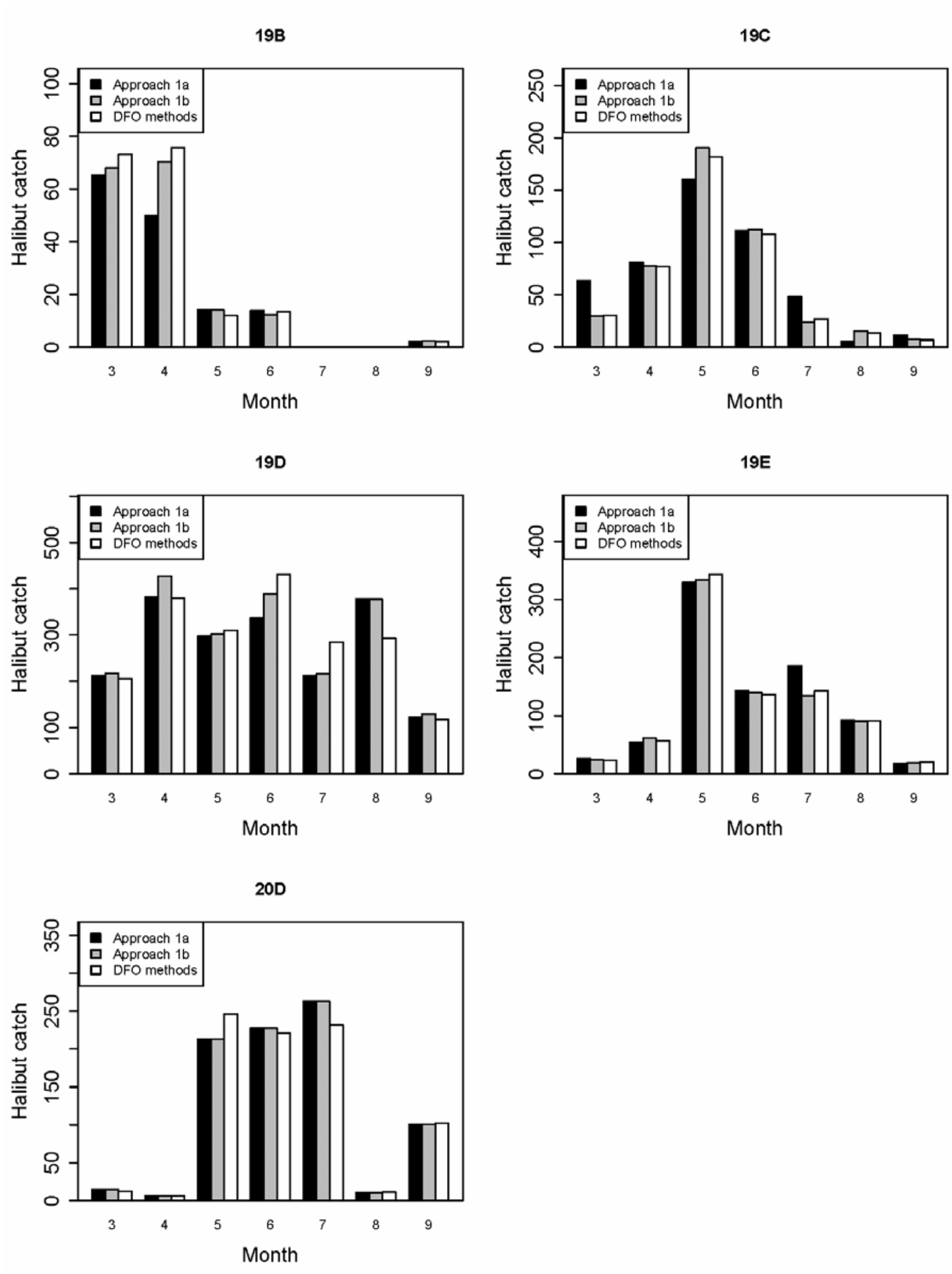


Figure 7: Comparison of the monthly estimates of halibut catch per subarea for current methods against Approaches 1a, using only interview data from landing sites specific to the subarea of interest; and 1b, using interview data from landing sites in or adjacent to the subarea of interest. Bar plots with no entries represent subarea-months where no interview data had halibut catches.

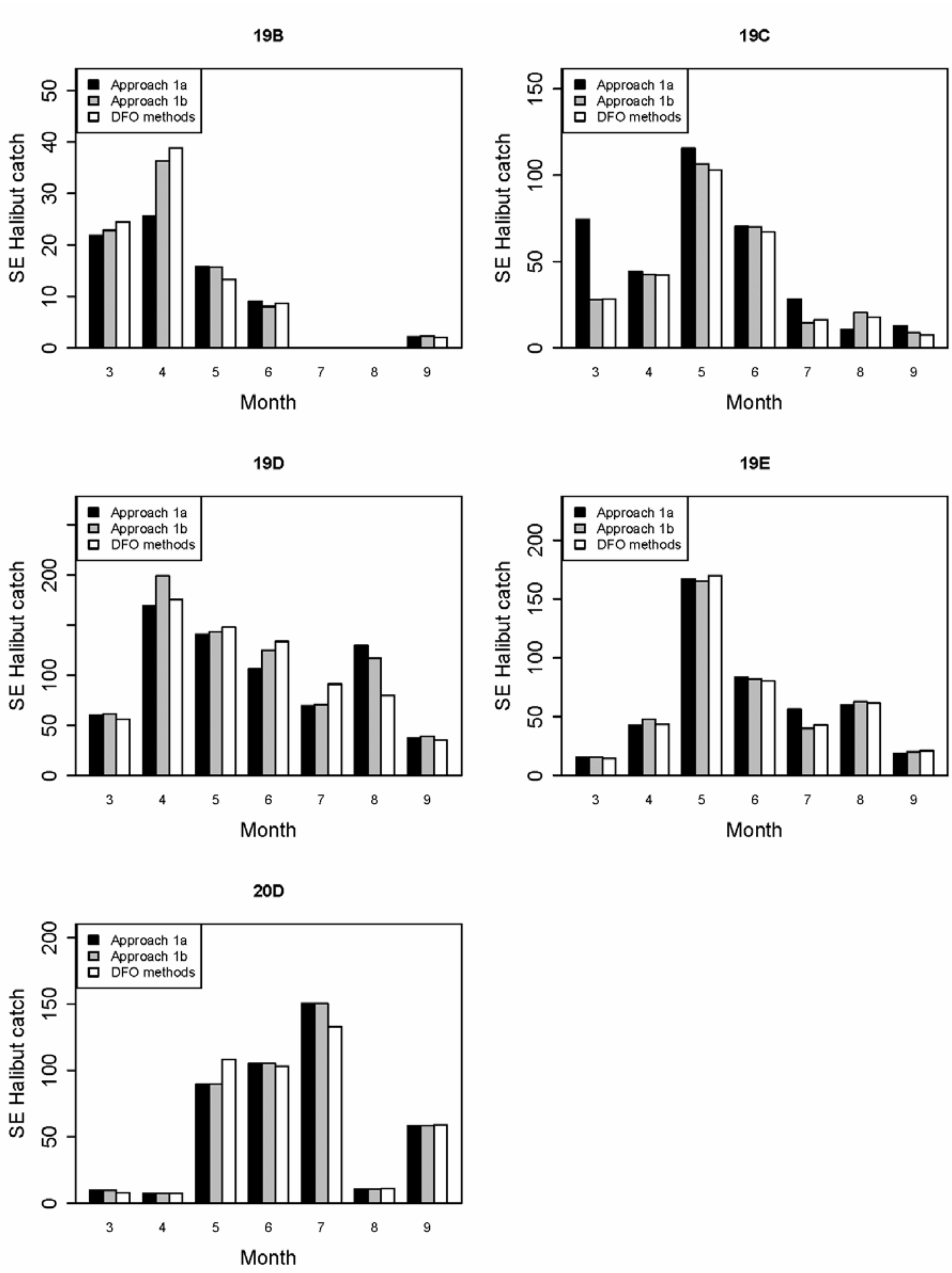


Figure 8: Comparison of the standard error of the monthly estimates of halibut catch per subarea for current methods against Approaches 1a, using only interview data from landing sites specific to the subarea of interest; and 1b, using interview data from landing sites in or adjacent to the subarea of interest.

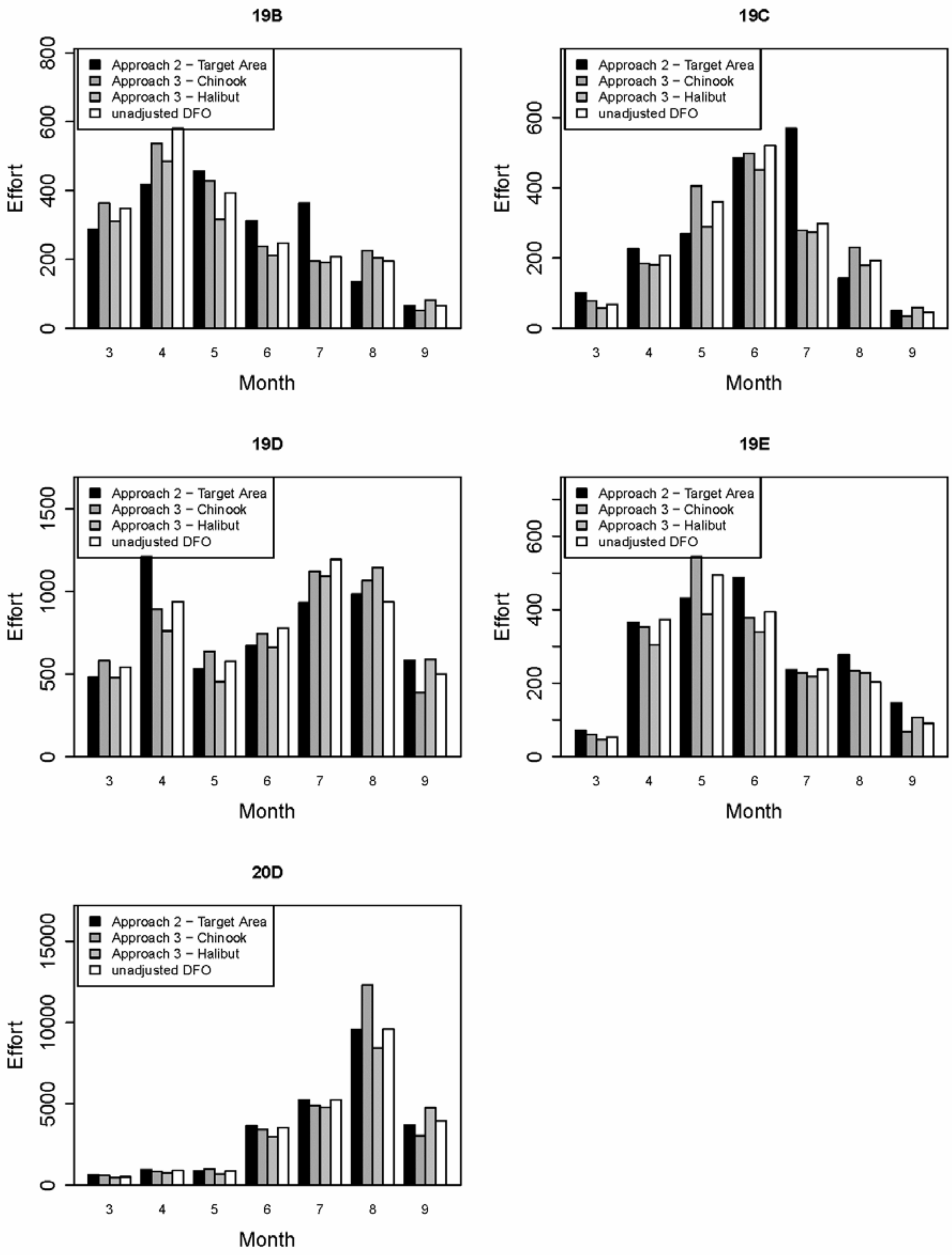


Figure 9: Comparison of the monthly estimates of effort per subarea for unadjusted current methods against Approach 2 – using information on the target subarea of fishing parties and Approach 3 – using interview data from fishing parties on the target species of interest which was either chinook salmon or halibut.

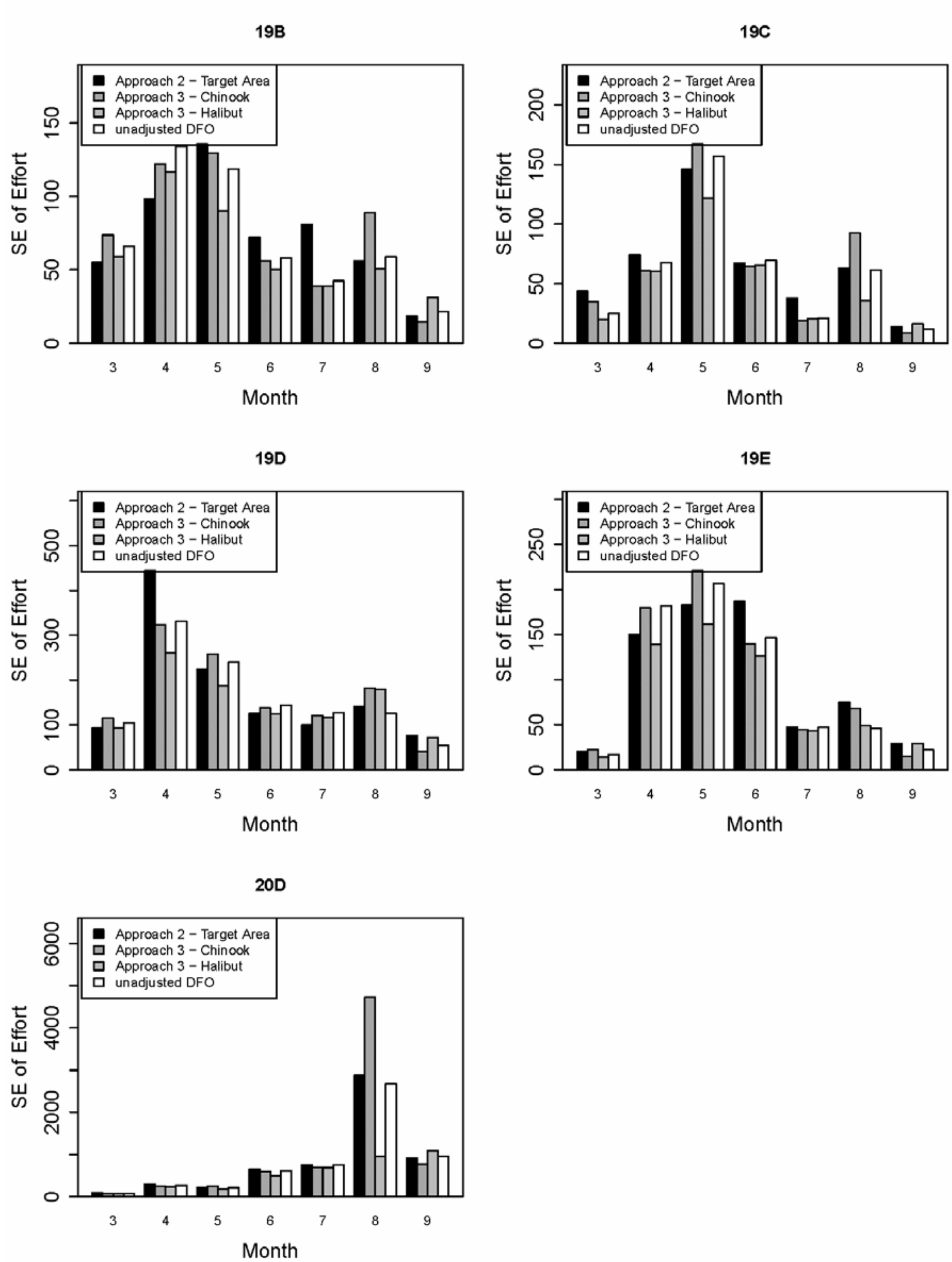


Figure 10: Comparison of the standard error of the monthly estimates of effort per subarea for unadjusted current methods against Approach 2 – using information on the target subarea of fishing parties and Approach 3 – using interview data from fishing parties on the target species of interest which was either chinook salmon or halibut.

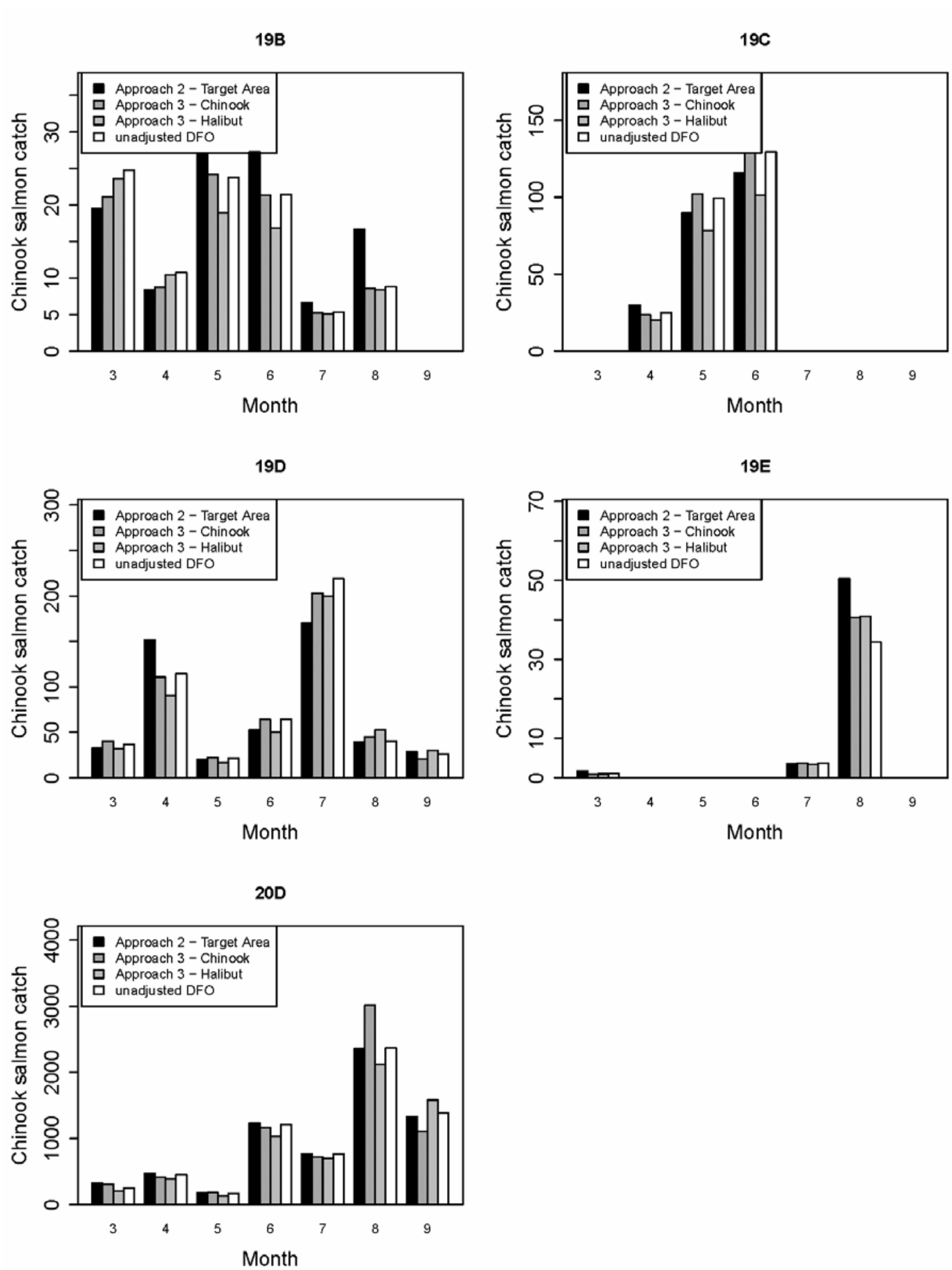


Figure 11: Comparison of the monthly estimates of catch of chinook salmon per subarea for unadjusted current methods against Approach 2 – using information on the target subarea of fishing parties and Approach 3 – using interview data from fishing parties on the target species of interest which was either chinook salmon or halibut. Bar plots with no entries represent subarea-months where no interview data had chinook salmon catches.

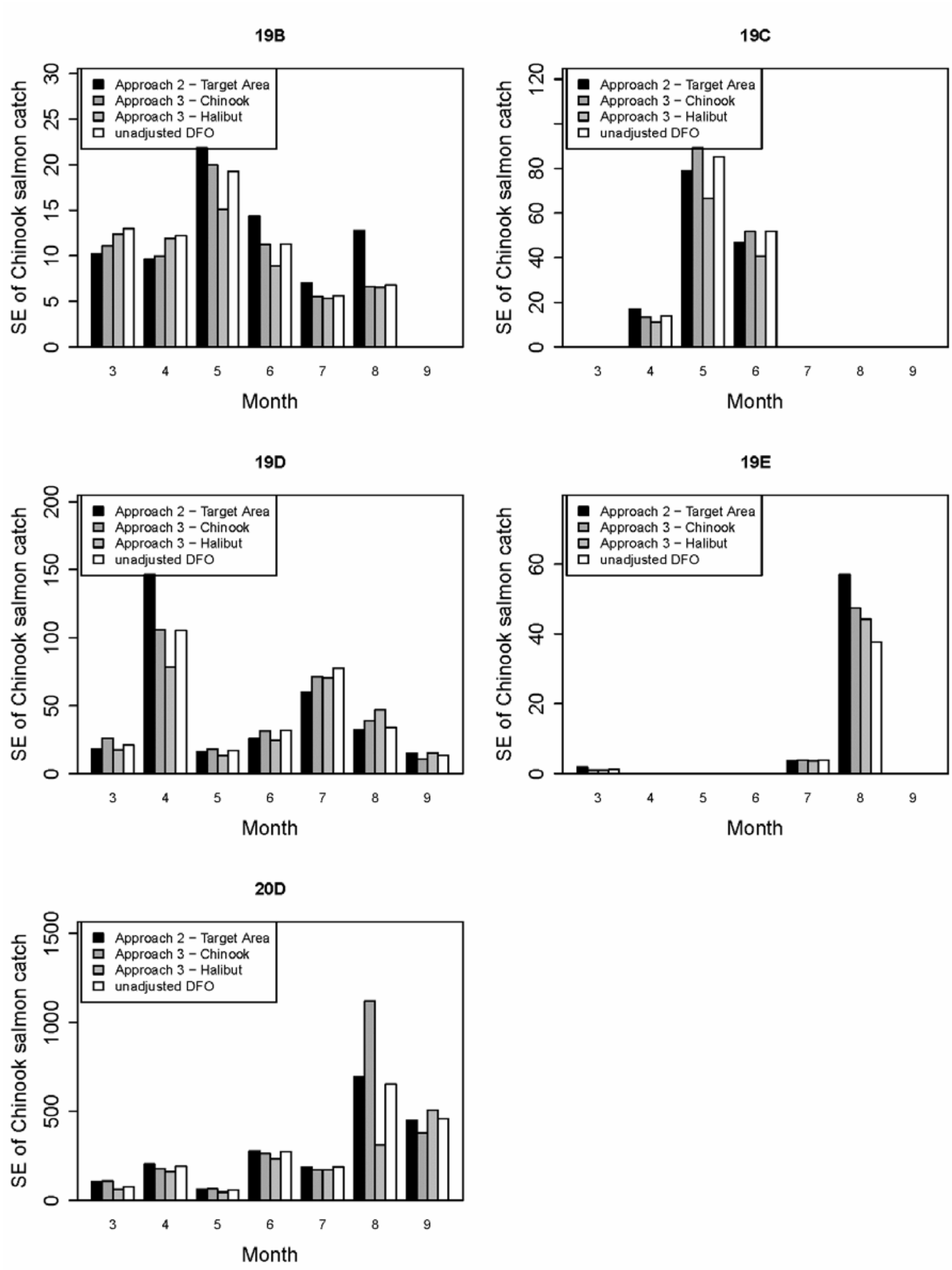


Figure 12: Comparison of the standard error of the monthly estimates of chinook salmon catch per subarea for unadjusted current methods against Approach 2 – using information on the target subarea of fishing parties and Approach 3 – using interview data from fishing parties on the target species of interest which was either chinook salmon or halibut.

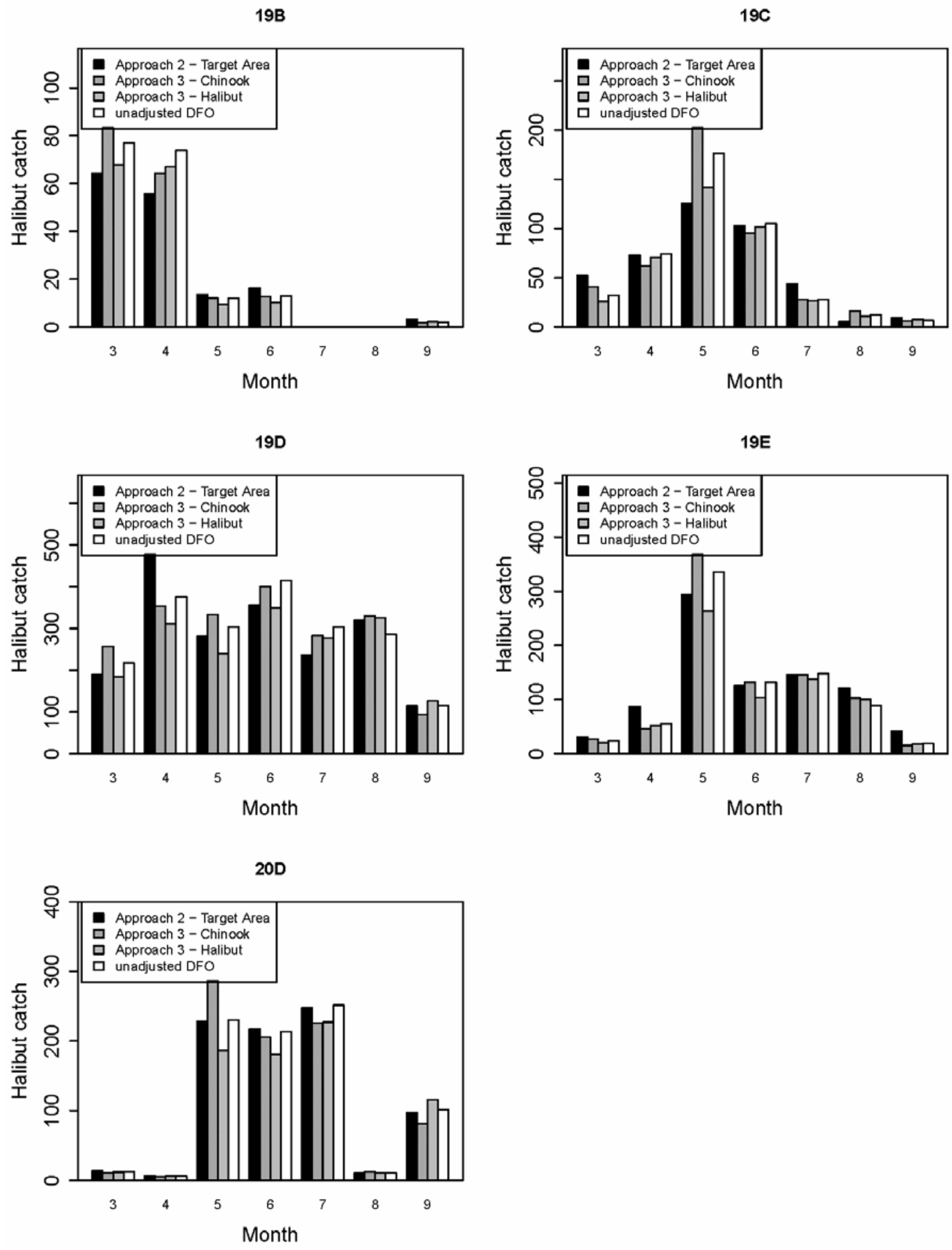


Figure 13: Comparison of the monthly estimates of halibut catch per subarea for unadjusted currnet methods against Approach 2 – using information on the target subarea of fishing parties and Approach 3 – using interview data from fishing parties on the target species of interest which was either chinook salmon or halibut.

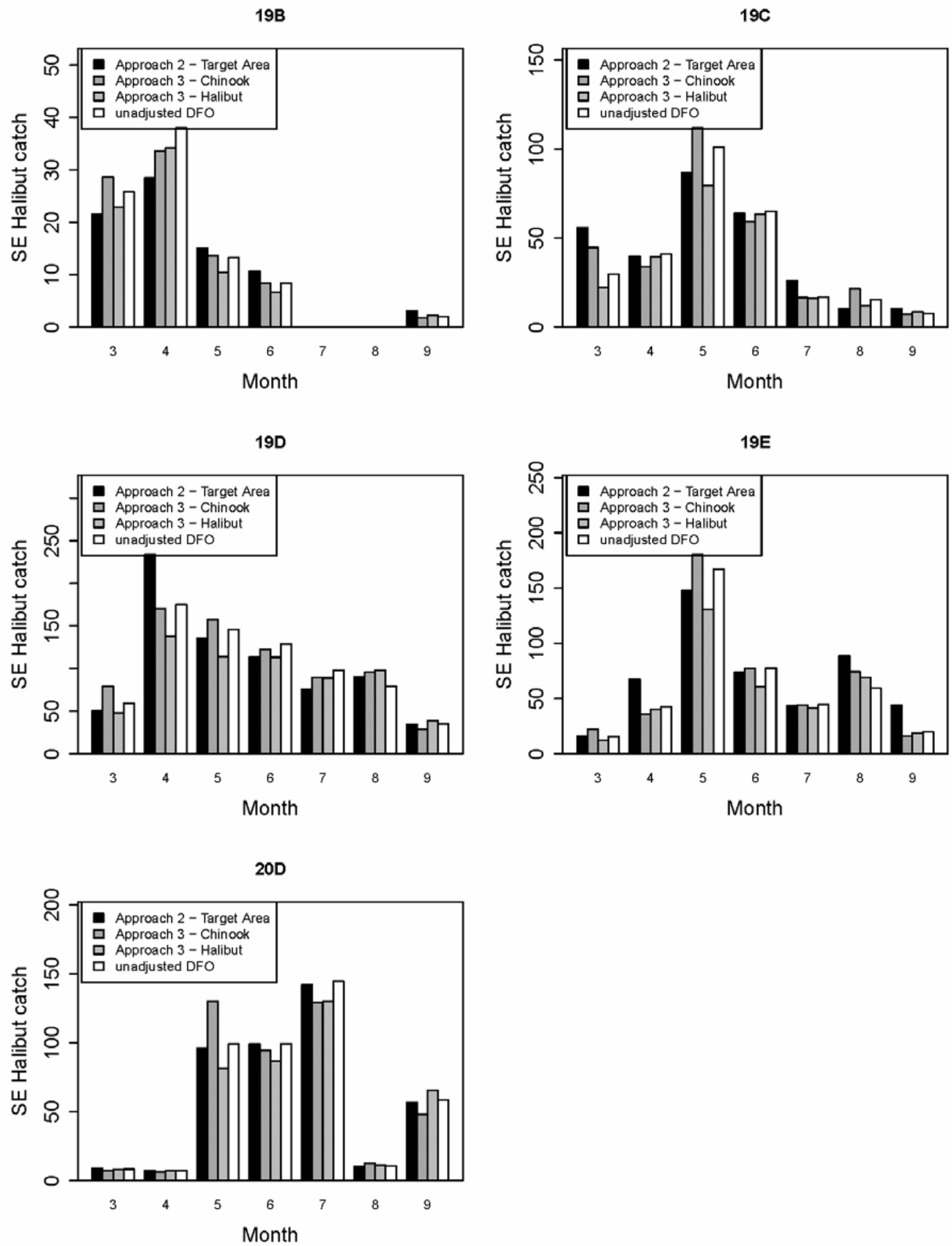


Figure 14: Comparison of the standard error of the monthly estimates of catch of halibut per subarea for unadjusted current methods against Approach 2 – using information on the target subarea of fishing parties and Approach 3 – using interview data from fishing parties on the target species of interest which was either chinook salmon or halibut.

8.0 TABLES

Table 1: The group of landing sites (*g*) used for each subarea in the Victoria recreational fisheries area under Method 1a and Method 1b.

Method	Subarea	Group of landing sites (*g*)
1a	19B	106
	19C	103
	19D	108
	19E	104*
	20D	1101, 104, 114
1b	19B	106, 103
	19C	103, 106, 108
	19D	108, 103
	19E	104, 1101, 108, 114
	20D	1101, 104, 114

* – In Method 1a, 19E does not have a landing site, so it uses the closest landing site (104).

Table 2: Comparisons of the percent of samples with a 10% change in precision (as measured by standard error) of effort and catch data between current methods and the approaches proposed in this study across all subareas and months sampled for the Victoria area recreational fishery (n=35). Bar charts are included in each cell to demonstrate the relative difference between categories.

Estimate Type	Relative change in standard error	Approach 1a	Approach 1b	Approach 2	Approach 3 - Chinook	Approach 3 - Halibut
Effort	Higher	43	26	40	26	17
	Same	37	69	37	57	23
	Lower	20	6	23	17	60
Chinook Catch	Higher	26	20	29	14	11
	Same	34	46	29	46	23
	Lower	40	34	43	40	66
Halibut Catch	Higher	26	26	31	29	14
	Same	49	60	40	37	34
	Lower	26	14	29	34	51

Table 3: Comparisons of the percent of samples with a 25% change in precision (as measured by standard error) of effort and catch data between current methods and the approaches proposed in this study across all subareas and months sampled for the Victoria area recreational fishery (n=35). Bar charts are included in each cell to demonstrate the relative difference between categories.

Estimate Type	Relative change in standard error	Approach 1a	Approach 1b	Approach 2	Approach 3 - Chinook	Approach 3 - Halibut
Effort	Higher	20	14	23	26	14
	Same	71	83	74	69	80
	Lower	9	3	3	11	6
Chinook Catch	Higher	11	6	20	14	3
	Same	60	69	54	46	66
	Lower	29	26	26	40	31
Halibut Catch	Higher	14	3	26	29	0
	Same	74	91	63	37	91
	Lower	11	6	11	34	9

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9.0 APPENDIX 1 – METHODS AND EQUATIONS USED IN ANALYSIS OF CATCH, CPE, AND EFFORT STATISTICS

This appendix contains a brief overview of methods used currently to generate estimates of catch, effort, and CPE. These methods are nearly a duplicate of those found in English et al. (2002), with some clarifications and changes that are discussed in Section 9.6. To interpret the English et al. (2002) methodologies, we found Hardie et al. (2002) and Zetterberg and Carter (2010) useful. Please note that this is not an exhaustive coverage of all of the methods found in the English et al. (2002) document.

9.1 DESCRIPTION OF TERMS

Stint Represents a combination of a day type and landing site which was sampled on a single day (i.e. one sampling stint performed by an interviewer)

Work block Represents one of four possible periods at a particular site of a given day type.
Work Block 1 is before 10AM
Work Block 2 is 10AM to 1:59PM
Work Block 3 is 2PM to 5:59PM
Work Block 4 is 6PM and after

Day type There are two day types: weekdays (1) and weekends (2); holidays are classified as weekends

Time block Each day is divided into 16 time blocks:

1) Before 7 AM
2) 7:00 – 7:59 AM
3) 8:00 – 8:59 AM

…

15) 8:00 – 8:59 PM
16) 9:00 PM and after

9.2 DESCRIPTION OF VARIABLES

A	Number of boats actively fishing
B	Number of boats observed on a flight
C	Catch
CPE	Catch per boat trip (i.e., catch per effort)
E	Effort (estimated number of boat trips)
I	Number of boats interviewed and found to have been fishing
L	Number of boats landing

n	Number sampled
N	Population size from which n samples were observed
P	Proportion
T	Number of boat trips
$W1$	Weighting factor to expand for all possible stints at each site
$W2$	Weighting factor to expand for all boats that landed in each site

9.3 DESCRIPTION OF INDICES

g	a set of landing sites
d	day type
i	landing site
j	work block
k	stint
l	landing time block
m	month
q	fishing party interviewed
r	species
s	subarea
c	spatial category
t	time block
t'	time block of aerial survey
u	flight
x	region
y	annual
σ	target subarea
ρ	target species

9.4 CALCULATION OF OUTPUT VARIABLES (CATCH, EFFORT AND CPE)

To estimate the period catch and effort, three components had to be calculated from applicable interview and flight data:

1) The weighted mean daily fishing pattern from interview data,
2) The mean catch per effort from interview data, and
3) The mean daily sport effort from a combination of 1) and overflight data.

The equations used to estimate the means and variances for all catch and effort statistics are shown below.

Weighting factors used to estimate the daily fishing activity pattern were calculated using the equations derived from DPA Consulting Ltd. (1982). The data obtained from each stint were multiplied by the following weighting factor ($W1$) to expand for all possible stints at each site. The formula reads:

$$W1_{dij} = \begin{cases} if\ n_{dij} = 0;\ 1 \\ if\ n_{dij} > 0;\ \dfrac{N_d}{n_{dij}} \end{cases} \qquad \text{(eq. A1)}$$

where N_d is the total number of type d days in that month and n_{dij} is the number of times that work block j was sampled at site i on type d days.

The interviews aggregated by work block were multiplied by the weighting factor $W2$ to expand for all boats that landed in each work block. The formula reads:

$$W2_{dijk} = \begin{cases} if\ I_{dijk} = 0;\ 1 \\ if\ I_{dijk} > 0;\ \dfrac{L_{dijk}}{I_{dijk}} \end{cases} \qquad \text{(eq. A2)}$$

where L_{dijk} is the number of boats landed and I_{dijk} is the number of boats interviewed during stint k in work block j at site i on type d days.

Prior to 2001 catch per effort (CPE) was estimated for each group of landing sites and the above weighting factors were used to adjust the CPE estimates for disproportional sampling of boat trips and landing sites. These weighting factors are no longer used to adjust the catch per effort estimates because the current CPE estimates are derived separately for each sub-Statistical Area. The current estimation procedure sums the interview data for each subarea to calculate the total observed catch (C_{cdsr}) and fishing trips (T_{cdsr}) for spatial category (c), for each day type (d), for each subarea (s) for species (r):

$$C_{cdsr} = \sum_s \sum_q C_{dsqr} \qquad \text{(eq. A3)}$$

$$T_{cds} = \sum_s \sum_q T_{dsq} \qquad \text{(eq. A4)}$$

Where C_{dsqr} is the catch of a species (r) and T_{dsq} is the effort, in boat trips, by a specific fishing party (q), from a subarea (s), for each day type (d). Thus, the mean monthly catch per effort (CPE_{cdsr}) measured in terms of numbers of fish caught per completed boat trip was calculated using:

$$CPE_{cdr} = \frac{C_{cdsr}}{T_{cds}} \qquad \text{(eq. A5)}$$

The weighting factors described above are still used to adjust the daily fishing activity for disproportional sampling both within and between work blocks. As in the previous analyses of Strait of Georgia creel survey data (DPA Consulting Ltd. 1982, English et al. 1986, Shardlow and Collicutt 1989, Hardie et al. 1999), we derive an estimate of the total monthly fishing trips

($\hat{T}_{dgj}$) and fishing activity in time block t ($\hat{A}_{dgjt}$) for each day type (d) and group (g) of landing sites (i) and work block (j) using

$$\hat{T}_{dgj} = \sum_i \left[W1_{dij} \sum_k \sum_q W2_{dijk} \right] \quad \text{(eq. A6)}$$

$$\hat{A}_{dgjt} = \sum_i \left[W1_{dij} \sum_k \sum_q \left(W2_{dijk} A_{dijkqt} \right) \right] \quad \text{(eq. A7)}$$

where A_{dijkqt} can equal 0 or 1, thereby indicating whether a specific fishing party (q) was actively fishing in each time block (t). Thus, the proportion of daily fishing effort active during the hour t (P_{dgjt}) can be calculated with the following equation:

$$P_{dgjt} = \frac{\hat{A}_{dgjt}}{\hat{T}_{dgj}} \quad \text{(eq. A8)}$$

where each group of landing sites (g) represents a geographic area with similar activity patterns.

The estimated number of boats fishing in each subarea on the day of the overflight was calculated using:

$$B_{dsu} = \frac{B_{dsut'}}{P_{dgt'}} \quad \text{(eq. A9)}$$

where B_{dsut} is the number of sport fishing vessel observed actively fishing at the time of the aerial survey t' on survey u in subarea s on day type d and P_{dgt} is the portion of the daily fishing effort active at time t derived from the activity pattern for the group of landing sites (g) associated with that subarea. The total monthly fishing effort E_{ds} for a specific day type (d) and subarea (s) was calculated using:

$$E_{ds} = \frac{\sum_u B_{dsu}}{n_{ds}} N_d \quad \text{(eq. A10)}$$

where n_{ds} is the number of type d days when subarea s could be surveyed and N_d is the number of type d days in the survey month.

The total effort and catch per boat trip for each specific subarea and day type were combined in the following equation to calculate total catch for each species (r) in each subarea (s):

$$C_{sr} = \sum_d \left(E_{ds} CPE_{cdsr} \right) \quad \text{(eq. A11)}$$

The CPE estimates in the above equation could be derived from data for a specific subarea or group of adjacent subareas depending on the interview data available for each subarea. If there were more than five interviews that reported fishing in a specific subarea, for a single day type, we computed a category 1 *CPE* estimate (CPE_{1dsr}) and used this value to estimate catch for that subarea. Category 2 *CPE* estimates (CPE_{2dsr}), derived from a minimum of five interview samples from adjacent subareas, were used in the above equation when the available data were not adequate to calculate a Category 1 estimate. Category 3 *CPE* estimates (CPE_{3dsr}), derived from a minimum of five interview samples from several Category 2 groups of adjacent subareas, were used in the above equation when the available data were not adequate to calculate a Category 1 or 2 estimate.

9.5 CALCULATION OF VARIANCE OF OUTPUT VARIABLES (CATCH, EFFORT AND CPE)

The variance for estimates of total fishing effort was calculated using the following two equations:

$$S^2_{B_{ds}} = \frac{\sum_u B^2_{dsu} - \frac{\left(\sum_u B_{dsu}\right)^2}{n_{ds}}}{n_{ds}-1}\left(\frac{N_d - n_{ds}}{N_d - 1}\right) \qquad \text{(eq. A12)}$$

where $S^2_{B_{ds}}$ is the variance for the daily fishing effort estimate for subarea *s* on day type *d* and all variables are as defined above, and

$$S^2_{E_{ds}} = N^2_d S^2_{B_{dsu}} \qquad \text{(eq. A13)}$$

where $S^2_{E_{ds}}$ is the variance for total effort estimate for subarea *s* on day type *d*.

The variance of catch per boat trip ($S^2_{CPE_{cdsr}}$) was calculated using the following equation:

$$S^2_{CPE_{cdsr}} = \frac{\sum_q CPE^2_{cdsr} - \frac{\left(\sum_q CPE_{cdsr}\right)^2}{T_{cds}}}{T_{cds}-1} \qquad \text{(eq. A14)}$$

where T_{cds} is the number of interviews of completed boat trips where fishing was conducted in spatial category *c* on day type *d*.

The standard error of the catch estimates for each species and subarea was derived using the following equation:

$$SE_{C_{sr}} = \sqrt{\sum_{d}\left(E_{ds}^{2}\frac{S_{CPE_{cdse}}^{2}}{T_{cds}} + CPE_{cdsr}^{2}\frac{S_{E_{ds}}^{2}}{n_{ds}} + \frac{S_{CPE_{cdsr}}^{2}}{T_{cds}}\frac{S_{E_{ds}}^{2}}{n_{ds}} \right)} \qquad \text{(eq. A15)}$$

Which is based on the standard formula for combining the variance of the product of two independent random variables (Goodman 1960).

The standard error for the effort estimate for each subarea was derived using the following equation:

$$SE_{E_{s}} = \sqrt{\sum_{d}\left(\frac{S_{E_{ds}}^{2}}{n_{ds}} \right)} \qquad \text{(eq. A16)}$$

where all variables are described as above.

9.6 DIFFERENCES BETWEEN CURRENT DFO METHODS AND METHODS OUTLINED IN ENGLISH ET AL. 2002.

Work block definitions in English et al. (2002) are that work block 1 is before 11AM. In the current methods, work block 1 is before 10AM, work blocks 2 and 3 are in 4 hour segments, and work block 4 is after 6PM. The term "shift" is used differently than English et al. (2002), and is not synonymous with stint. DFO uses "shift" to represent the hours that an individual worked to collect boat interview data. Shift 0 is from 11AM to 6PM, Shift 1 is from 8AM to 3PM, and Shift 2 is from 2PM to 9PM.

Equations 1 and 2 required conditional statements – if the ratio has a denominator of zero then $W1$ and $W2$ are set to 1. Another way of stating this is that if there are no interviews in that area, then $W1 = 1$; if there are no boats then $W2 = 1$. The original equations did not have the conditional statement.

In the English et al. (2002) study, P_{dgt} is defined as "the proportion of daily fishing effort active during **the hour of the aerial survey**". This should be a general definition, and therefore should read "the proportion of daily fishing effort active during the hour *t*". Additionally, English et al. (2002) uses the subscript *t* to mean a specific time block *t* and the time of aerial survey *t*. We make the distinction between these two indices so that *t'* now represents the time block *of the aerial survey*. Between these two changes, the description for equation A9 needed to be corrected to read "… the number of sport fishing vessels observed actively fishing **at the time of the aerial survey *t'*** ".

Operationally, DFO methods use time block specific activity profiles, and work block specific estimates of the total monthly fishing trips. This is not represented in the English et al. (2002) methods. Furthermore, there is a typographic error in the original equation A7 which indicated that all values in the brackets were required to be summed across all work blocks (*j*). This cannot be the case because the values of ($\hat{A}_{dgjt}$) must be time block specific. Between these two points, we represent the new equations as equations A6 and A7 respectively and not the original versions, which read:

$$\hat{T}_{dg} = \sum_i \sum_j \left[W1_{dij} \sum_k \sum_q W2_{dijk} \right] \qquad \text{(eq. A17)}$$

$$\hat{A}_{dgt} = \sum_i \sum_j \left[W1_{dij} \sum_k \sum_q \left(W2_{dijk} A_{dijkqt} \right) \right] \qquad \text{(eq. A18)}$$

The description for the estimate of fishing activity was also changed to reflect the time block specificity. It now reads “we derive an estimate of … fishing activity in **time block *t*** ($\hat{A}_{dgjt}$) for each day type (*d*) and group (*g*) of landing sites (*i*) and work block (*j*) …”

Finally, in equation A10 there is a typographic error, where the subscripts are rearranged – B_{sdu} should read B_{dsu}.

9.7 EQUATIONS FOR APPROACH 2

W2 could not be calculated for approach 2, as activity profiles were generated from subarea-specific interview data – so we used unadjusted DFO methods. The current DFO methods have landing site-specific corrections to interview data, where they expand for all possible stints at each site ($W1_{dij}$) and for all boats that landed in each work block for a given landing site ($W2_{dijk}$). $W1$ can be modified such that it accounts for the number of days that there were interviews in a specific *subarea* (not landing site); the $W2$ expansion, however, cannot be calculated because the boats missed is tied to the landing site. Because $W2$ values could not be calculated for Approach 2, we chose to evaluate this method against an *unadjusted* DFO method (i.e., DFO method without $W1$ and $W2$ calculations). Therefore, the updated $W1$ and $W2$ equations (A1 and A2 respectively) are $W1' = 1$ and $W2' = 1$.

The equation for the estimates of fishing activity in time block *t* ($\hat{A}_{dgjt}$) for each day type (*d*) and group (*g*) of landing sites (*i*) and work block (*j*) for Approach 2 is the same as equation A7 in the DFO methods except it includes an additional index for the targeted subarea (σ):

$$\hat{A}_{dgj\sigma t} = \sum_i \left[W1_{dij} \sum_k \sum_q \left(W2_{dijk} A_{dijkq\sigma t} \right) \right] \qquad \text{(eq. A19)}$$

This leads to a change in the calculation of the activity profile ($P_{dgj\sigma t}$) to also include the additional index of the targeted subarea (σ):

$$P_{dgj\sigma t} = \frac{\hat{A}_{dgj\sigma t}}{\hat{T}_{dgj}} \qquad \text{(eq. A20)}$$

The remaining equations for Approach 2 are the same as those found in the DFO methods. In equations A18, A19, and A20, all landing sites are included in the calculations.

9.8 EQUATIONS FOR APPROACH 3

We use the unadjusted DFO methods. The current DFO methods have landing site-specific corrections to interview data, where they expand for all possible stints at each site ($W1_{dij}$) and for all boats that landed in each work block for a given landing site ($W2_{dijk}$). $W1$ can be modified such that it accounts for the number of days that there were interviews in a specific *subarea* (not landing site); the $W2$ expansion, however, cannot be calculated because the boats missed is tied to the landing site. Because $W2$ values could not be calculated for Approach 2, we chose to evaluate this method against an *unadjusted* DFO method (i.e., DFO method without $W1$ and $W2$ calculations). Therefore, the updated $W1$ and $W2$ equations (A1 and A2 respectively) are $W1' = 1$ and $W2' = 1$.

Similar to Approach 2, the equation for the estimates of fishing activity in time block t ($\hat{A}_{dgjt}$) for each day type (d) and group (g) of landing sites (i) and work block (j) for Approach 3 is the same as equation A7 in the DFO methods except it includes an additional index for the targeted species (ρ).

$$\hat{A}_{dgj\rho t} = \sum_{i}\left[W1_{dij}\sum_{k}\sum_{q}\left(W2_{dijk}\,A_{dijkq\rho t}\right)\right] \qquad \text{(eq. A21)}$$

This leads to a change in the calculation of the activity profile ($P_{dgj\rho t}$) to also include the additional index of the targeted subarea (ρ):

$$P_{dgj\rho t} = \frac{\hat{A}_{dgj\rho t}}{\hat{T}_{dgj}} \qquad \text{(eq. A22)}$$

10.0 APPENDIX 2 – DIFFERENCES BETWEEN ESTIMATES BASED ON THE ANALYSIS USED IN THIS STUDY AND THOSE GENERATED BY THE CURRENT DFO ANALYSIS PACKAGE.

Figure A1 (next page): The proportional difference in activity profiles between the derivation of current methods used in this study and the activity profiles generated by the current analysis package. Columns titled PBAt are the proportion of boats active in timeblock t. Proportions are calculated as (Estimate from this study – Estimate from DFO analysis package)/(Estimate from this study). Red cells show a negative bias; yellow cells show small or zero bias; and green cells show a positive bias. Cells outlined in black represent the range of hours of the aerial surveys for those months. The reason for these differences in the calculation of activity profiles requires further investigation.

YEAR	MONTH	AREA	DAYTYPE	PBA1	PBA2	PBA3	PBA4	PBA5	PBA6	PBA7	PBA8	PBA9	PBA10	PBA11	PBA12	PBA13	PBA14	PBA15	PBA16
2010	3	19B	1	-0.42	-0.06	-0.08	-0.11	-0.04	-0.01	0.00	0.00	-0.06	0.06	0.25	0.00	0.00	0.00	0.00	0.00
2010	3	19C	1	-0.42	-0.06	-0.08	-0.11	-0.04	-0.01	0.00	0.00	-0.06	0.06	0.25	0.00	0.00	0.00	0.00	0.00
2010	3	19D	1	-0.42	-0.06	-0.08	-0.11	-0.04	-0.01	0.00	0.00	-0.06	0.06	0.25	0.00	0.00	0.00	0.00	0.00
2010	3	19E	1	-0.42	-0.06	-0.08	-0.11	-0.04	-0.01	0.00	0.00	-0.06	0.06	0.25	0.00	0.00	0.00	0.00	0.00
2010	3	20D	1	-0.42	-0.06	-0.08	-0.11	-0.04	-0.01	0.00	0.00	-0.06	0.06	0.25	0.00	0.00	0.00	0.00	0.00
2010	3	19B	2	-0.19	-0.21	-0.13	-0.10	-0.03	-0.03	-0.03	-0.03	-0.04	-0.08	-0.15	-2.53	0.00	0.00	0.00	0.00
2010	3	19C	2	-0.19	-0.21	-0.13	-0.10	-0.03	-0.03	-0.03	-0.03	-0.04	-0.08	-0.15	-2.53	0.00	0.00	0.00	0.00
2010	3	19D	2	-0.19	-0.21	-0.13	-0.10	-0.03	-0.03	-0.03	-0.03	-0.04	-0.08	-0.15	-2.53	0.00	0.00	0.00	0.00
2010	3	19E	2	-0.19	-0.21	-0.13	-0.10	-0.03	-0.03	-0.03	-0.03	-0.04	-0.08	-0.15	-2.53	0.00	0.00	0.00	0.00
2010	3	20D	2	-0.19	-0.21	-0.13	-0.10	-0.03	-0.03	-0.03	-0.03	-0.04	-0.08	-0.15	-2.53	0.00	0.00	0.00	0.00
2010	4	19B	1	0.08	-0.10	-0.20	-0.22	-0.21	-0.17	-0.06	0.02	0.02	-0.01	-0.17	-1.51	0.10	0.10	0.00	0.00
2010	4	19C	1	0.08	-0.10	-0.20	-0.22	-0.21	-0.17	-0.06	0.02	0.02	-0.01	-0.17	-1.51	0.10	0.10	0.00	0.00
2010	4	19D	1	0.08	-0.10	-0.20	-0.22	-0.21	-0.17	-0.06	0.02	0.02	-0.01	-0.17	-1.51	0.10	0.10	0.00	0.00
2010	4	19E	1	0.08	-0.10	-0.20	-0.22	-0.21	-0.17	-0.06	0.02	0.02	-0.01	-0.17	-1.51	0.10	0.10	0.00	0.00
2010	4	20D	1	0.08	-0.10	-0.20	-0.22	-0.21	-0.17	-0.06	0.02	0.02	-0.01	-0.17	-1.51	0.10	0.10	0.00	0.00
2010	4	19B	2	-1.62	-0.57	-0.20	-0.10	-0.12	-0.10	-0.09	-0.01	-0.07	-0.16	-0.47	-1.14	-1.25	-1.25	0.00	0.00
2010	4	19C	2	-1.62	-0.57	-0.20	-0.10	-0.12	-0.10	-0.09	-0.01	-0.07	-0.16	-0.47	-1.14	-1.25	-1.25	0.00	0.00
2010	4	19D	2	-1.62	-0.57	-0.20	-0.10	-0.12	-0.10	-0.09	-0.01	-0.07	-0.16	-0.47	-1.14	-1.25	-1.25	0.00	0.00
2010	4	19E	2	-1.62	-0.57	-0.20	-0.10	-0.12	-0.10	-0.09	-0.01	-0.07	-0.16	-0.47	-1.14	-1.25	-1.25	0.00	0.00
2010	4	20D	2	-1.62	-0.57	-0.20	-0.10	-0.12	-0.10	-0.09	-0.01	-0.07	-0.16	-0.47	-1.14	-1.25	-1.25	0.00	0.00
2010	5	19B	1	0.59	0.32	0.20	0.06	0.06	0.07	-0.03	0.00	0.08	0.07	-0.04	-0.18	0.64	0.64	0.00	0.00
2010	5	19C	1	0.59	0.32	0.20	0.06	0.06	0.07	-0.03	0.00	0.08	0.07	-0.04	-0.18	0.64	0.64	0.00	0.00
2010	5	19D	1	0.59	0.32	0.20	0.06	0.06	0.07	-0.03	0.00	0.08	0.07	-0.04	-0.18	0.64	0.64	0.00	0.00
2010	5	19E	1	0.59	0.32	0.20	0.06	0.06	0.07	-0.03	0.00	0.08	0.07	-0.04	-0.18	0.64	0.64	0.00	0.00
2010	5	20D	1	0.59	0.32	0.20	0.06	0.06	0.07	-0.03	0.00	0.08	0.07	-0.04	-0.18	0.64	0.64	0.00	0.00
2010	5	19B	2	-0.10	-0.16	-0.14	-0.10	-0.08	-0.07	-0.05	0.01	0.00	-0.08	-0.24	-1.67	0.04	0.00	0.00	0.00
2010	5	19C	2	-0.10	-0.16	-0.14	-0.10	-0.08	-0.07	-0.05	0.01	0.00	-0.08	-0.24	-1.67	0.04	0.00	0.00	0.00
2010	5	19D	2	-0.10	-0.16	-0.14	-0.10	-0.08	-0.07	-0.05	0.01	0.00	-0.08	-0.24	-1.67	0.04	0.00	0.00	0.00
2010	5	19E	2	-0.10	-0.16	-0.14	-0.10	-0.08	-0.07	-0.05	0.01	0.00	-0.08	-0.24	-1.67	0.04	0.00	0.00	0.00
2010	5	20D	2	-0.10	-0.16	-0.14	-0.10	-0.08	-0.07	-0.05	0.01	0.00	-0.08	-0.24	-1.67	0.04	0.00	0.00	0.00
2010	6	19B	1	-1.23	-0.39	-0.14	0.12	0.11	0.14	0.17	0.22	0.17	0.07	-0.09	-0.55	-0.11	-0.03	0.00	0.00
2010	6	19C	1	-1.23	-0.39	-0.14	0.12	0.11	0.14	0.17	0.22	0.17	0.07	-0.09	-0.55	-0.11	-0.03	0.00	0.00
2010	6	19D	1	-1.23	-0.39	-0.14	0.12	0.11	0.14	0.17	0.22	0.17	0.07	-0.09	-0.55	-0.11	-0.03	0.00	0.00
2010	6	19E	1	-1.23	-0.39	-0.14	0.12	0.11	0.14	0.17	0.22	0.17	0.07	-0.09	-0.55	-0.11	-0.03	0.00	0.00
2010	6	20D	1	-1.23	-0.39	-0.14	0.12	0.11	0.14	0.17	0.22	0.17	0.07	-0.09	-0.55	-0.11	-0.03	0.00	0.00
2010	6	19B	2	-0.19	-0.22	-0.17	-0.10	-0.02	0.00	0.05	0.09	-0.15	-0.21	-0.36	-2.02	-1.42	-1.42	-1.42	0.00
2010	6	19C	2	-0.19	-0.22	-0.17	-0.10	-0.02	0.00	0.05	0.09	-0.15	-0.21	-0.36	-2.02	-1.42	-1.42	-1.42	0.00
2010	6	19D	2	-0.19	-0.22	-0.17	-0.10	-0.02	0.00	0.05	0.09	-0.15	-0.21	-0.36	-2.02	-1.42	-1.42	-1.42	0.00
2010	6	19E	2	-0.19	-0.22	-0.17	-0.10	-0.02	0.00	0.05	0.09	-0.15	-0.21	-0.36	-2.02	-1.42	-1.42	-1.42	0.00
2010	6	20D	2	-0.19	-0.22	-0.17	-0.10	-0.02	0.00	0.05	0.09	-0.15	-0.21	-0.36	-2.02	-1.42	-1.42	-1.42	0.00
2010	7	19B	1	-0.10	0.04	0.15	0.17	0.04	0.01	0.02	0.05	0.14	0.01	-0.13	-0.90	-1.09	-1.42	0.00	0.00
2010	7	19C	1	-0.10	0.04	0.15	0.17	0.04	0.01	0.02	0.05	0.14	0.01	-0.13	-0.90	-1.09	-1.42	0.00	0.00
2010	7	19D	1	-0.10	0.04	0.15	0.17	0.04	0.01	0.02	0.05	0.14	0.01	-0.13	-0.90	-1.09	-1.42	0.00	0.00
2010	7	19E	1	-0.10	0.04	0.15	0.17	0.04	0.01	0.02	0.05	0.14	0.01	-0.13	-0.90	-1.09	-1.42	0.00	0.00
2010	7	20D	1	-0.10	0.04	0.15	0.17	0.04	0.01	0.02	0.05	0.14	0.01	-0.13	-0.90	-1.09	-1.42	0.00	0.00
2010	7	19B	2	-0.11	-0.10	-0.07	-0.08	-0.04	0.01	0.11	0.17	0.12	0.01	-0.10	-0.89	-0.08	-0.08	-0.08	0.00
2010	7	19C	2	-0.11	-0.10	-0.07	-0.08	-0.04	0.01	0.11	0.17	0.12	0.01	-0.10	-0.89	-0.08	-0.08	-0.08	0.00
2010	7	19D	2	-0.11	-0.10	-0.07	-0.08	-0.04	0.01	0.11	0.17	0.12	0.01	-0.10	-0.89	-0.08	-0.08	-0.08	0.00
2010	7	19E	2	-0.11	-0.10	-0.07	-0.08	-0.04	0.01	0.11	0.17	0.12	0.01	-0.10	-0.89	-0.08	-0.08	-0.08	0.00
2010	7	20D	2	-0.11	-0.10	-0.07	-0.08	-0.04	0.01	0.11	0.17	0.12	0.01	-0.10	-0.89	-0.08	-0.08	-0.08	0.00
2010	8	19B	1	0.30	0.25	0.22	0.17	-0.08	-0.01	0.07	0.16	0.12	0.12	0.02	-0.28	-0.41	-0.44	0.00	0.00
2010	8	19C	1	0.30	0.25	0.22	0.17	-0.08	-0.01	0.07	0.16	0.12	0.12	0.02	-0.28	-0.41	-0.44	0.00	0.00
2010	8	19D	1	0.30	0.25	0.22	0.17	-0.08	-0.01	0.07	0.16	0.12	0.12	0.02	-0.28	-0.41	-0.44	0.00	0.00
2010	8	19E	1	0.30	0.25	0.22	0.17	-0.08	-0.01	0.07	0.16	0.12	0.12	0.02	-0.28	-0.41	-0.44	0.00	0.00
2010	8	20D	1	0.30	0.25	0.22	0.17	-0.08	-0.01	0.07	0.16	0.12	0.12	0.02	-0.28	-0.41	-0.44	0.00	0.00
2010	8	19B	2	-0.21	-0.17	-0.15	-0.11	-0.01	0.02	0.07	0.17	0.08	-0.04	-0.38	-1.20	-0.65	-0.65	-0.65	0.00
2010	8	19C	2	-0.21	-0.17	-0.15	-0.11	-0.01	0.02	0.07	0.17	0.08	-0.04	-0.38	-1.20	-0.65	-0.65	-0.65	0.00
2010	8	19D	2	-0.21	-0.17	-0.15	-0.11	-0.01	0.02	0.07	0.17	0.08	-0.04	-0.38	-1.20	-0.65	-0.65	-0.65	0.00
2010	8	19E	2	-0.21	-0.17	-0.15	-0.11	-0.01	0.02	0.07	0.17	0.08	-0.04	-0.38	-1.20	-0.65	-0.65	-0.65	0.00
2010	8	20D	2	-0.21	-0.17	-0.15	-0.11	-0.01	0.02	0.07	0.17	0.08	-0.04	-0.38	-1.20	-0.65	-0.65	-0.65	0.00
2010	9	19B	1	-0.10	0.09	0.00	-0.04	0.04	0.03	0.06	0.07	-0.07	-0.15	-0.32	-0.74	-0.59	-0.91	0.00	0.00
2010	9	19C	1	-0.10	0.09	0.00	-0.04	0.04	0.03	0.06	0.07	-0.07	-0.15	-0.32	-0.74	-0.59	-0.91	0.00	0.00
2010	9	19D	1	-0.10	0.09	0.00	-0.04	0.04	0.03	0.06	0.07	-0.07	-0.15	-0.32	-0.74	-0.59	-0.91	0.00	0.00
2010	9	19E	1	-0.10	0.09	0.00	-0.04	0.04	0.03	0.06	0.07	-0.07	-0.15	-0.32	-0.74	-0.59	-0.91	0.00	0.00
2010	9	20D	1	-0.10	0.09	0.00	-0.04	0.04	0.03	0.06	0.07	-0.07	-0.15	-0.32	-0.74	-0.59	-0.91	0.00	0.00
2010	9	19B	2	-1.30	-0.31	-0.14	0.00	0.01	0.00	-0.01	-0.02	-0.01	-0.07	-0.16	-0.35	-0.59	0.00	0.00	0.00
2010	9	19C	2	-1.30	-0.31	-0.14	0.00	0.01	0.00	-0.01	-0.02	-0.01	-0.07	-0.16	-0.35	-0.59	0.00	0.00	0.00
2010	9	19D	2	-1.30	-0.31	-0.14	0.00	0.01	0.00	-0.01	-0.02	-0.01	-0.07	-0.16	-0.35	-0.59	0.00	0.00	0.00
2010	9	19E	2	-1.30	-0.31	-0.14	0.00	0.01	0.00	-0.01	-0.02	-0.01	-0.07	-0.16	-0.35	-0.59	0.00	0.00	0.00
2010	9	20D	2	-1.30	-0.31	-0.14	0.00	0.01	0.00	-0.01	-0.02	-0.01	-0.07	-0.16	-0.35	-0.59	0.00	0.00	0.00

11.0 APPENDIX 2 – DIFFERENCES BETWEEN CURRENT AND UNADJUSTED RESULTS

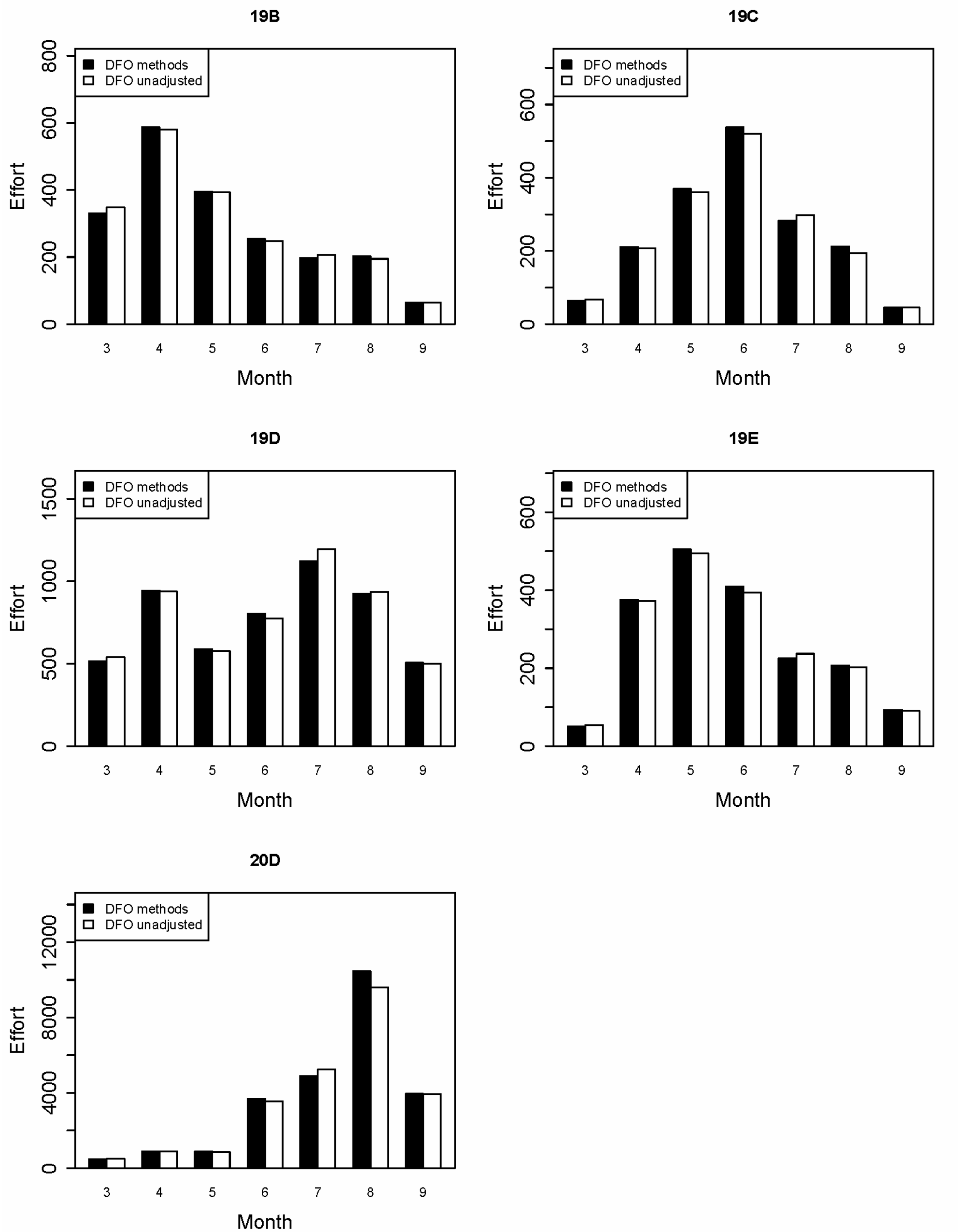

Figure A2: Comparison of monthly estimates of effort per subarea using the current methods and the unadjusted methods that do not expand estimates for the number of days sampled and the number of boats missed.

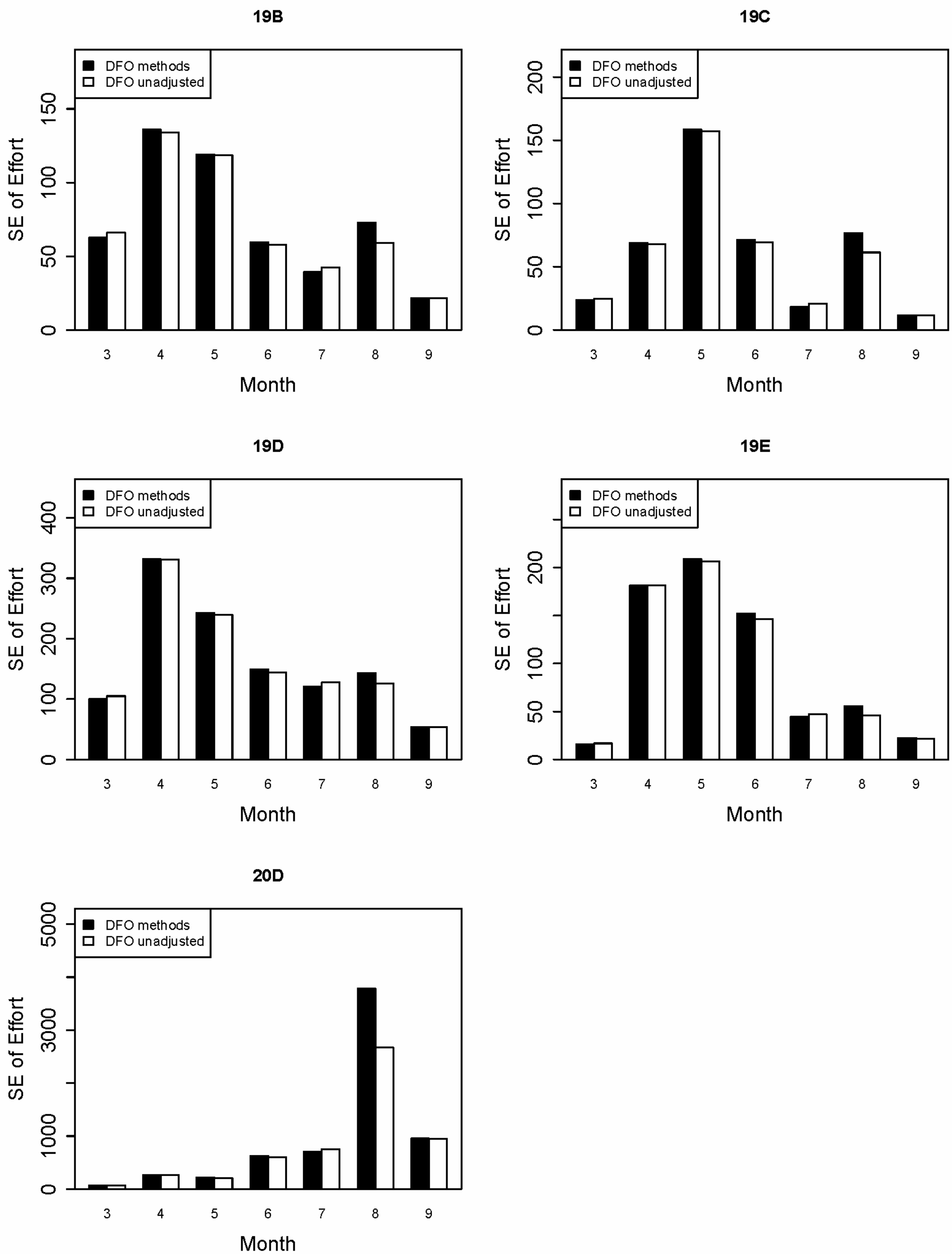

Figure A3: Comparison of the standard error in the monthly estimates of effort per subarea using the current methods and the unadjusted methods that do not expand estimates for the number of days sampled and the number of boats missed.

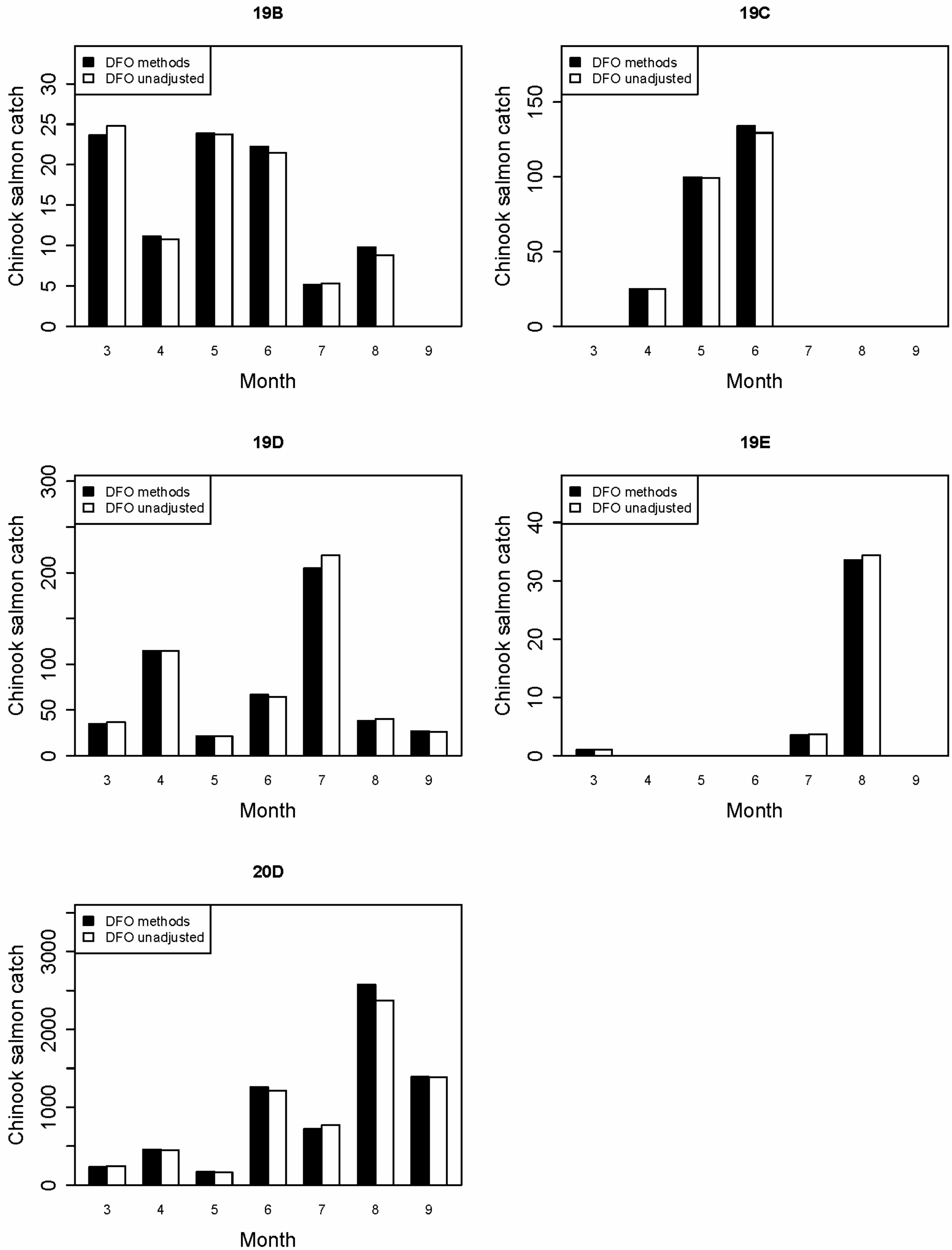

Figure A4: Comparison of monthly estimates of catch of chinook salmon per subarea using the current methods and the unadjusted methods that do not expand estimates for the number of days sampled and the number of boats missed.

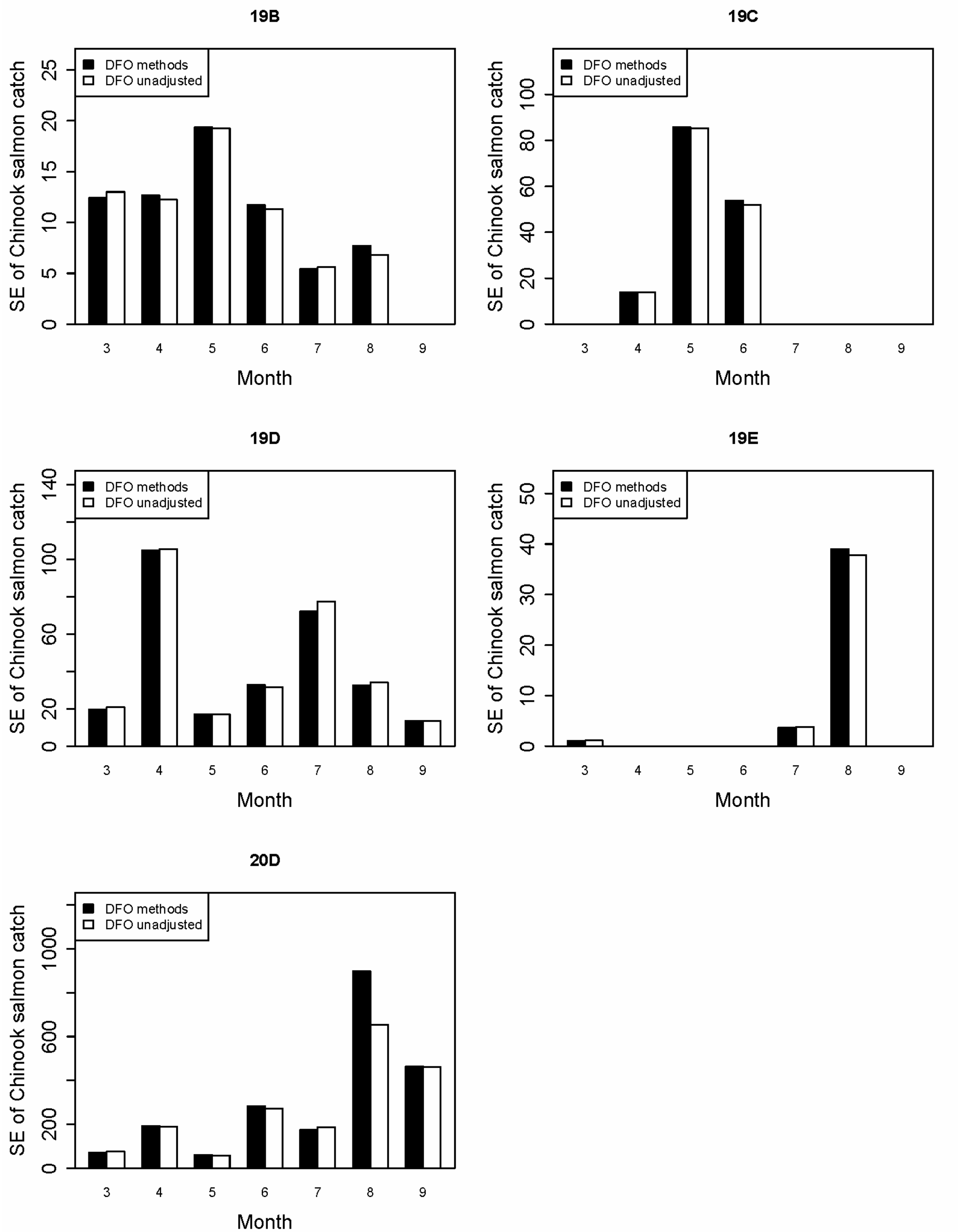

Figure A5: Comparison of the standard error in the monthly estimates of chinook salmon catch per subarea using the current methods and the unadjusted methods that do not expand estimates for the number of days sampled and the number of boats missed.

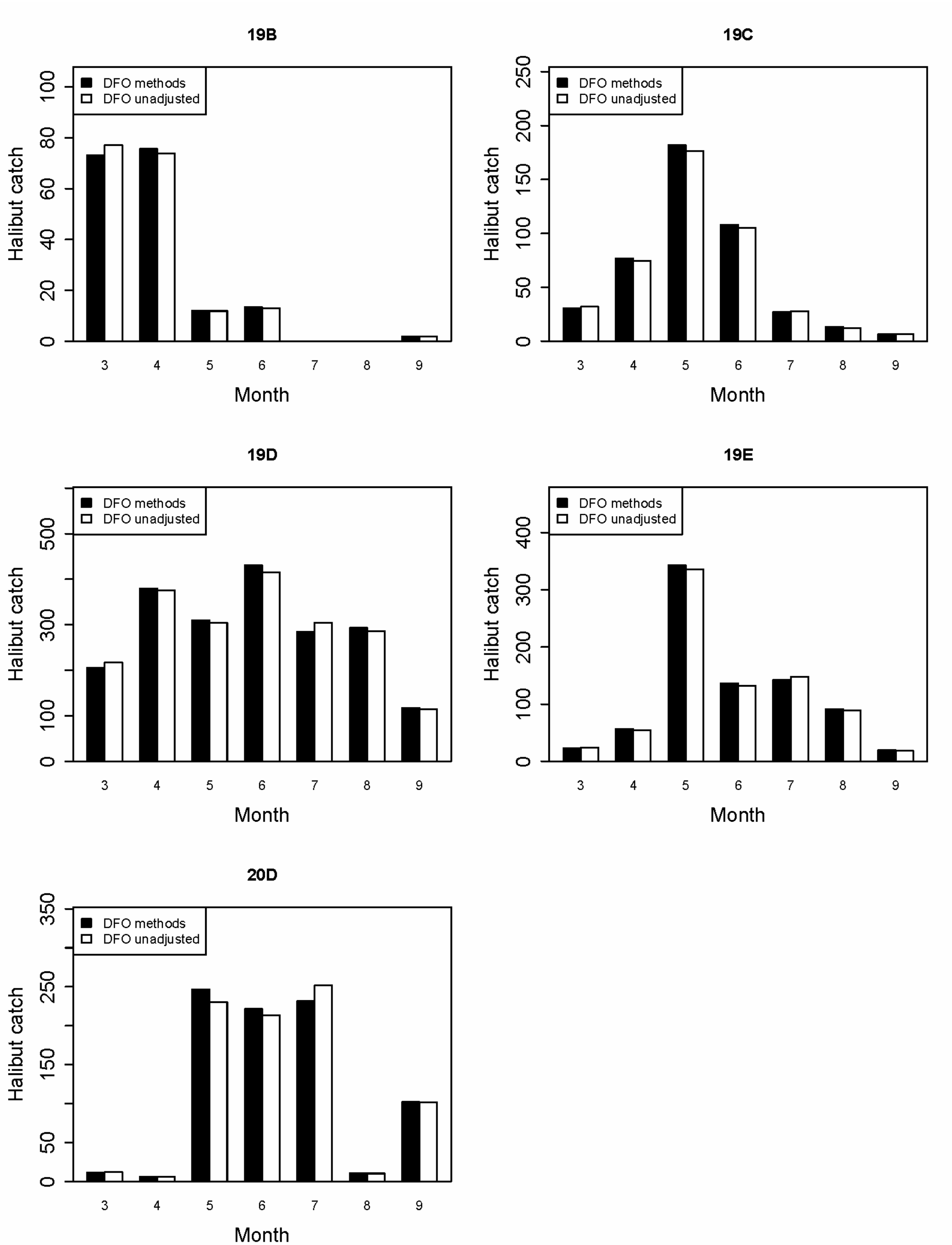

Figure A6: Comparison of monthly estimates of catch of halibut per subarea using the current and the unadjusted methods that do not expand estimates for the number of days sampled and the number of boats missed.

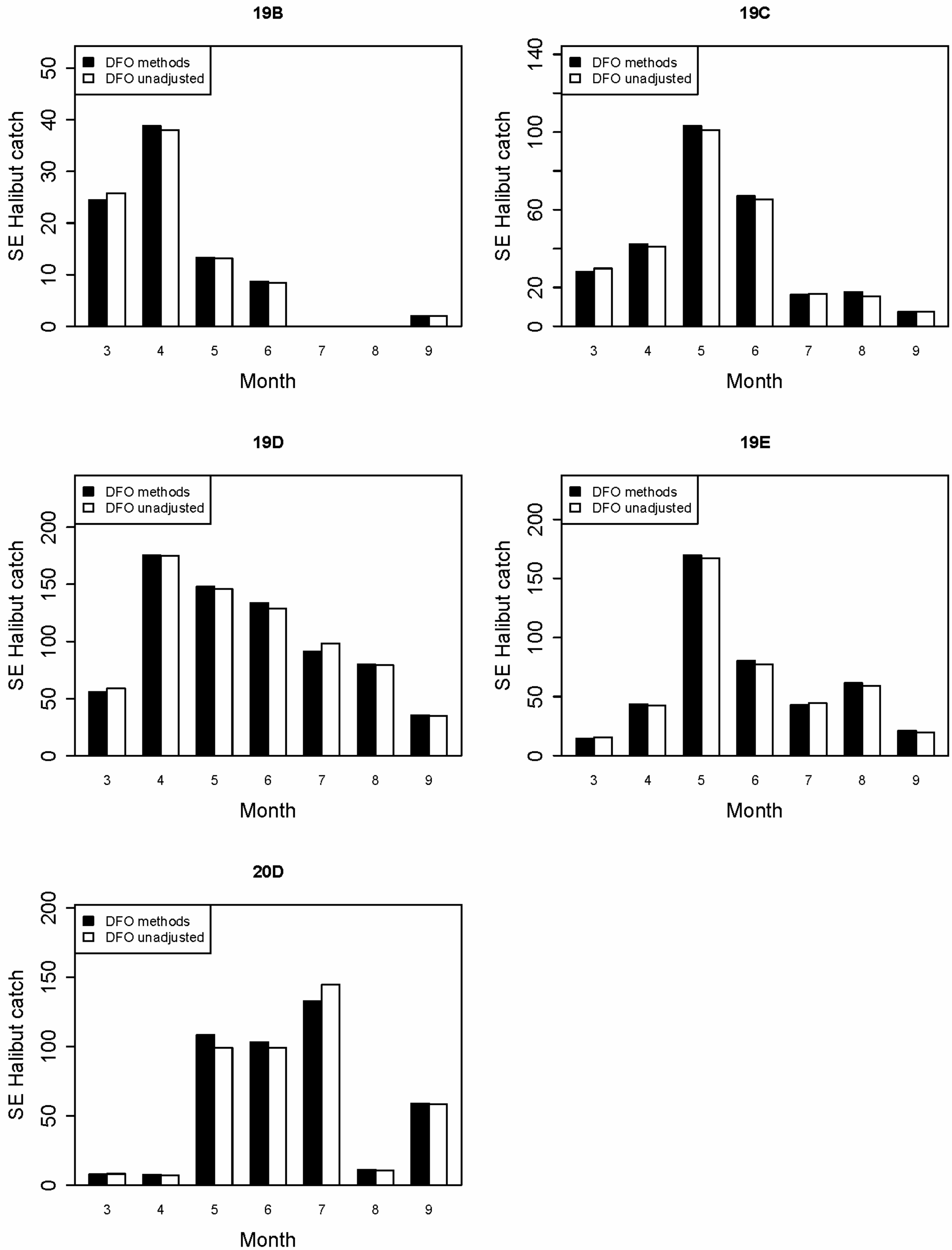

Figure A7: Comparison of the standard error in the monthly estimates of halibut catch per subarea using the current methods and the unadjusted methods that do not expand estimates for the number of days sampled and the number of boats missed.