DRAFT

Assessment of Two Methods for Estimating the Composition of Chinook Encounters Early in the Fishing Season

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Executive Summary

An important component of the in-season creel surveys conducted for Chinook mark-selective fisheries (MSF) is a test fishery (TF) and/or angler Voluntary Trip Report (VTR) survey that provides the data used to estimate the size (legal or sub-legal) and mark (marked or unmarked) composition of the Chinook being encountered by the fishery. Early in the fishing season, sample sizes for these programs are often small (< 20 fish) and estimates of the size|mark composition are imprecise and can vary greatly from day to day. This presents a challenge to fishery co-managers as the early-season assessments of the total encounters and mortalities of marked and unmarked Chinook that have occurred to date may fluctuate considerably (increasing or decreasing) until later in the season when sample sizes are larger and the estimated size|mark composition is more stable. The objective of the analyses conducted for this report is to determine if there are alternative methods of estimating the size|mark composition of Chinook encounters that can be used when the sample sizes for the TF or VTR programs are small early in a fishing season. Two alternative methods are examined: (1) the mean of the three prior years of size|mark composition estimates and (2) in-season information collected during dockside interviews of anglers exiting the MSF; from these interviews, Chinook harvested and Chinook released are tabulated by size|mark composition category.

Based on an examination of the size|mark composition estimates from each alternative method and retrospective analyses, the following recommendations are made:

- ***Dockside angler interview data collected in-season should be used to estimate the size|mark composition of Chinook encounters early in the season prior to the collection of an adequate sample size by the in-season TF/VTR programs.***
- ***Adequate sample sizes for the in-season TF/VTR programs should be defined as a sample size that produces an estimate for the proportion of legal-size and marked encounters that has a coefficient of variation ≤20%.***
- ***Whenever Method 2 is used to estimate the total number of Chinook encounters in a MSF, and dockside data are being used instead of TF/VTR data to estimate the size|mark composition of Chinook encounters, bias-correction methods should be applied to the estimate of the size|mark composition and the bias-corrected estimate of %LM should be used to estimate total encounters and apportion the encounters to size|mark categories.***
- ***Size|mark composition estimates using the dockside angler interview data should replace the beta regression method currently used for post-season MSF analyses and reporting when sample sizes from an area's TF/VTR programs are small and do not meet the 20% CV standard.***

Introduction

In-season creel surveys have been used to estimate the harvest and total encounters of Chinook salmon by mark-selective fisheries (MSF) conducted in the marine areas of Puget Sound since 2003. Detailed descriptions of the creel surveys and estimation methods are presented in WDFW (2012). Estimates of total Chinook encounters are apportioned into four size|mark categories[1] and total mortalities of marked (hatchery) and unmarked (predominately wild fish) Chinook are estimated and include both harvest and mortalities due to the catch and release of Chinook by anglers (release mortalities). An important component of the in-season creel surveys is a test fishery (TF) and/or angler Voluntary Trip Report (VTR) survey that provides the data used to estimate the size|mark composition of the Chinook being encountered[2] by the fishery. The data from these sampling programs are used not only to apportion the estimate of total encounters but the proportion of legal-size and marked (LM) Chinook from these data are also used in the estimate of total encounters using Method 2 (WDFW 2012). Method 2 is the recommended method for estimating total encounters and mortalities in Chinook MSFs (Conrad and McHugh 2008).

Early in the fishing season, sample sizes (number of Chinook sampled for size|mark composition) in these sampling programs are often small (< 20 fish) and estimates of the size|mark composition are imprecise and can vary greatly from day to day as more Chinook are sampled. This presents a challenge to fishery co-managers as the early-season assessments of the total mortalities and encounters of marked and unmarked Chinook that have occurred to date may fluctuate considerably (increasing or decreasing) until later in the season when sample sizes are larger and the estimated size|mark composition is more stable.

The objective of the analyses conducted for this report is to determine if there are alternative methods of estimating the size|mark composition of Chinook encounters that can be used when the sample sizes for the test fishery and/or VTR (TF/VTR) programs are small early in a fishing season. Retrospective analyses are used to compare and evaluate two possible alternatives, one based on the prior three-year mean composition for the fishery and the other based on in-season creel survey information collected during access site surveys that tabulate the number of Chinook harvested by anglers and angler-reported releases of Chinook by size|mark category.

[1] Legal size and marked (LM), legal size and unmarked (LU), sub-legal size and marked (SM), and sub-legal size and unmarked (SU).

[2] An encounter is a Chinook caught by an angler and brought to the boat where a decision is made by the angler to keep (harvest) or release the fish.

Methods

Two alternative methods for estimating the size|mark composition of Chinook encounters early in the season are compared and evaluated:

1. The mean of the three prior years of size|mark composition estimates used in the post-season MSF analysis for a marine area, and
2. In-season information collected during dockside interviews of anglers exiting the MSF in a marine area; from these interviews, Chinook harvested and Chinook released are tabulated by size|mark category.

Prior Three-year Mean (3YM):

Each year, WDFW produces post-season reports summarizing the in-season creel surveys conducted during summer (May through September) and winter (October through April) Chinook MSFs. The most recent reports are WDFW (2019) and WDFW (2020), respectively. These annual reports include the results of TF/VTR programs conducted in each marine area where a Chinook MSF was conducted.

For marine areas with in-season creel surveys, we calculated the mean of the three prior years of size|mark composition estimates[3] from the TF/VTR programs. Test fishing data are believed to be of higher quality than VTR data, as they are collected by trained samplers (WDFW and NWIFC 2013). When test fishery sample sizes are adequate[4], typically only the test fishery data are used. When test fishery sample sizes are small, they are sometimes combined with VTR data to estimate the size|mark composition of the encounters. For a marine area, the size|mark composition data used to produce each year's post-season estimates are used as the annual standard for comparison in the retrospective analyses and are also used to estimate the three-year mean composition.

Dockside Angler Interview Data (Dockside):

Prior to WDFW implementing electronic data collection in May of 2017, only the mark status (marked [adipose fin clipped], unmarked [adipose fin intact], undetermined, or unknown) of released Chinook was collected during a Dockside creel interview. After the implementation of electronic data collection, legal-size status (legal, sub-legal, unknown, not applicable) of reported releases was added to the Dockside interview protocol and has since been collected in every Puget Sound fishery. Before electronic data collection, a kept fish's length was recorded on scale cards and data were not keyed until 3-4 months after the fishery had ended. With the implementation of electronic data collection, the size of kept fish is now available immediately so the size composition of the harvest can be estimated in-season.

Electronically-collected Dockside data are available for the summer 2017, 2018, and 2019 seasons and the 2017 and 2018 winter seasons (the 2019 winter season ended in April 2020).

[3] The exceptions are:

- for the Area 7 summer MSF, which has only been conducted since 2016, the 2018 retrospective analysis uses a two-year mean (2016 and 2017) and there is no retrospective analysis for the 2017 MSF, and
- for the Area 10 summer MSF, the fishery was closed in 2015, so data from 2013 and 2014 are used in the calculation of 3-year means for 2017 (2013 and 2014) and 2018 (2014).

[4] Adequate sample sizes are defined as a sample size that produces an estimate for the proportion of LM encounters that has a coefficient of variation ≤ 20% (WDFW and NWIFC 2013).

Unlike the size|mark composition estimates based on the three-year mean of previous years, the Dockside data are collected during the current fishing season. Sample size is a consideration for the in-season data, and it is important that the sample size is large enough so that estimate precision is not an issue with the early-season estimates of the size|mark composition of Chinook encounters. However, sample size for the Dockside data is not as straightforward as for the TF/VTR programs. For the TF/VTR programs, the sample unit is the encounter as the size|mark status of each Chinook encountered is recorded at the time of capture. For the Dockside data, the sample unit is the boat and the encounters by all anglers in a boat are recorded by size|mark category.

In most seasons, an alternative to the TF/VTR estimate of the size|mark composition of Chinook encounters is typically needed early in the season when sample sizes for these programs are small. Therefore, we examine sample sizes for the Dockside interview data as both the number of boats interviewed and the total number of Chinook encounters (observed harvest plus reported releases) during week 1, weeks 1 and 2 combined, and for the season. Angler reports of released encounters often include unknown species released and Chinook of unknown mark and/or size status released. These "unknown" fish are not included in the analyses and the reported sample size since in any accounting of them, they would be apportioned based on the species and Chinook size|mark composition from angler reports where this information was identified.

Retrospective Analyses:

Two different retrospective analyses are presented. The first retrospective analysis is more quantitative in that the differences between the TF/VTR-based estimates used for the post-season analysis and the estimates from the alternative methods are calculated. An assessment based on these differences is the basis for a recommendation on the preferred alternative method. The second retrospective analysis is more qualitative and consists of a visual comparison of the size|mark composition estimates from different temporal components of the recommended in-season method to the end-of-season TF/VTR-based estimates and an assessment of sample sizes.

The first retrospective analysis compares an area's size|mark composition estimates from the TF/VTR program (the estimates used for the post-season estimates) to the 3YM and Dockside estimates. The purpose of this analysis is to examine how closely the estimates from the alternative methods resemble the end-of-season estimates from the TF/VTR programs. For this analysis, the difference between the TF/VTR estimate and alternative method estimate is calculated for each of the size|mark categories (alternative estimate – TF/VTR estimate). The mean of the absolute value of these differences across all four size|mark categories is also calculated as a summary measure of total difference.

The second retrospective analysis compares in-season estimates of size|mark composition from the Dockside sampling program to the post-season TF/VTR-based estimates using data collected in the first week of the fishery and the combined data from the first and second week of the fishery. Sample sizes for the TF/VTR sampling programs are typically so small than temporal stratification for these comparisons is not warranted.

The precision of the size|mark composition estimates from the TF/VTR program is estimated using methods for simultaneous confidence intervals (CIs) for multinomial proportions (Goodman 1965). The 95% CIs for the TF/VTR estimates are calculated and displayed on graphs comparing the estimates by the different methods. Because of the effective sample size issue for the Dockside data discussed

previously, no confidence intervals are calculated for the size|mark composition estimates from the Dockside data.

The major assumption for the analyses presented is that ***the size|mark composition estimate from the TF/VTR programs used for the post-season analysis is the "best" estimate of the size|mark composition of Chinook encountered by the mark-selective fishery conducted in a marine area.*** A brief discussion of these programs and their assumptions follows.

For the test fishery program, the data are collected by biologists and the quality (accuracy) of the data is considered high. However, the following major assumptions are necessary for the test fishery program:

1. The population of Chinook being encountered by the test fishers is representative of the population being encountered by the recreational fishery in a marine area. Marine areas are large and the recreational fishery is widely spread (although high use areas are known and targeted for sampling by the test fishery). The test fishery covers only a very small proportion of the area fished by the recreational fishery.
2. The gear used, and method of fishing, by the test fishers is representative of that being used in the recreational fishery. WDFW collects gear usage data during Dockside interviews to inform the fishing methods used by the test fishers. It is assumed that the composition of the encountered fish that are actually brought to the boat is the same (especially in size composition) for test fishers and recreational anglers.

These same two assumptions are necessary for the VTR program, but in this case the data are being collected by the recreational anglers themselves. However, because only a relatively small number of anglers are involved in the VTR programs, we must assume that their times of fishing, areas fished, and methods of fishing are representative of recreational anglers in general. In addition, we must assume that the data are being recorded accurately by the voluntary anglers in the program.

Sample sizes for the test fishery and VTR programs can be small (< 20) which can result in relatively imprecise estimates of the size|mark composition for the Chinook encountered.

The major assumption for Dockside interview data is that anglers accurately recall the number of Chinook that they report as being released in each size|mark category. Pollock et al (1994) discuss potential sources of bias related to angler interview surveys that rely upon angler recall and reporting of data. Conrad and McHugh (2008) discuss and provide examples of some of the biases associated with angler recall (prestige bias, digit bias, etc.) in Chinook MSFs conducted in Puget Sound. Large numbers of boats, and hence anglers, are sampled during the Dockside sampling program for the MSFs which have in-season creel surveys. Therefore, concerns about the data being representative of the recreational anglers fishing in an area is minimal. *The main concern with the Dockside data is its accuracy due to angler recall and potential for bias.*

<u>Examination of Bias between Dockside and TF/VTR Estimates of Size|Mark Composition:</u>

In the retrospective analysis #1 results, the mean of the differences between the Dockside and TF/VTR estimates[5] of the proportion of Chinook encounters that are legal-size and marked (%LM) across all areas and seasons was +5.3%. For 15 of the 23 (65%) comparisons examined for the retrospective

[5] Differences calculated as Dockside estimate – TF/VTR estimate.

analysis, the Dockside estimate of %LM was greater than the TF/VTR estimate. Because the TF/VTR data are considered more accurate than the Dockside data, we compare end-of-season Dockside estimates to TF/VTR estimates for each of the size|mark composition categories. The objective of these analyses is to:

1. assess whether the differences between the estimates of encounter composition from the two data sources are statistically significant, and
2. assess the consistency of these differences and determine whether some adjustments to the Dockside estimates of the size|mark composition are warranted before being used in MSF analyses.

The same data were used for these analyses as in the retrospective analyses (see Appendix C) with two exceptions: (a) data from the VTR program for Area 06 summer MSFs was added as the VTR sample sizes for this fishery are relatively large (98-149), and (b) the data for the areas 8-1 and 8-2 winter MSFs were not used because of small VTR sample sizes which usually requires their data to be pooled for post-season analyses.

Proportional data, such as the encounter size|mark composition estimates, are inherently non-normal in their distribution. Therefore, the non-parametric Wilcoxon Signed Ranks (WSR) test is used to compare the size|mark composition estimates from the end-of-season Dockside and TF/VTR programs. The WSR test is a pair-wise procedure for comparing related samples. The test uses the signed rank of the difference between the estimate of size|mark composition from each data source for each area, season, and year (the data pairs) and tests the hypothesis that the median of the differences across all comparisons is zero (Conover 1980). Each size|mark composition category is tested separately.

Both a ratio estimator and simple linear regression analysis are evaluated as methods for estimating the relationship between the Dockside estimate of the percentage of a size|mark category (the *X* variable) and the TF/VTR estimate of the percentage of the same size|mark category (the response or *Y* variable). The ratio estimator is appropriate when the relationship between the two variables is a straight line through the origin and the variance of the data around the line is proportional to X (Cochran 1978). The regression estimator is appropriate when the relationship between the two variables is linear and the variance of the data around the line is homoscedastic (i.e., the variation of the data around the regression line is approximately the same over the range of *X*). If the 95% confidence interval for the estimated slope of the line from an estimator is significant ($P \leq 0.05$) but includes 1.0 we conclude that there is no evidence of statistically significant bias[6] between the two methods. If the estimated slope is significant and the 95% confidence interval for the estimated slope does not include 1.0 we conclude that there is evidence of statistically significant bias.

[6] Although both the *X* and *Y* variables are estimates, the TF/VTR data are considered to provide the "best" estimate of the size|mark composition of Chinook encounters. Therefore, in our assessment of differences, bias is considered to be relative to the TF/VTR estimates.

Results

Retrospective Analysis #1 – End-of-season comparisons

The purpose of these comparisons is to assess how closely the end-of-season Dockside and 3YM estimates of the size|mark composition of Chinook encounters resemble the post-season estimates of composition from the TF/VTR programs. Table 1 summarizes the mean differences between the Dockside and 3YM estimates from the post-season TF/VTR estimates for each of the four size|mark categories. Bar graphs comparing the different size|mark composition estimates for each area and season are presented in Appendix A.

Although there is not a large difference in the performance of the two alternative methods examined, the Dockside method performs slightly better than the 3YM:

- For the mean percentage difference for the individual size|mark categories across all areas and seasons, the Dockside method has the smallest absolute (regardless of sign) mean percentage difference in 19 comparisons while the 3YM method has the smallest absolute mean percentage difference in 17 comparisons.
- For the mean absolute difference (MAD) across all four categories, the Dockside method has the smallest mean percentage difference for seven comparisons (range: 3.4% to 10.6%) compared to only two for the 3YM method (range: 5.6% to 14.2%).
- The Dockside method performs better than the 3YM across all categories for Area 10 summer,
- The 3YM performs better than the Dockside method across all categories for Area 11 summer.

Because the estimate of the proportion of LM encounters is also used in the estimate of total encounters (Method 2), this category is examined in more detail. The mean of the percentage differences (preserving the sign of the differences) across all areas and seasons is **+5.3%** for the Dockside method and **-9.7%** for the 3YM. *This indicates that relative to the post-season estimates of size|mark composition using data from the TF/VTR programs, the Dockside method slightly over-estimates the percentage of LM encounters while the 3YM slightly underestimates the percentage of LM encounters.*

Recommendation: ***Based on the above comparisons, we recommend that the Dockside method be used to estimate the size|mark composition of Chinook encounters early in the season prior to the collection of an adequate sample size by the in-season TF/VTR programs. In addition to performing slightly better than the 3YM method, Dockside data are collected in-season and should better reflect the size|mark composition of Chinook encounters that are occurring during a season compared to estimates based on the mean of previous years' data.***

Table 1. Summary of mean differences from the post-season estimates of size|mark composition for the Dockside and 3YM estimates. Green shaded cells indicate the method with the smallest difference (absolute percentage) for the two methods. The mean absolute difference (MAD) is the mean of the absolute values for the percentage difference across all four categories.[a]

Marine Area	Season Years	Data Source	Difference from TF/VTR (X% - TF/VTR%) LM	LU	SM	SU	MAD
05	**Summer**	**Dockside**	5.9%	6.8%	-7.8%	-4.9%	6.4%
	17, 18, 19	**3YM**	-6.0%	-2.3%	5.4%	3.0%	7.3%
07	**Summer**	**Dockside**	-0.4%	-5.7%	5.4%	0.7%	3.4%
	18, 19	**3YM**	-25.3%	1.9%	16.0%	7.5%	12.7%
09	**Summer**	**Dockside**	5.4%	2.3%	-9.0%	1.3%	5.9%
	17, 18, 19	**3YM**	-14.3%	3.1%	7.3%	3.9%	14.2%
10	**Summer**	**Dockside**	-0.1%	2.4%	-2.4%	0.1%	4.3%
	17, 18, 19	**3YM**	-9.6%	-3.6%	8.2%	5.0%	11.4%
11	**Summer**	**Dockside**	7.5%	-9.1%	8.7%	-7.1%	10.6%
	17, 18, 19	**3YM**	3.7%	-6.5%	5.6%	-2.8%	6.9%
06	**Winter**	**Dockside**	6.0%	-0.9%	0.5%	-5.5%	4.5%
	17, 18	**3YM**	-9.6%	-0.4%	10.4%	-0.3%	7.2%
07	**Winter**	**Dockside**	17.1%	-4.5%	-4.2%	-8.5%	8.6%
	17, 18	**3YM**	-9.2%	-2.0%	8.4%	2.8%	5.6%
09	**Winter**	**Dockside**	-5.9%	-5.3%	10.7%	0.4%	5.6%
	17, 18	**3YM**	-11.3%	-3.8%	11.7%	3.4%	8.0%
10	**Winter**	**Dockside**	2.8%	2.4%	3.2%	-8.4%	6.0%
	17, 18	**3YM**	-11.4%	0.0%	4.6%	6.9%	7.6%

[a]Dockside data from Areas 8-1 and 8-2 are compiled separately but VTR data is typically combined to increase the sample size and the combined data used to estimate and apportion encounters for both sub-areas. No difference assessment is conducted for these areas.

Retrospective Analysis #2 - Weeks 1 and 1+2 comparisons using Dockside data

Dockside data are collected throughout the fishing season and the size|mark composition estimates from the data will change as more angler interview data are accumulated. The purpose of the second retrospective analysis is to examine how the Dockside estimates of size|mark composition from the first week of data collection, and the first and second week of data collection combined, compare to the end-of-season estimates. Figures B1 through B11 in Appendix B compare the seasonal progression of Dockside estimates of the size|mark composition of Chinook encounters to the final post-season estimates. Final post-season encounter composition estimates from the corresponding TF/VTR program are shown, also. Tables with the information in these figures, including sample sizes, are presented in Appendix C. The size|mark composition estimates using Dockside data are expected to change over time as more interviews are conducted and the degree of change will be a function of both actual changes occurring in the population of Chinook being encountered by a fishery and sampling uncertainty.

Figure 1 presents a box plot summarizing the differences between the Dockside and TF/VTR estimates of the percentage of encounters that were LM after week 1 of the season, weeks 1 and 2 combined, and for the entire season. The median difference between the estimates decreases when week 2 data are added to week 1 data for the summer season. Median differences for the winter season are similar for week 1 compared to weeks 1+2 estimates. The variability of the differences, as reflected by the size of the box encompassing the central 50% of the data and the range encompassed by the box whiskers, is smaller for estimates using Dockside data for the entire season.

Sample sizes in terms of the number of boats interviewed by the Dockside sampling program are generally robust for the summer MSFs (Figure 2). During the first week of sampling, about 300 or more boats were typically interviewed in each of the areas in each year (range: 239 to 1,275 boats interviewed). These interviews typically reported about 200 or more Chinook encounters during the first week of the season across all areas and years (range: 76 to 1,354 encounters reported). The one exception is the Area 11 MSF in 2017 when only 76 encounters were reported for the 239 boats interviewed.

Sample sizes are generally smaller for the winter MSFs (Figure 3). During the first week of sampling, about 100 or more boats were typically interviewed in each of the areas in each year (range: 18 to 190 boats interviewed). These interviews typically reported about 100 or more encounters during the first week of the season across all areas and years (range: 34 to 479 encounters reported). The exceptions are:

- Areas 8-1 in 2017 and 2018 where less than 35 boats were interviewed each year and 93 and 34 Chinook encounters were reported, respectively.
- Areas 8-2 in 2017 where only 59 boats were interviewed.
- Area 10 in 2017 where only 18 boats were interviewed and 28 Chinook encounters were reported.

For the MSFs in areas 8-1 (2017 and 2018) and 10 (2017 only), the relatively small sample sizes continued through the second week of the season.

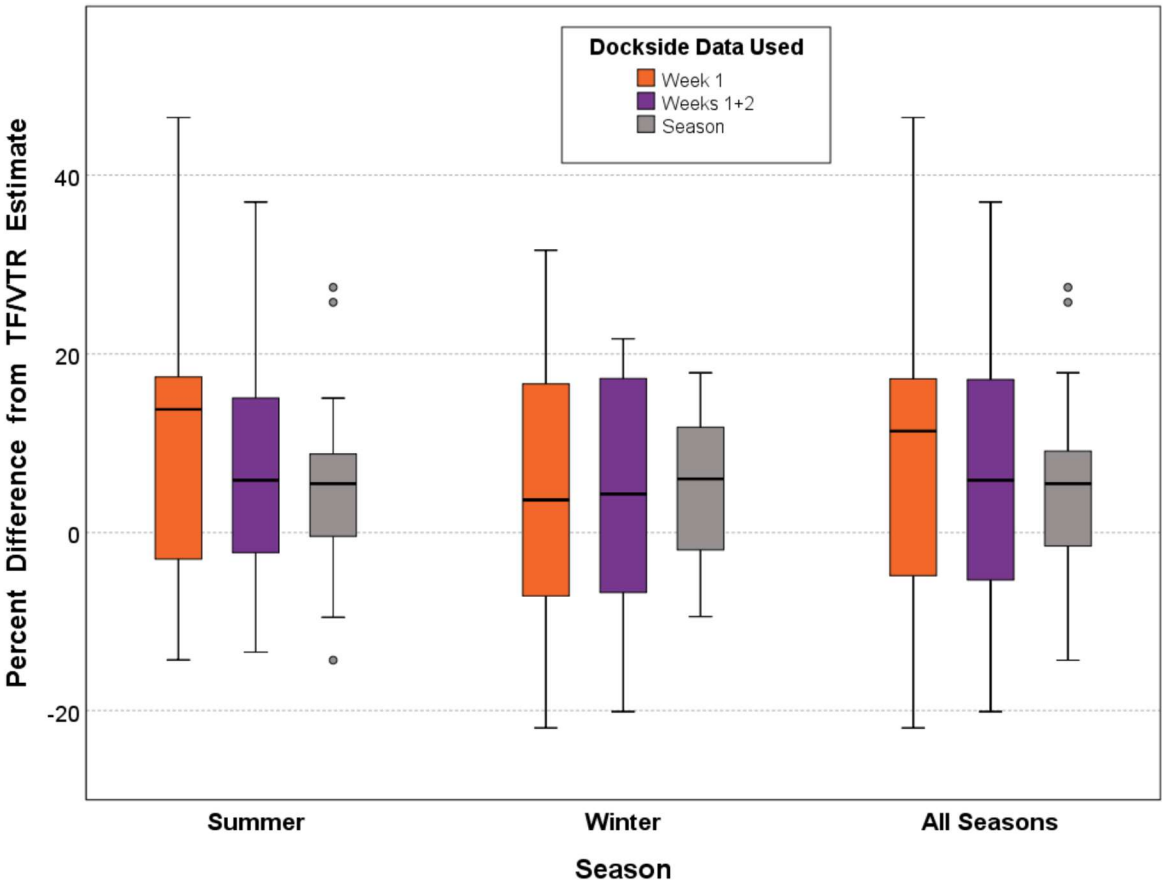

Figure 1. Box plots summarizing the differences between the Dockside and TF/VTR estimates of the percentage of encounters that were legal-size and marked (Dockside – TF/VTR estimate) after week 1 of the season, weeks 1 and 2 combined, and for the entire season.

Recommendation: ***Based on the above review, the number of boats interviewed and number of Chinook reported as encountered are usually sufficient to provide reliable estimates of the size|mark composition of Chinook encounters early in the season prior to the collection of an adequate sample size by the in-season TF/VTR programs. The one exception may be for the winter MSFs in areas 8-1 and 8-2. Depending upon the sample sizes achieved in-season, the Dockside data for these two areas could be combined, if needed, as is often done with their VTR data.***

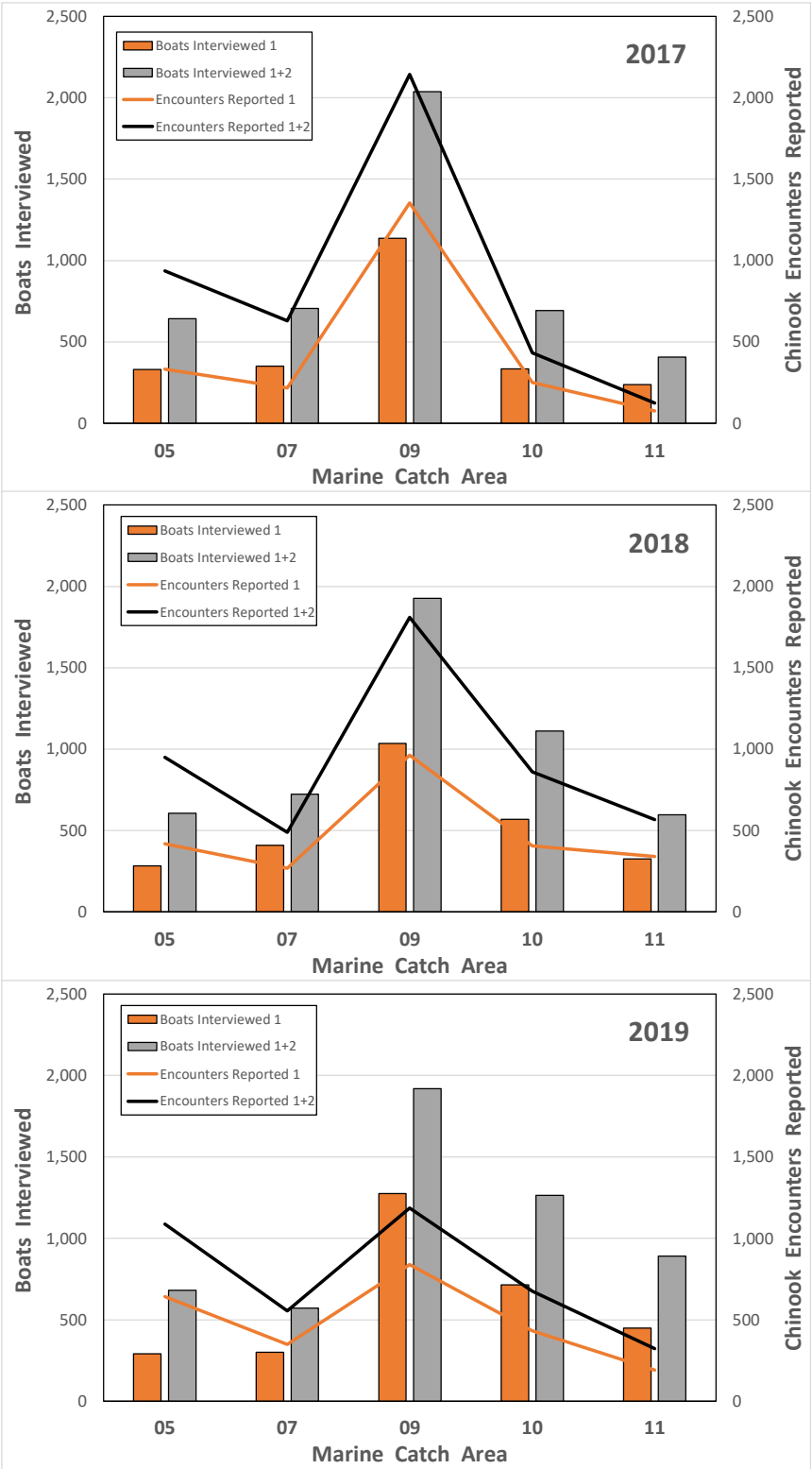

Figure 2. Sample sizes (number of boats interviewed) and Chinook encounters reported during week 1 and weeks 1 and 2 combined for Dockside sampling of summer Chinook MSFs with in-season harvest estimates.

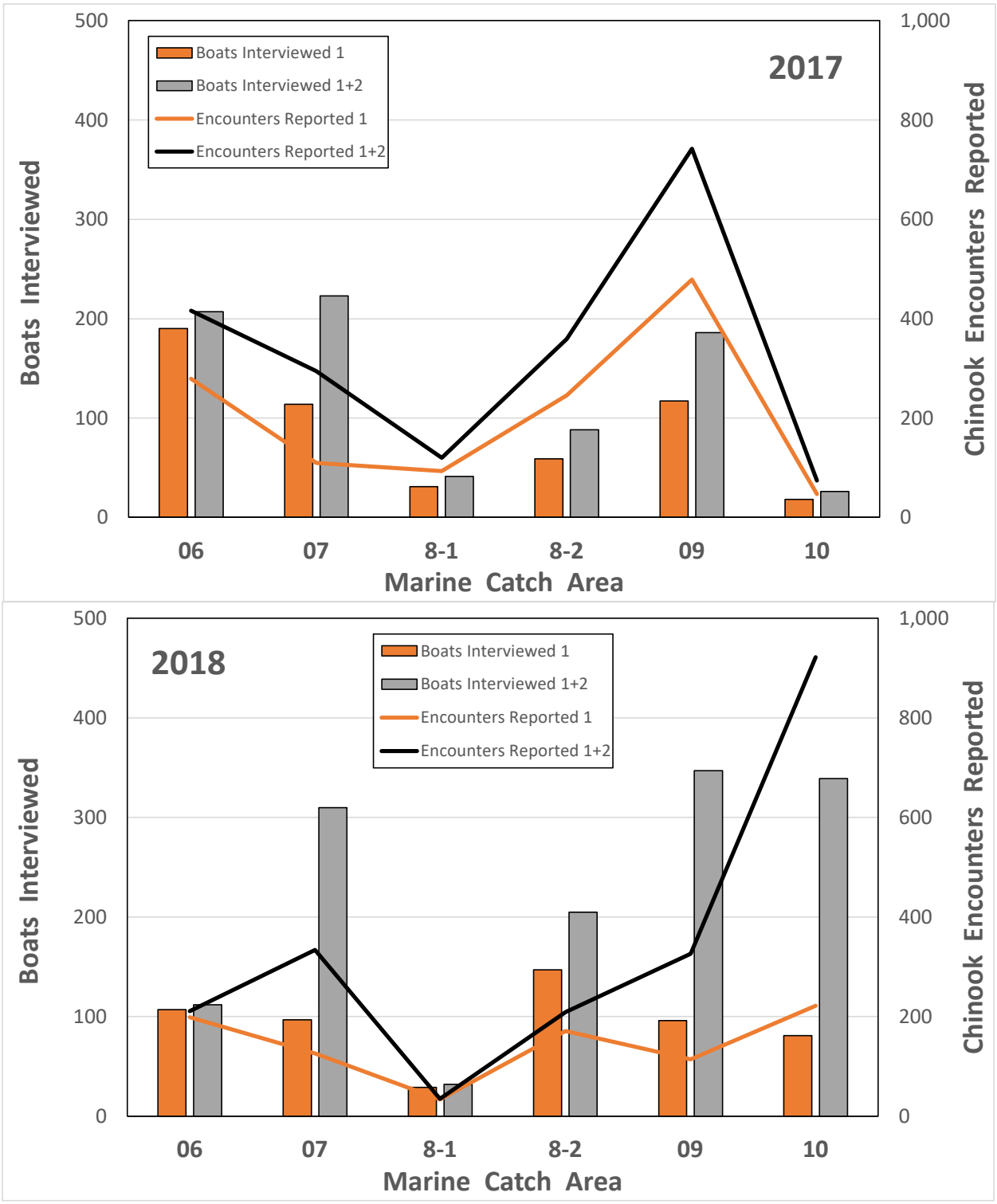

Figure 3. Sample sizes (number of boats interviewed) and Chinook encounters reported during week 1 and weeks 1 and 2 combined for Dockside sampling of winter Chinook MSFs with in-season harvest estimates.

Examination of Bias between Dockside and TF/VTR Estimates of Size|Mark Composition:

Table 2 summarizes the results for the non-parametric, pair-wise Wilcoxon Signed Ranks tests that were used to compare the size|mark composition estimates from the end-of-season Dockside and TF/VTR programs. The WSR test rejected the hypothesis of a median difference equal to zero for the LM and SU categories (P = 0.014 and 0.002, respectively). The test results for the other two size|mark composition categories (LU and SM) were not significant (P > 0.500).

Table 2. Summary of the results of the pair-wise Wilcoxon Signed Ranks test used to compare the estimates of size|mark composition from the Dockside and TF/VTR programs, by size|mark category.

Size|Mark Category	Mean Difference	Median Difference	Test Significance
LM	0.054	0.056	0.014
LU	-0.018	-0.003	0.532
SM	0.001	-0.032	0.822
SU	-0.037	-0.026	0.002

Initially, simple linear regression was used to examine the relationship between the Dockside (X) and TF/VTR (Y) estimates of size|mark composition for each of the categories (Figure 4). All four regressions were statistically significant (P < 0.001) with R^2 values ranging from 0.39 (for the SU category) to 0.75 (for the SM category). The estimate for the Y-intercept parameter was not significant for the LM, LU, and SM regressions. The ratio estimator is considered the best estimator when (1) the relationship between X and Y is a straight line through the origin and (2) the variance of Y about the line is proportional[7] to X (Cochran 1977). The ratio estimator was determined to be the appropriate estimator to evaluate the bias between the Dockside and TF/VTR estimates because:

- Based on a visual examination of the data, the variance of the data around the regression line appears to increase as X increases for the LM and LU categories,
- the homoscedastic variance assumption does not appear appropriate for the SU category, and
- intuitively, including the origin (the 0%-0% point) in the relationship is a reasonable assumption.

Table 3 summarizes the results for the ratio estimator by size|mark category.

The estimated ratios for the LM and SU categories do not include 1.0 within their 95% confidence limits indicating a significant and consistent bias. The estimated ratios indicate that *the Dockside data consistently overestimated the %LM category* and *consistently underestimated the %SU category* relative to the TF/VTR data**.** There was no indication of bias (consistent differences) between the two methods of estimation for the LU and SM size|mark categories.

[7] For linear regression, the variation of the data around the regression line should be homoscedastic.

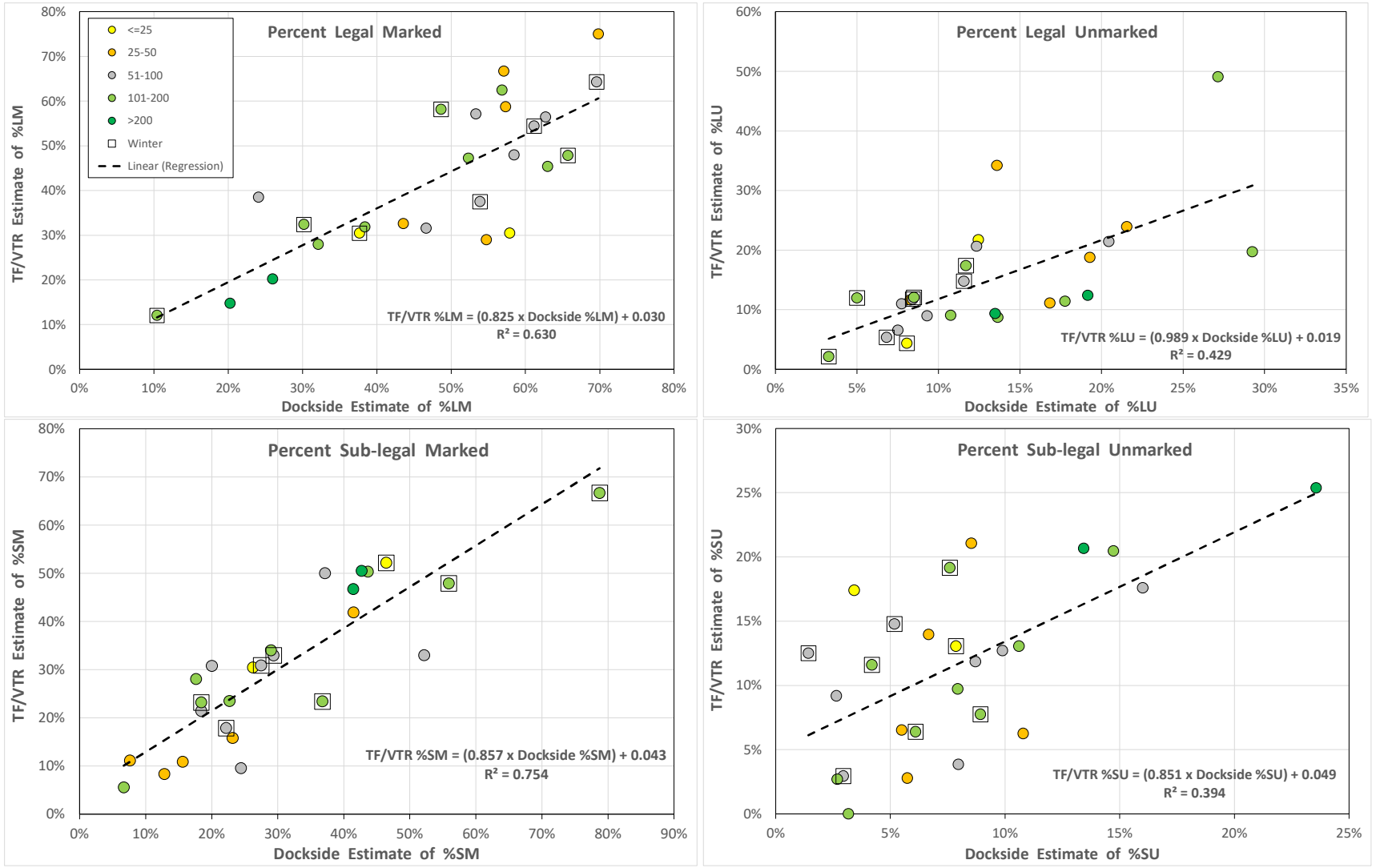

Figure 4. Plots showing the relationship between end-of-season Dockside and TF/VTR estimates of the size|mark composition of Chinook encounters in MSFs, by size|mark category. Linear regression line and equation details are shown. Data are coded to indicate the sample size for the TF/VTR data used in the regression (≤25, 26-50, etc.) and season the MSF was conducted (summer ○ or winter ▣).

Table 3. Summary statistics and approximate 95% confidence interval for the ratio estimate ($\frac{\bar{Y}}{\bar{X}}$) of the relationship between the Dockside estimate = *X* and TF/VTR estimate = *Y*, for each size|mark category.

Size|Mark Category	Ratio Estimate	Standard Error	Relative Precision	Approximate 95% Confidence Interval
LM	0.887	0.042	4.7%	0.805 - 0.969
LU	1.133	0.112	9.9%	0.914 - 1.352
SM	0.998	0.054	5.4%	0.893 - 1.103
SU	1.470	0.149	10.2%	1.177 - 1.763

The results of the WSR tests, the simple regression analyses, and the ratio estimates all indicate a statistically significant and consistent difference between the Dockside and TF/VTR estimates for the LM and SU categories. If the %LM estimate from the Dockside data is adjusted for bias using these results, some adjustment to the other size|mark composition estimates is needed so that the sum of the four estimated percentages totals to 100%. We recommend that the decrease in the %LM estimate simply be added to the estimate for the %SU category since there is no indication of bias for the %LU and %SM size|mark categories and this ensures the estimates sum to 100%. Specifically,

$$\widehat{\%LM}_{BC} = \widehat{\%LM}_{Dockside}\ x\ 0.89, \text{ and}$$

$$\widehat{\%SU}_{BC} = \widehat{\%SU}_{Dockside} + \left(\widehat{\%LM}_{Dockside}\ x\ 0.11\right)$$

where the subscript *BC* indicates the bias-corrected estimate. Figure 5 presents a box plot summarizing the differences between the bias-corrected Dockside and TF/VTR estimates of the percentage of encounters for the LM and SU categories. Before bias-correction, the median difference between the estimates was +5.6% for the LM category and -2.6% for the SU category (Table 2). After bias-correction, the median difference between the estimates is +0.3% for the LM category and +1.1% for the SU category. Bar graphs comparing the Dockside, bias-corrected Dockside, and TF/VTR size|mark composition estimates for each area and season are presented in Appendix D.

Recommendation: ***Because the %LM is used in the estimate of the total number of Chinook encounters, and it is important not to underestimate total encounters, we recommend that a bias adjustment be applied to the estimate of the %LM from the Dockside data and that the corresponding decrease in the estimate of %LM be added to the estimate of the %SU so that estimates of the size|mark composition total to 100% across all four size|mark categories.***

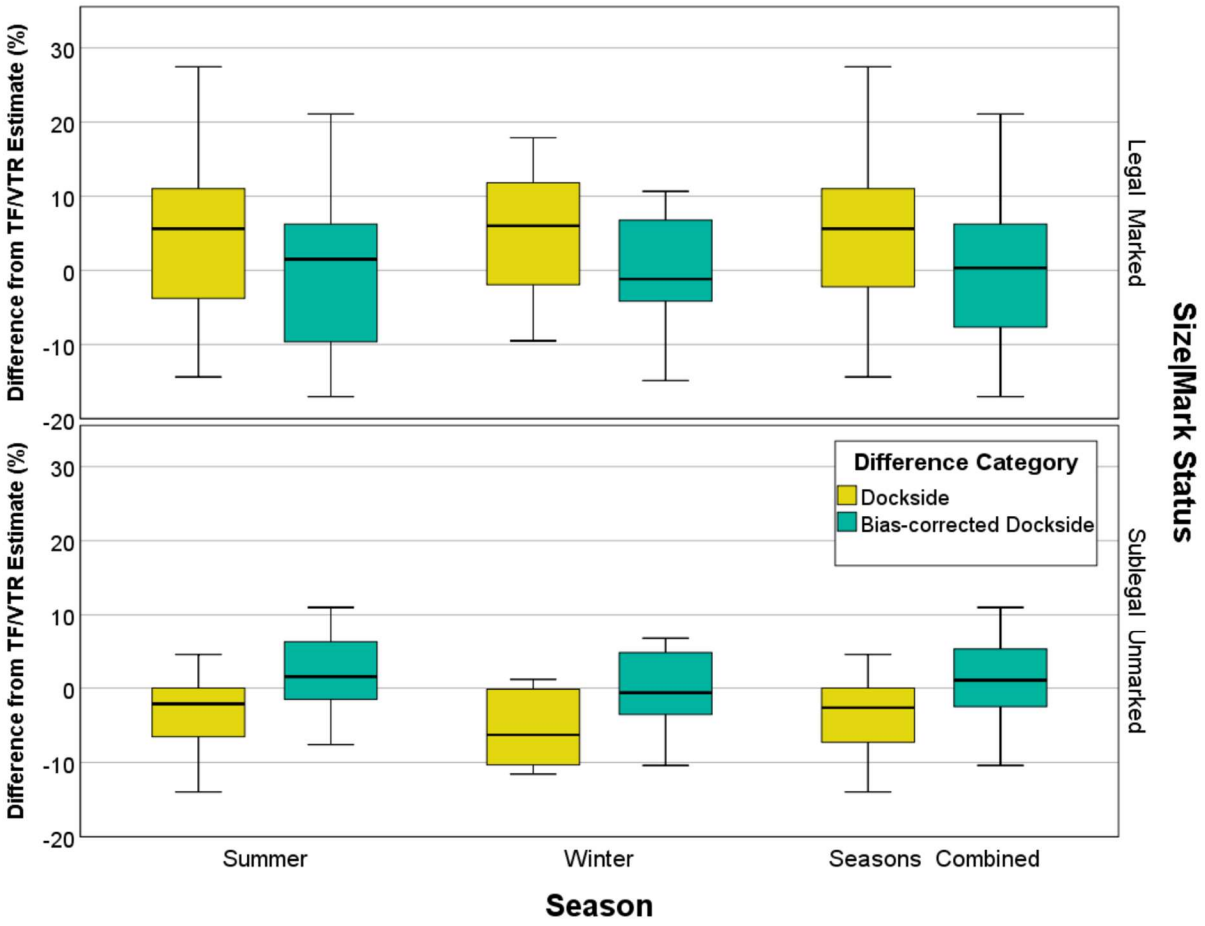

Figure 5. Box plots summarizing the differences of the post-season Dockside and bias-corrected Dockside estimates from the TF/VTR estimates (Dockside – TF/VTR estimate) of the percentage of encounters that were legal-size and marked and sub-legal size and unmarked, by season and for the seasons combined.

Discussion

The objective of the analyses conducted for this report is to determine if there are alternative methods of estimating the size|mark composition of Chinook encounters that can be used when the sample sizes for the test fishery and/or voluntary trip report programs are small early in a fishing season. *The analyses are predicated on the assumption that the estimates from the TF/VTR programs provide the "best" estimates of the composition of the Chinook being encountered by recreational anglers in a marine catch area*. The assumptions required by the TF/VTR programs were presented and discussed. One of the greatest challenges to the size|mark composition estimates from these programs is the relatively small sample size that is sometimes obtained during a fishing season. Small sample sizes give imprecise estimates of the size|mark composition of the encounters and may be less likely to represent the size|mark composition of the population of Chinook being encountered across a large marine catch area during a season that may last four or more weeks.

We recommend that the Dockside angler interview data collected in-season should be used to estimate the size|mark composition of Chinook encounters early in the season prior to the collection of an adequate sample size by the in-season TF/VTR programs. The Dockside interview data are collected from anglers participating in the fishery and are usually based on more than a hundred interviews and angler reports of several hundred Chinook encounters, even for the first week of a season. Although there are often differences between the Dockside program estimates and the TF/VTR program estimates, it is important to consider the following:

(A) The estimates from the Dockside program often fall within the 95% confidence interval for the size|mark composition estimates from the TF/VTR programs.
(B) Week 1 and weeks 1+2 Dockside estimates are being compared to final season estimates from the TF/VTR programs. We expect the size|mark composition of Chinook encounters to change during a season, especially when seasons last four or more weeks. Therefore, some differences between the early-season and final post-season estimate of size|mark composition are expected.
(C) Because of the relatively large sample sizes (number of boats interviewed) for the Dockside program, size|mark composition estimates from the Dockside program will be more stable early in the season and fluctuate less than early-season estimates from the TF/VTR programs based on small sample sizes.
(D) Dockside estimates of the size|mark composition will be typically be replaced by estimates from the TF/VTR programs once an adequate sample size has been achieved later in the season.

Conrad and McHugh (2008) discuss and provide examples of some of the biases associated with angler reported data (prestige bias, digit bias, etc.) in Chinook MSFs conducted in Puget Sound. They demonstrated that angler reports of the number of Chinook they have encountered during a fishing trip (Method 1) are typically higher than those generated from harvest (landed Chinook) estimates used in combination with an independent estimate of the size|mark composition of the Chinook being encountered by a fishery (Method 2). The positive bias (overestimate relative to the TF/VTR data) for the proportion of legal-size and marked Chinook released as reported by anglers during Dockside interviews may be a result of these same biases. Anglers may exaggerate the number of LM Chinook that they report as released to be viewed as "good" anglers (prestige bias) and there is a demonstrated tendency for anglers to round the number of fish reported as released upward to even numbers or multiples of five (digit bias).

Bias-correction to the estimate of the percentage of Chinook released that were LM based on the Dockside data accounts for a different bias than that documented by Conrad and McHugh (2008). The bias adjustment to the estimate of total Chinook encounters from Method 2 (1.15) is used to account for (1) the intentional release of some LM Chinook by anglers and (2) the unintentional release of some LM Chinook that are brought to the boat but mistakenly identified as sub-legal in size and released (i.e., if the angler had properly identified them as being LM they would have been kept). A major assumption for Method 2 is that anglers keep (harvest) all LM Chinook they bring to the boat.

We recommend that whenever Method 2 is used to estimate the total number of Chinook encounters in a MSF, and Dockside data are being used instead of TF/VTR data to estimate the size|mark composition of Chinook encounters, that the bias-correction methods described above be applied to the estimate of the size|mark composition and the bias-corrected estimate of %LM be used to estimate total encounters and apportion the encounters to size|mark categories.

In the discussion of potential bias in Conrad and McHugh (2008), the following estimates were provided for the intentional release of LM Chinook by anglers during Chinook MSFs:

- for summer MSFs, 4.3% of the LM Chinook brought to the boat and correctly identified as LM were intentionally released, and
- for winter MSFs, this corresponding percentage was 7.6%.

For the Dockside angler interview data used in this report (specifically the data used for the assessment of bias), anglers reported releasing an average of:

- 4.3% of the LM Chinook they brought to the boat during summer MSFs, and
- 10.5% of the LM Chinook they brought to the boat during winter MSFs.

The similarity between these two independent sets of estimates using data collected more than a decade apart is encouraging and indicates that the methods that have been developed are relatively robust.

Recommendations

1. ***The Dockside angler interview data collected in-season should be used to estimate the size|mark composition of Chinook encounters early in the season prior to the collection of an adequate sample size by the in-season TF/VTR programs.***

2. ***Adequate sample sizes for the in-season TF/VTR programs should be defined as a sample size that produces an estimate for the proportion of legal-size and marked (LM) encounters that has a coefficient of variation ≤20% (WDFW and NWIFC 2013).***

3. ***Whenever Method 2 is used to estimate the total number of Chinook encounters in a MSF, and Dockside data are being used instead of TF/VTR data to estimate the size|mark composition of Chinook encounters, bias-correction methods should be applied to the estimate of the size|mark composition and the bias-corrected estimate of %LM should be used to estimate total encounters and apportion the encounters to size|mark categories.***

4. ***The bias-correction factor applied to the estimate of %LM should be periodically examined (e.g., every 4 to 5 years) to assess whether it has changed over time.***

5. ***Size|mark composition estimates using the Dockside angler interview data should replace the beta regression method (WDFW and NWIFC 2013) currently used for post-season MSF analyses and reporting when sample sizes from an area's TF/VTR programs are small and do not meet the 20% CV standard in #2.***

6. ***Methods to estimate the variance for the estimates of the size|mark composition of Chinook encounters based on dockside data should be explored. Bootstrap re-sampling methods are suggested as a possible method to estimate the variance of encounter composition observations based on boats as a sample unit.***

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APPENDIX A

Bar graphs comparing estimates of the size|mark composition of Chinook encounters in Puget Sound mark-selective fisheries from end-of-season Dockside interview data and the previous three-year mean of test fishery and/or VTR sampling program estimates to the final post-season estimate of size|mark composition from the test fishery and/or VTR sampling programs. Simultaneous 95% confidence intervals (Goodman 1965) are displayed for the TF/VTR estimates.

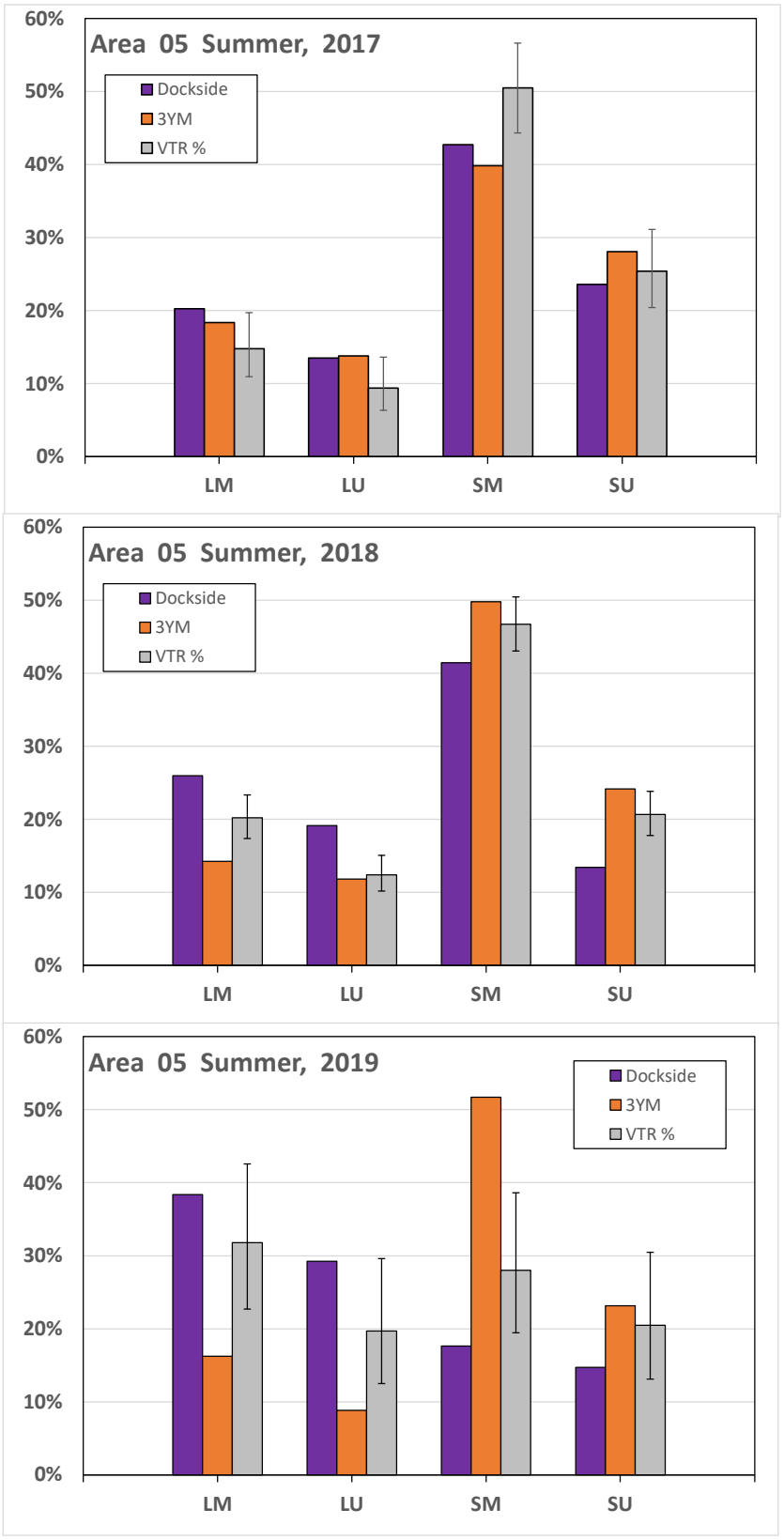


Figure A1. Comparison of size|mark composition estimates for Area 05 summer.

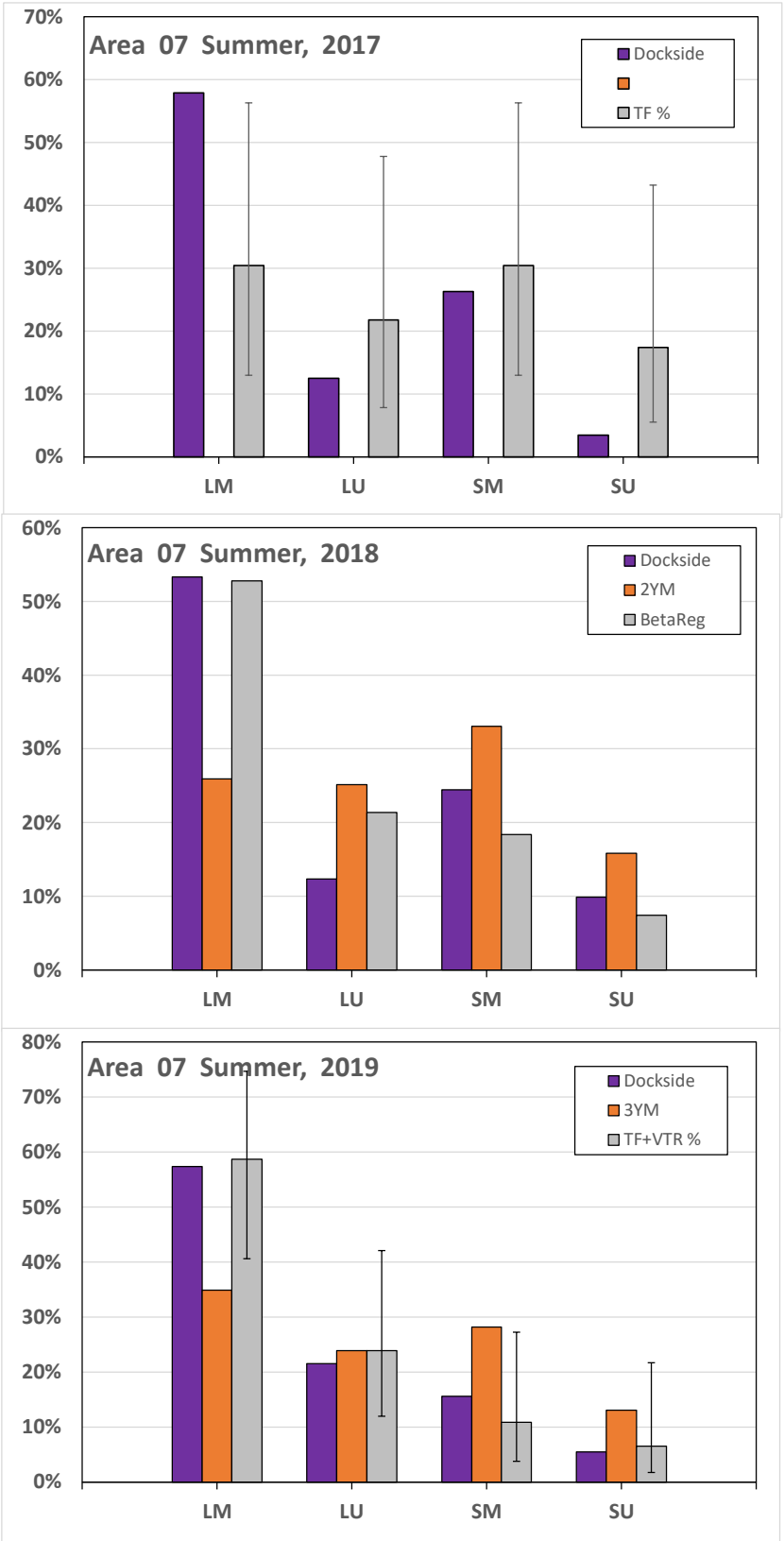


Figure A2. Comparison of size|mark composition estimates for Area 07 summer.

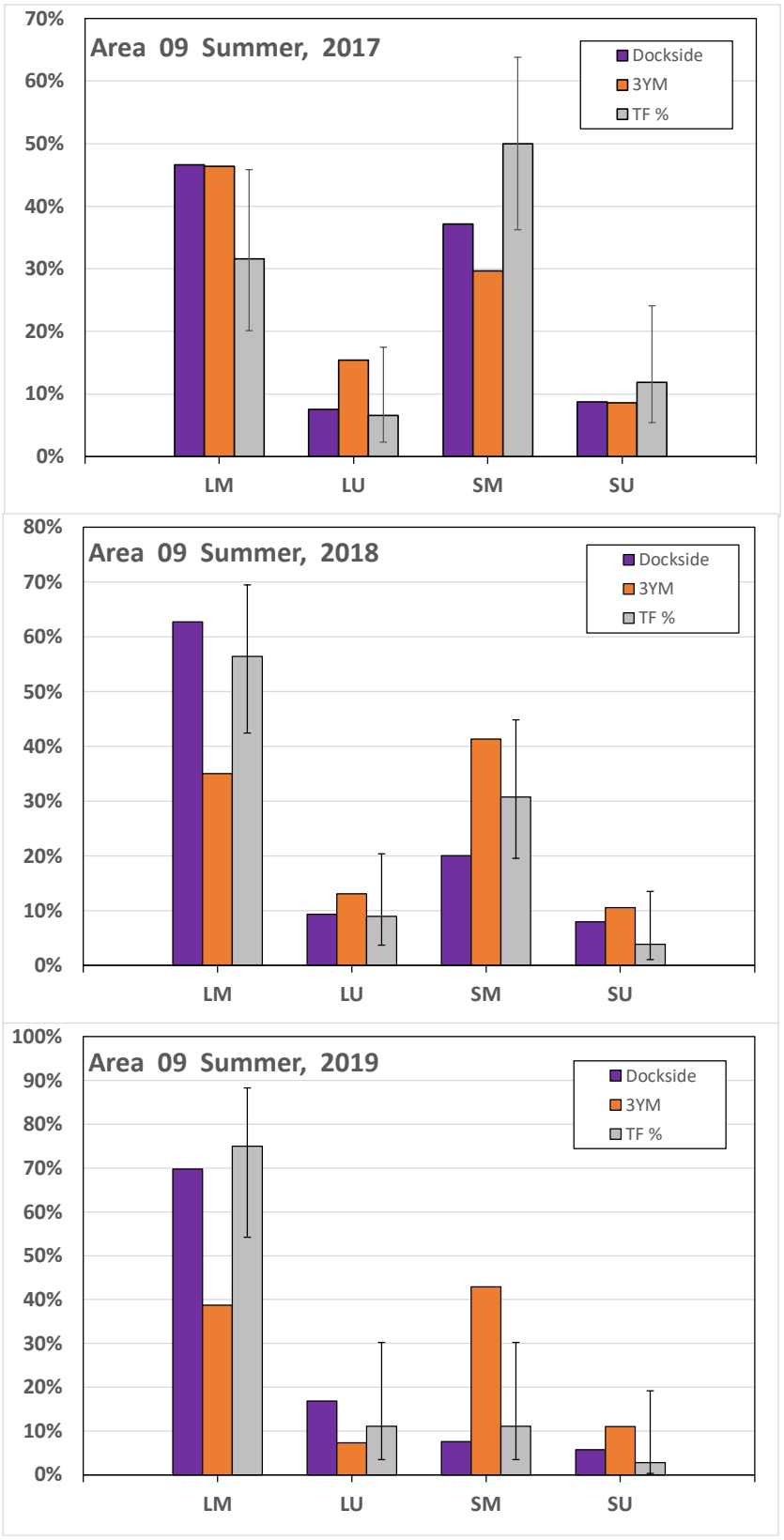


Figure A3. Comparison of size|mark composition estimates for Area 09 summer.

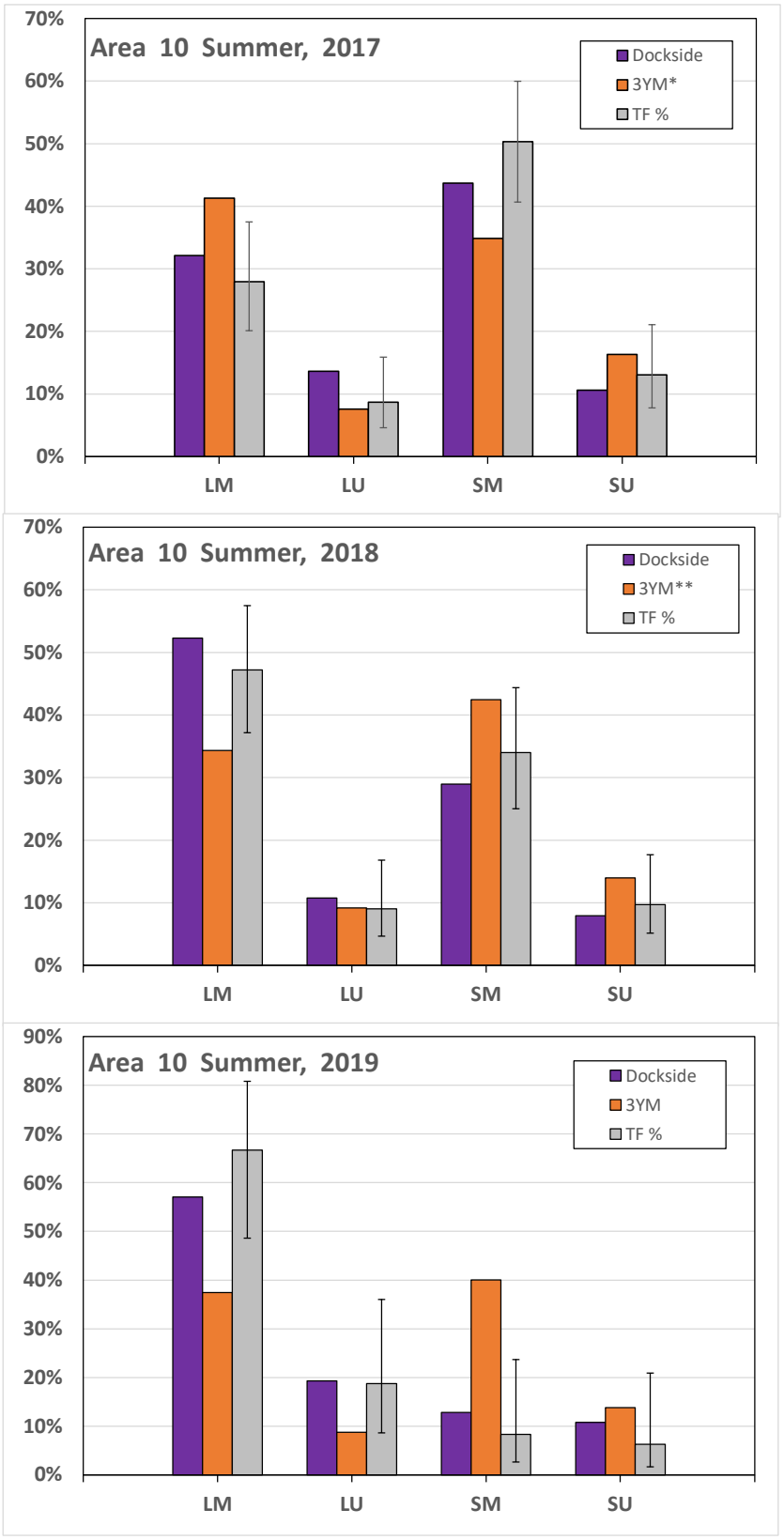


Figure A4. Comparison of size|mark composition estimates for Area 10 summer.

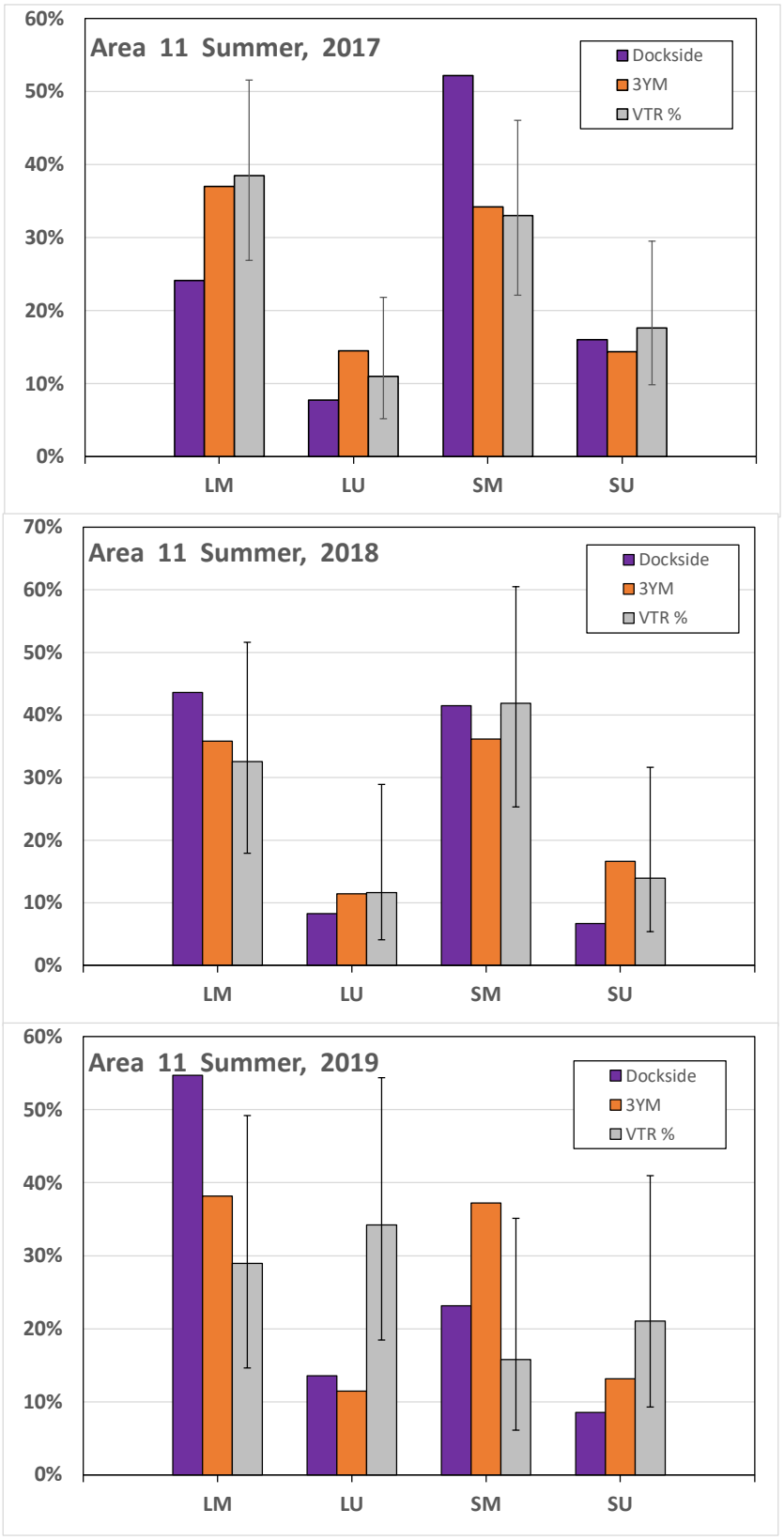


Figure A5. Comparison of size|mark composition estimates for Area 11 summer.

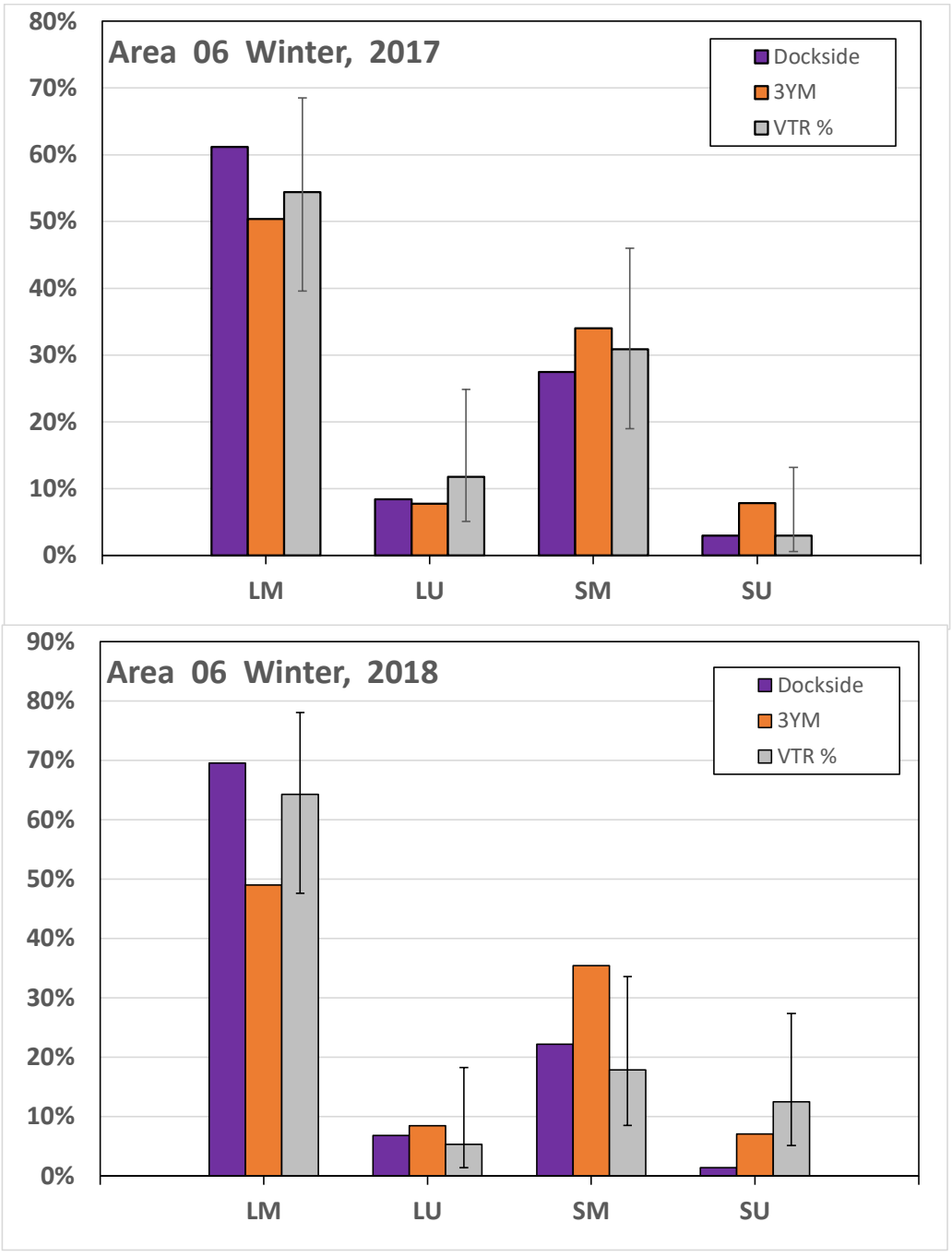


Figure A6. Comparison of size|mark composition estimates for Area 06 winter.

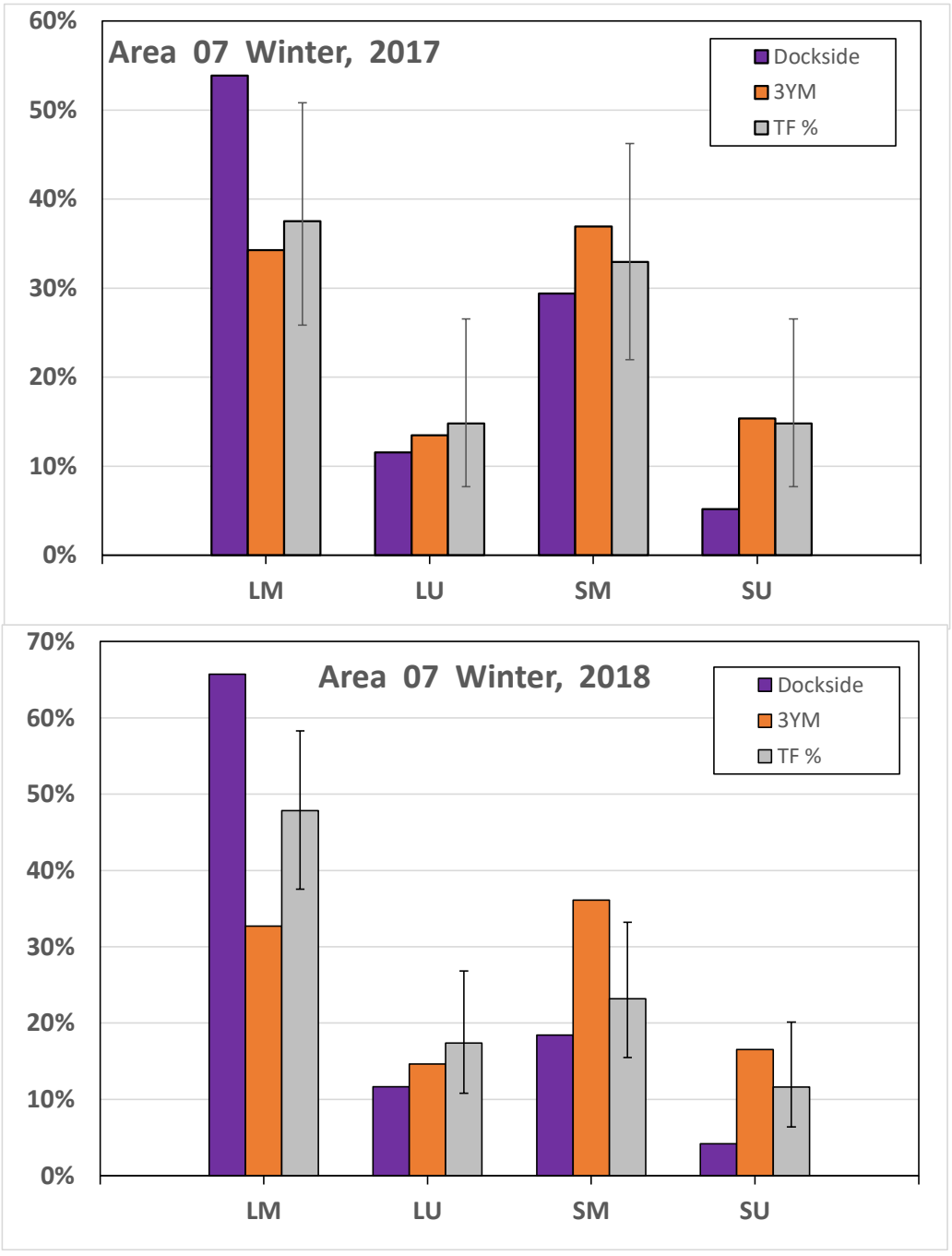


Figure A7. Comparison of size|mark composition estimates for Area 07 winter.

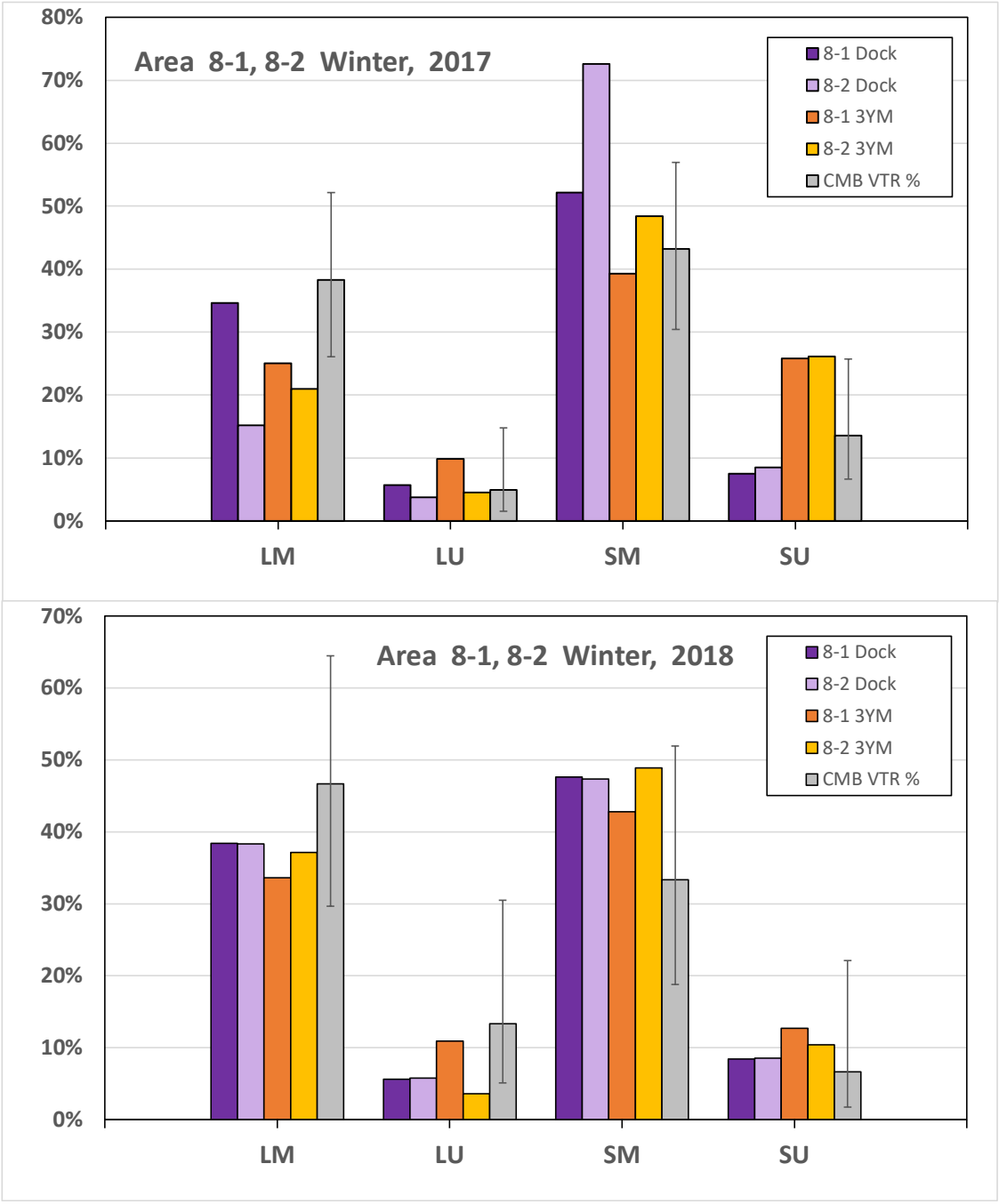


Figure A8. Comparison of size|mark composition estimates for Areas 8-1 and 8-2 winter. Dockside data from Areas 8-1 and 8-2 are compiled separately but VTR data is typically combined to increase the sample size and the combined data used to estimate and apportion encounters for both sub-areas. No difference assessment (Table 1) was conducted for this area.

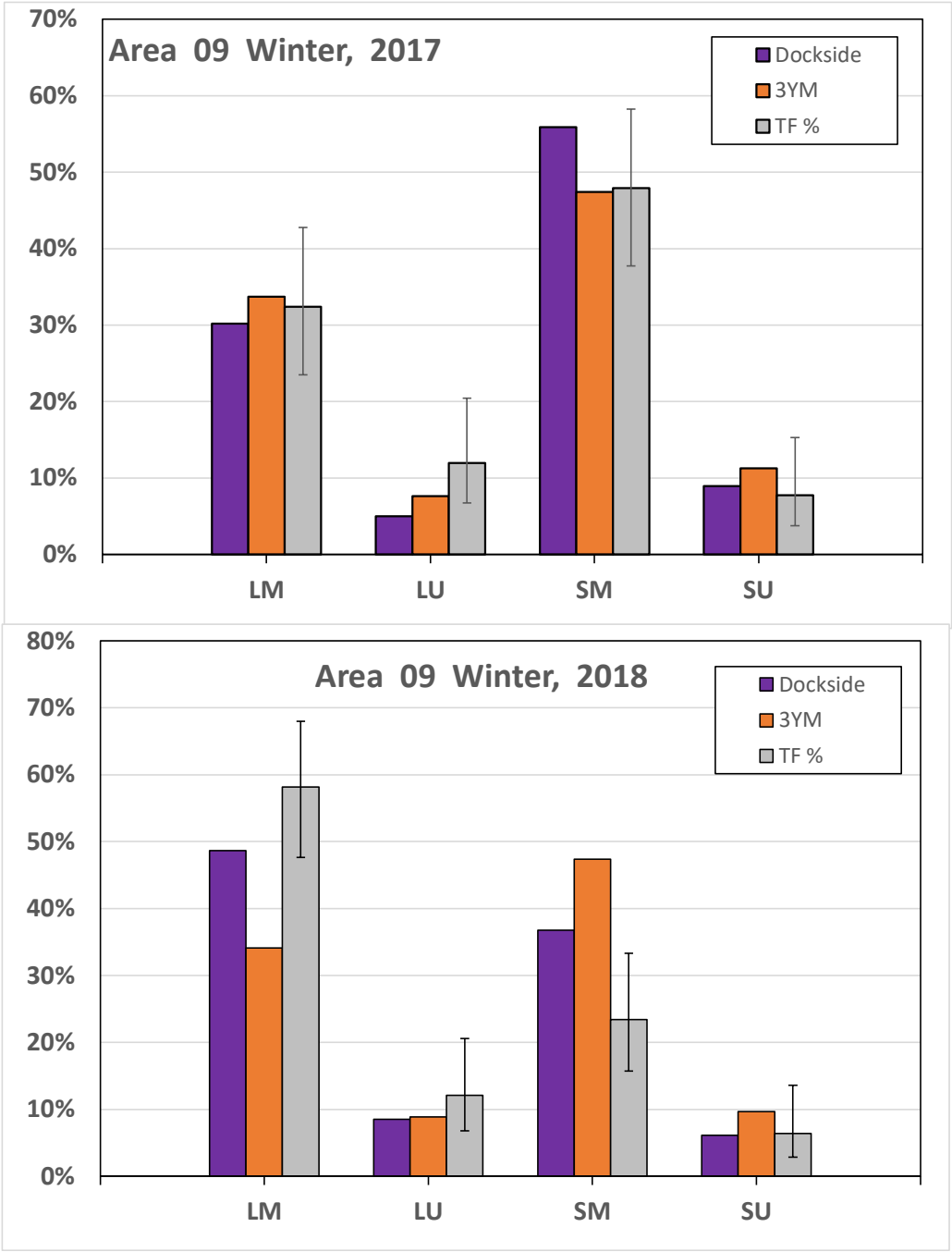


Figure A9. Comparison of size|mark composition estimates for Area 09 winter.

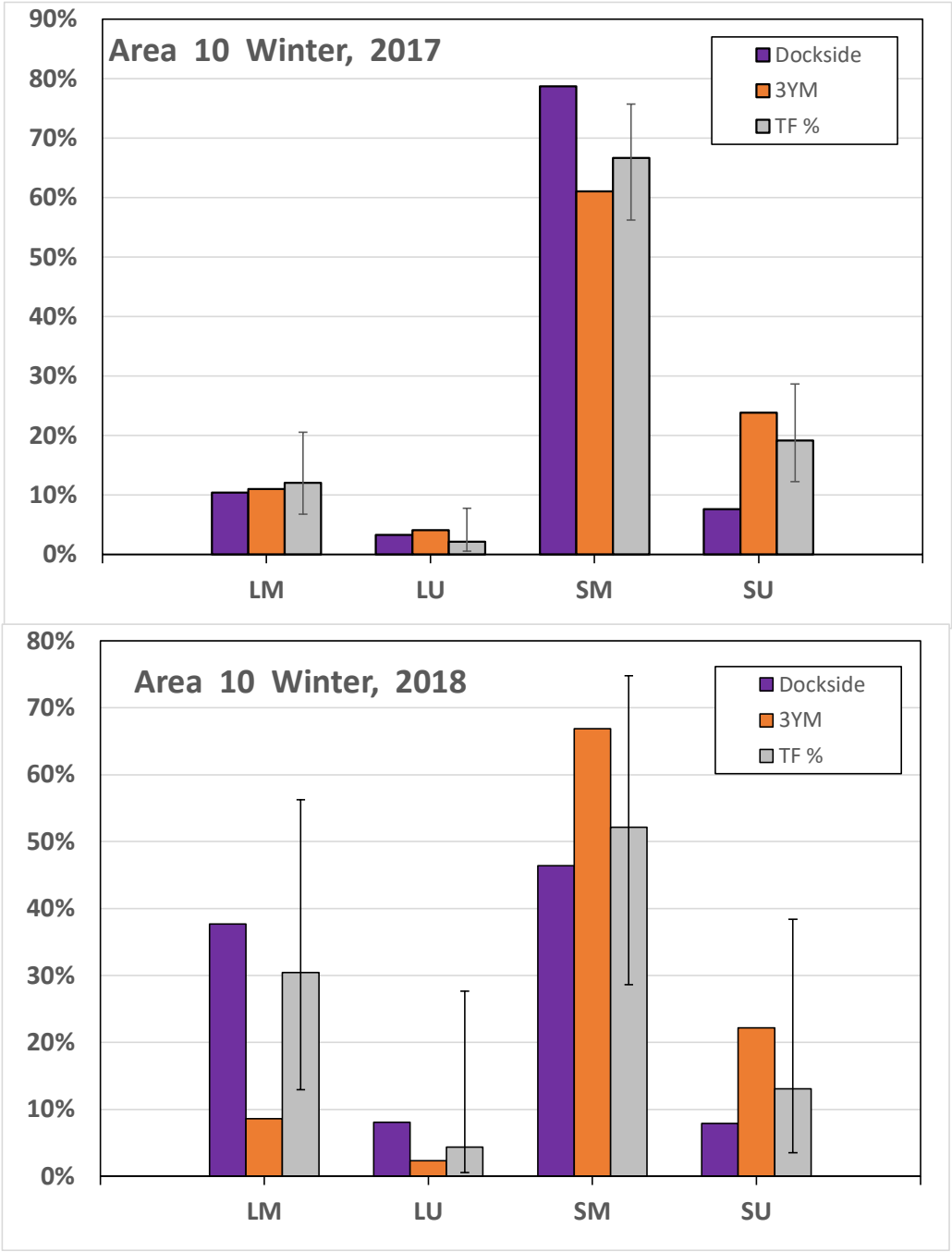


Figure A10. Comparison of size|mark composition estimates for Area 10 winter.

APPENDIX B

Bar graphs comparing estimates of the size|mark composition of Chinook encounters in Puget Sound mark-selective fisheries from Dockside interview data collected during week 1, weeks 1 and 2, and for the season to the final post-season estimate of size|mark composition from the test fishery and/or VTR sampling programs. Simultaneous 95% confidence intervals (Goodman 1965) are displayed for the TF/VTR estimates. Dock-1 indicates dockside data collected during week 1 of the season, Dock-2 indicates dockside data collected during weeks 1 and 2 of the season, and Dock-S indicates dockside data collected for the entire season.

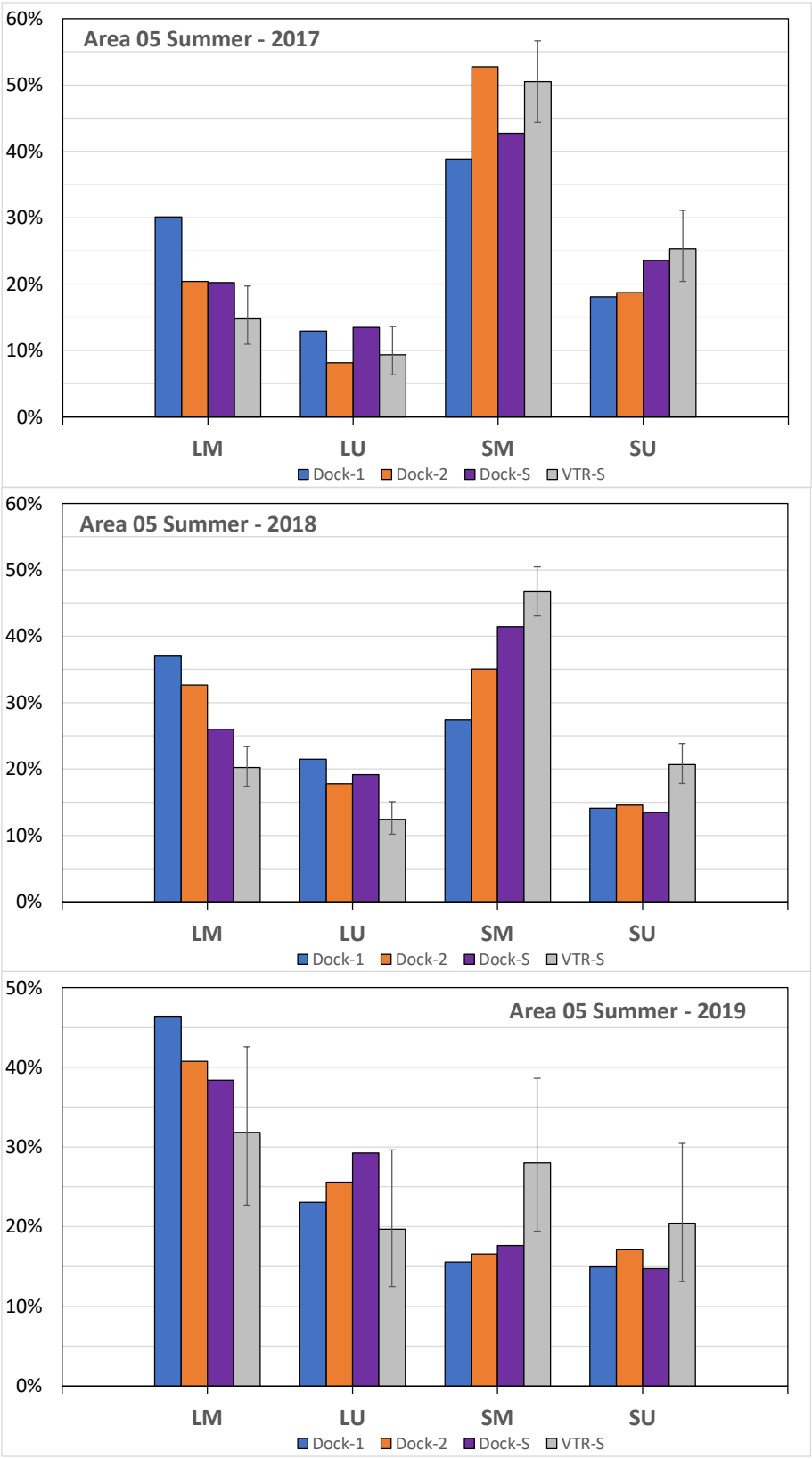


Figure B1. Comparison of the Dockside size|mark composition estimates for Area 05 summer.

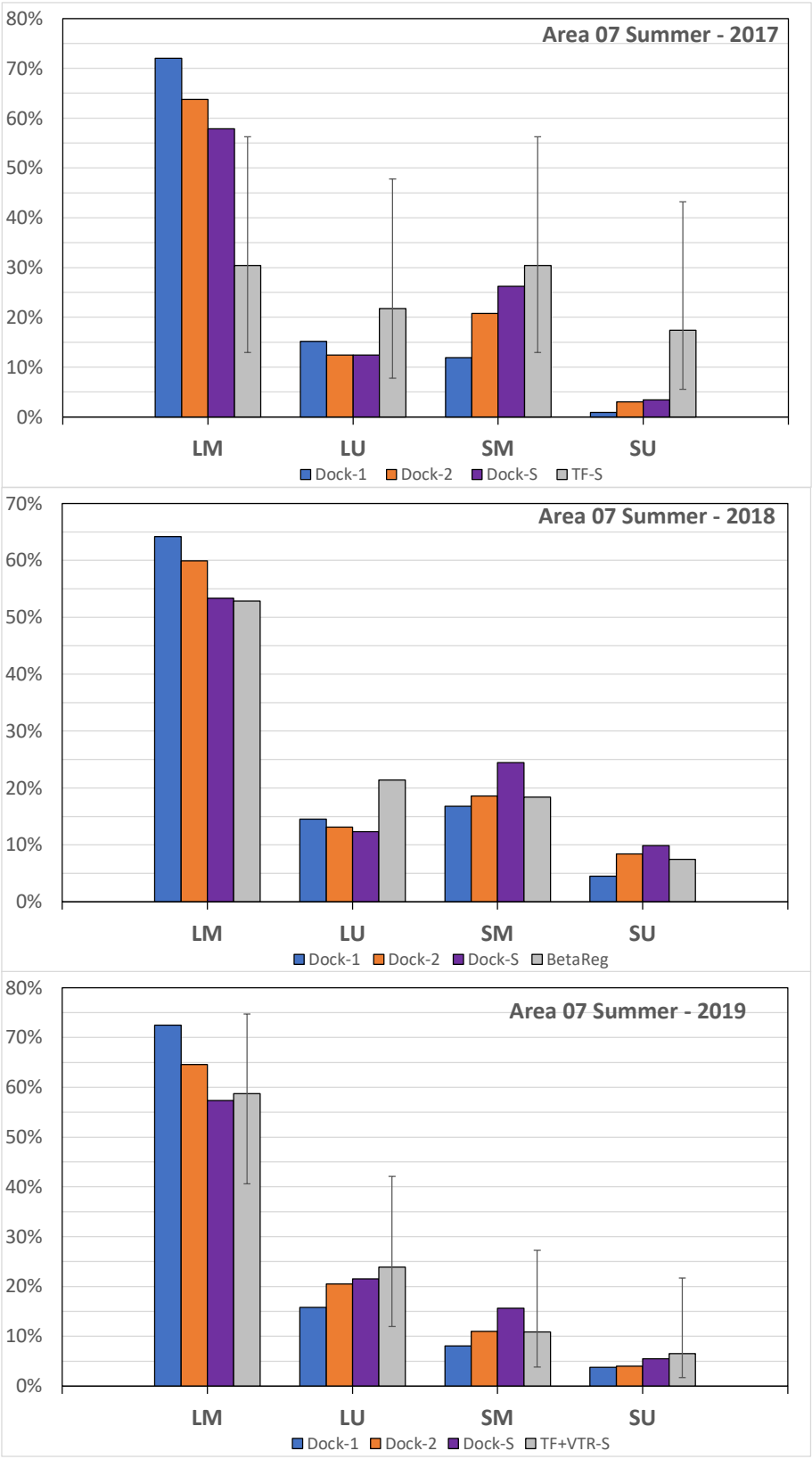


Figure B2. Comparison of the Dockside size|mark composition estimates for Area 07 summer.

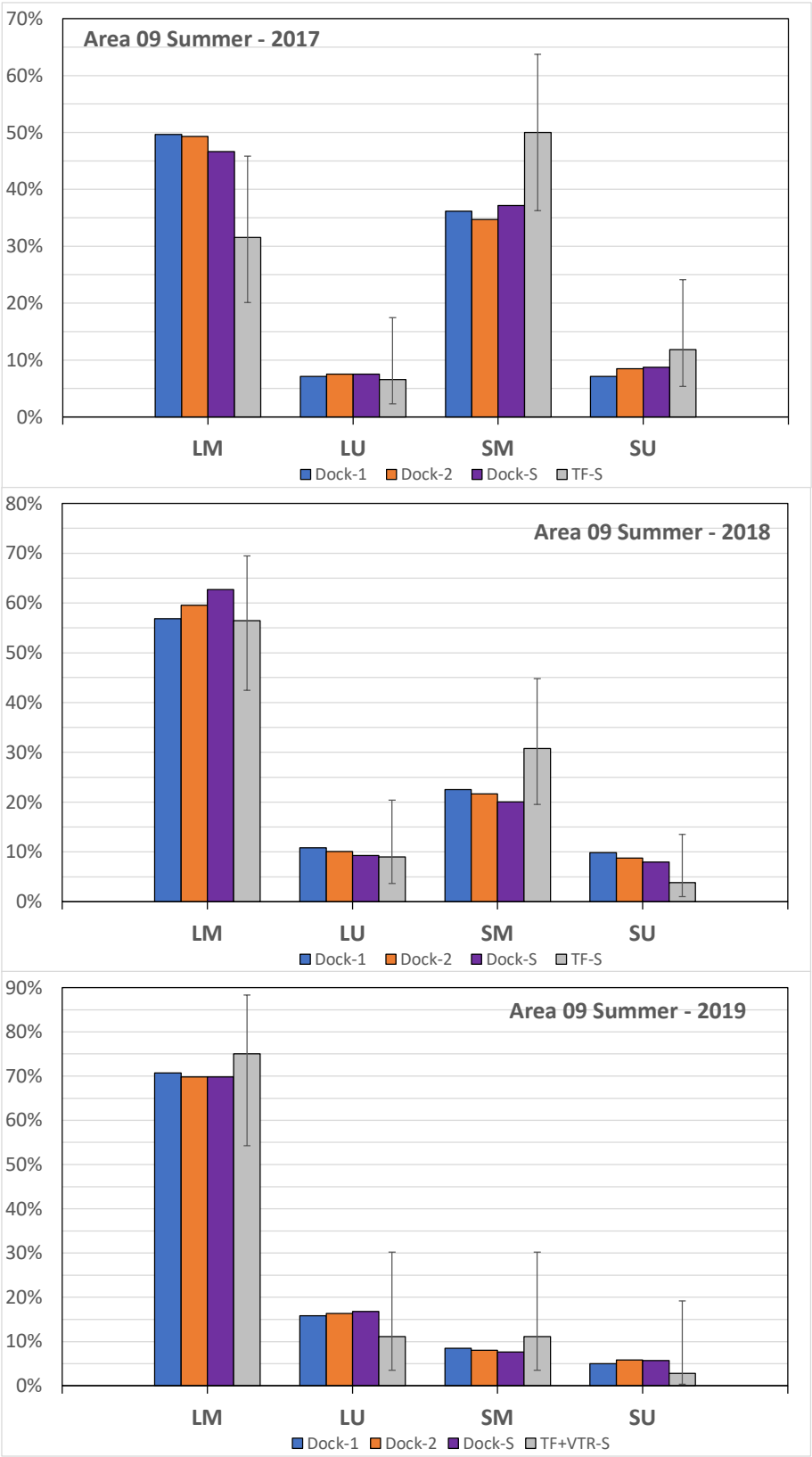


Figure B3. Comparison of the Dockside size|mark composition estimates for Area 09 summer.

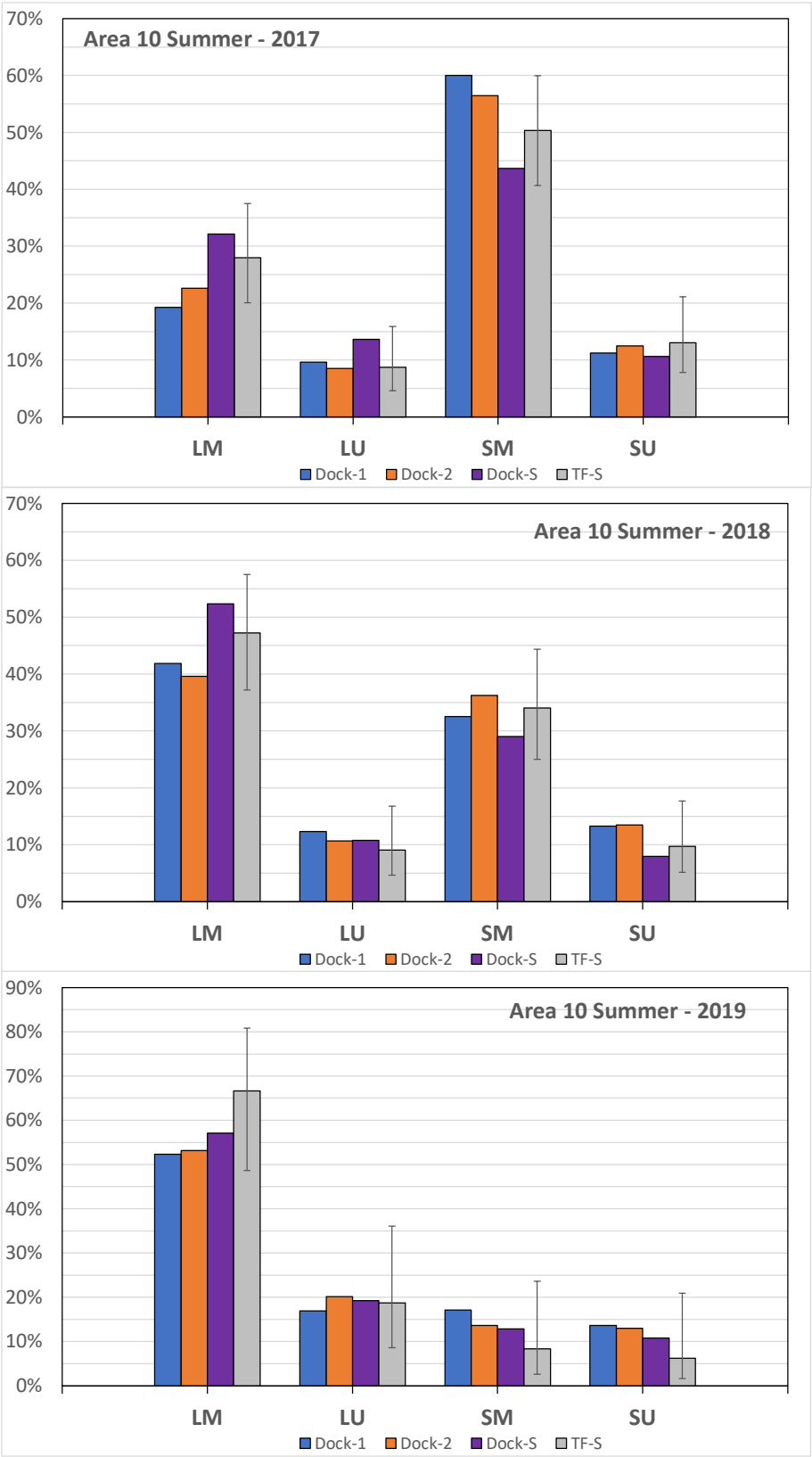


Figure B4. Comparison of the Dockside size|mark composition estimates for Area 10 summer.

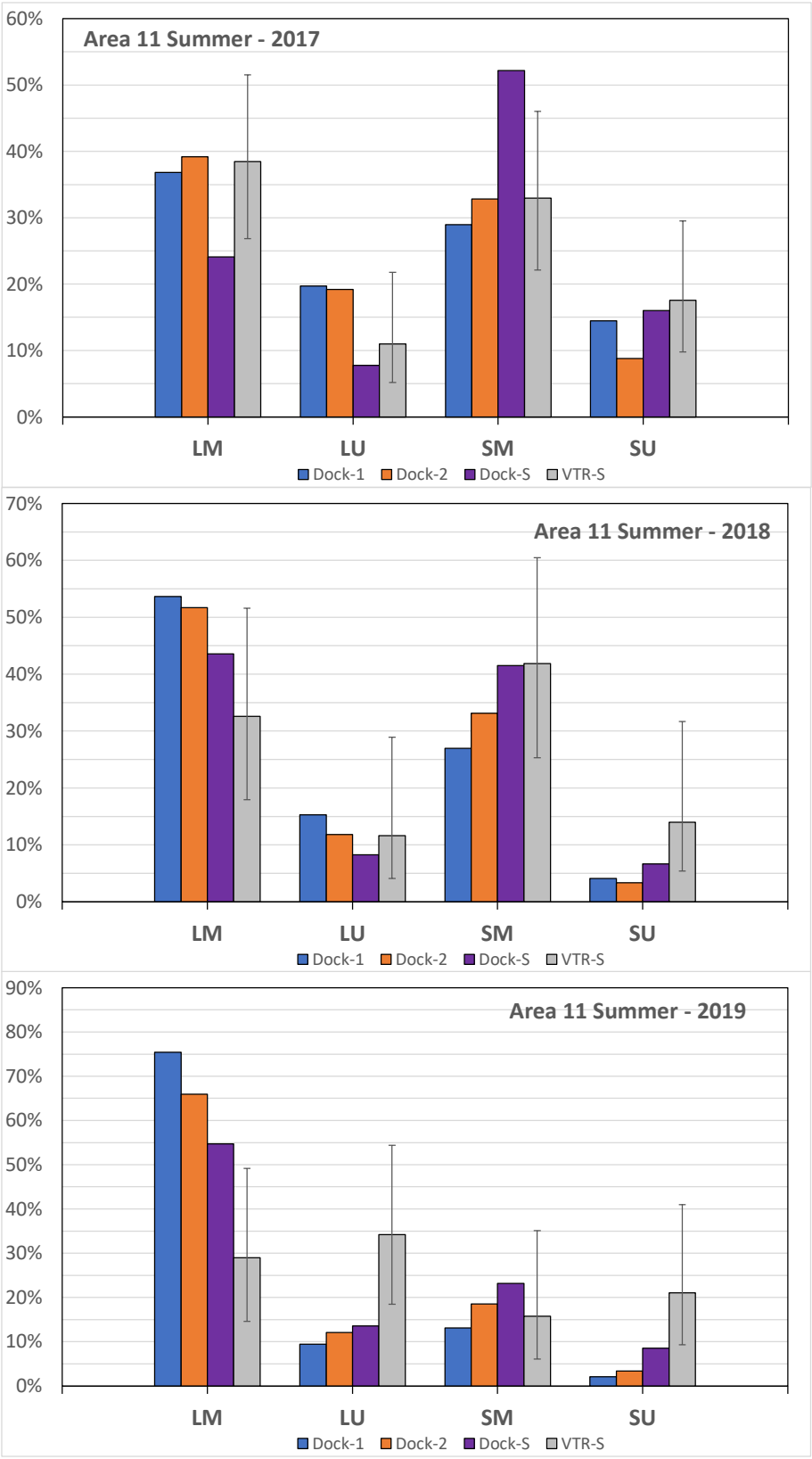


Figure B5. Comparison of the Dockside size|mark composition estimates for Area 11 summer.

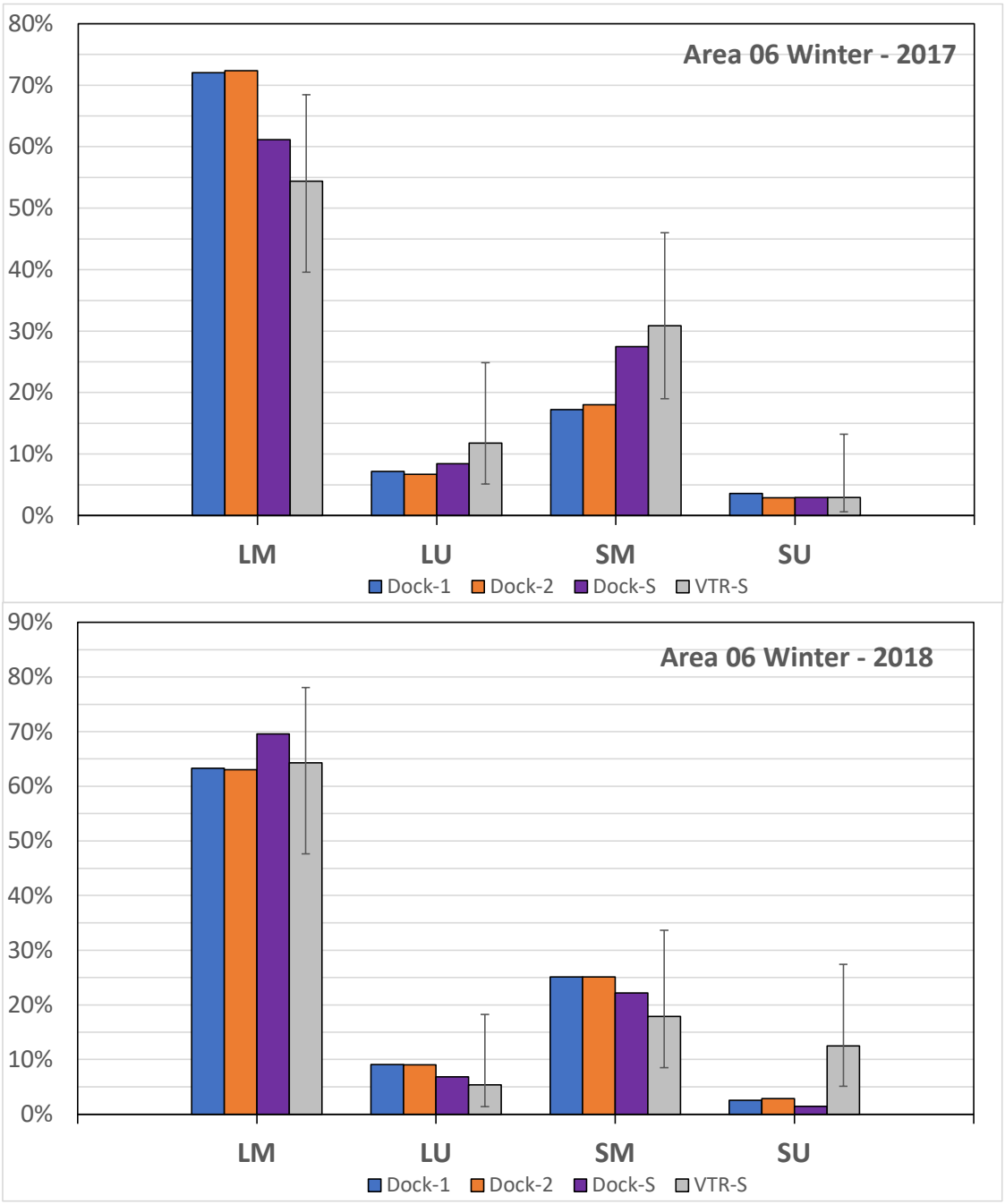


Figure B6. Comparison of the Dockside size|mark composition estimates for Area 06 winter.

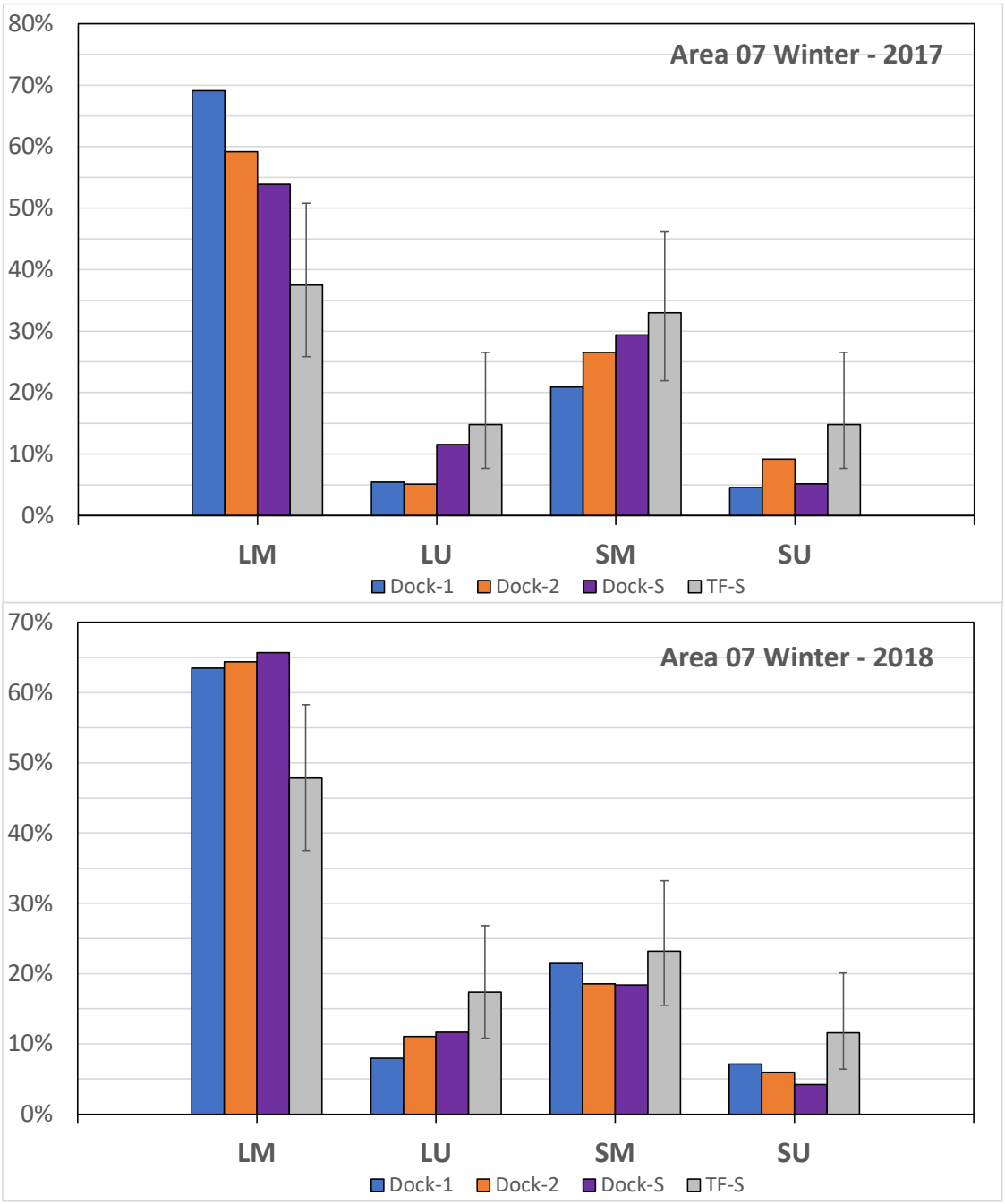


Figure B7. Comparison of the Dockside size|mark composition estimates for Area 07 summer.

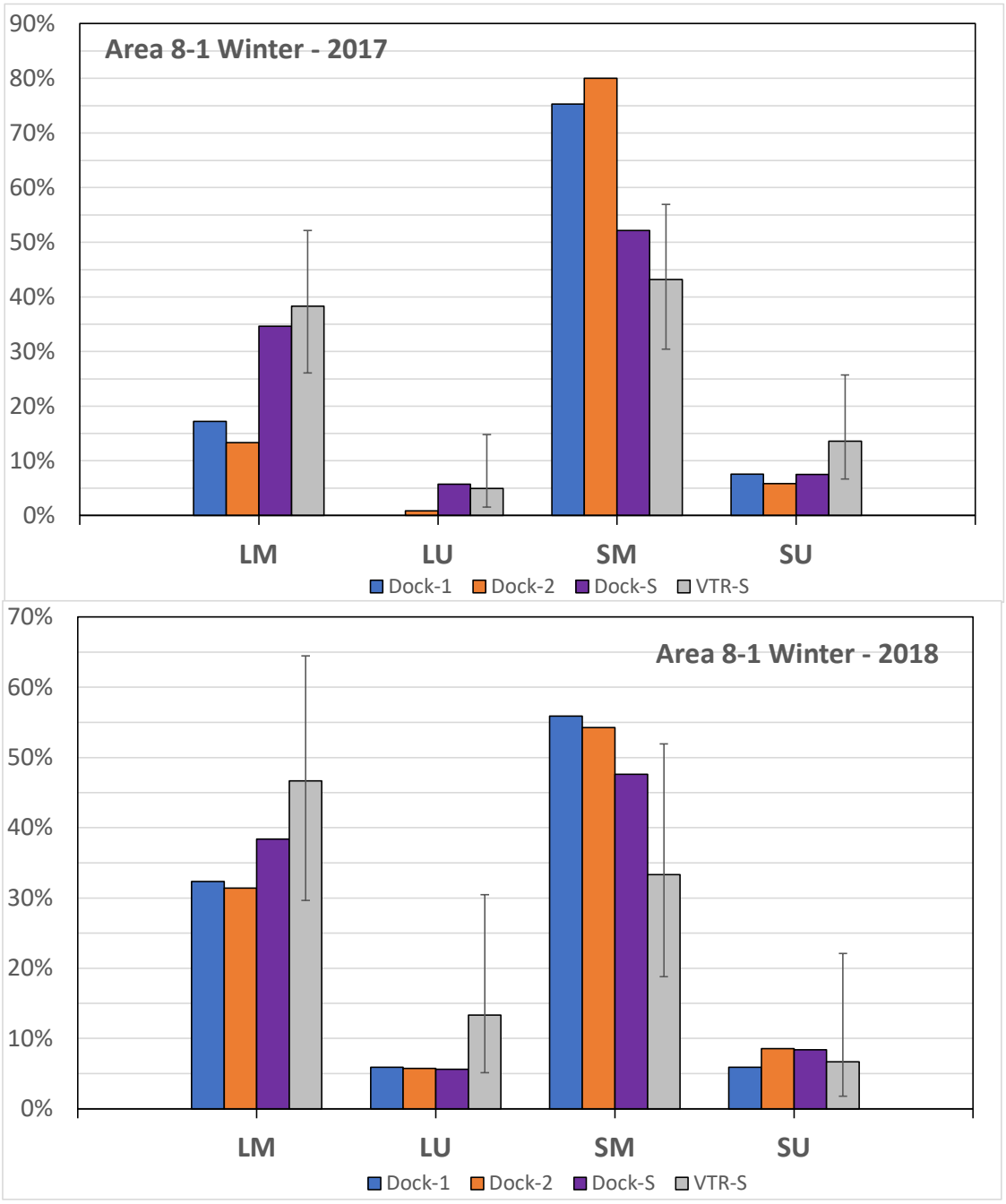


Figure B8. Comparison of the Dockside size|mark composition estimates for Areas 8-1 winter.

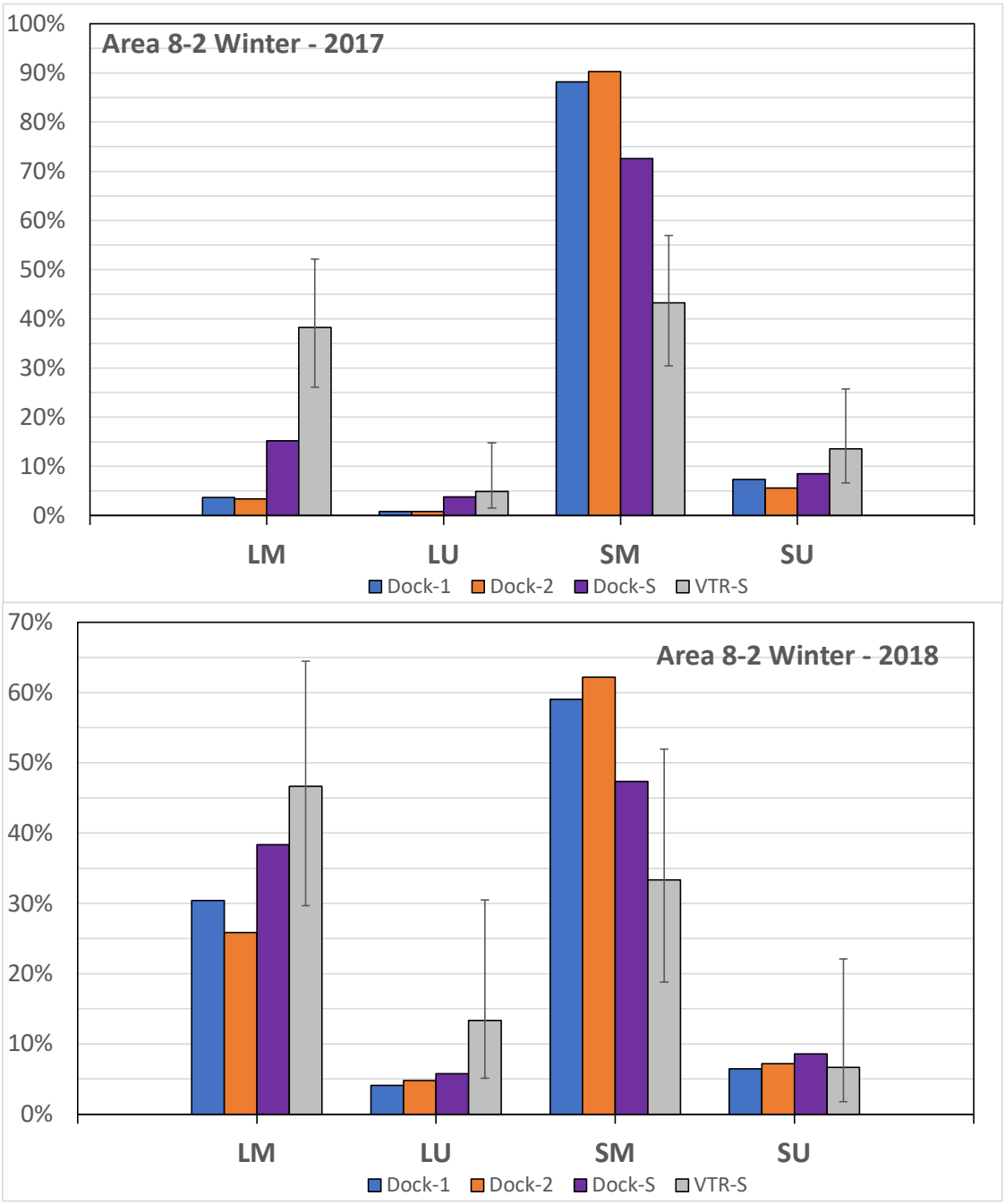


Figure B9. Comparison of the Dockside size|mark composition estimates for Areas 8-2 winter.

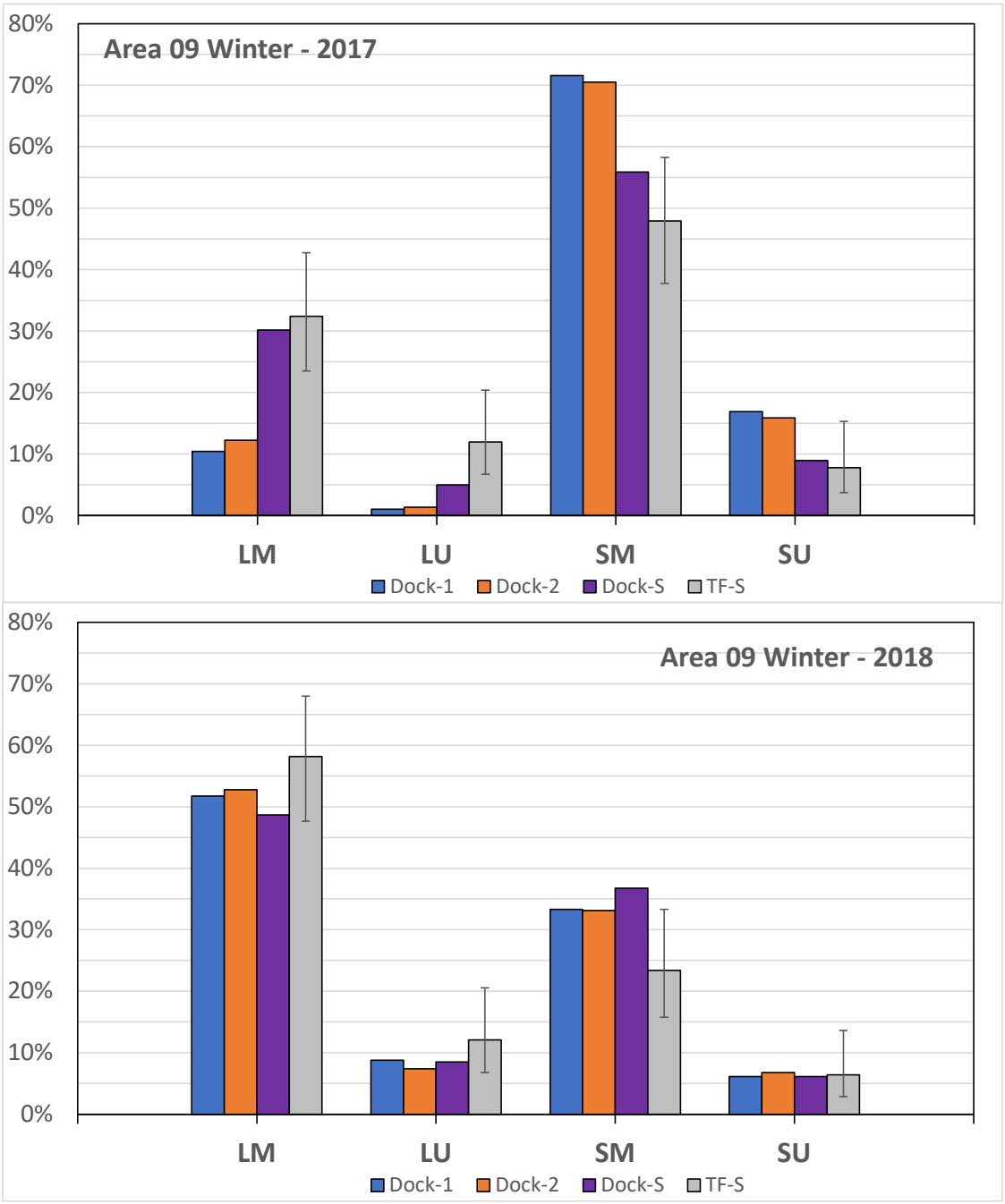


Figure B10. Comparison of the Dockside size|mark composition estimates for Area 09 winter.

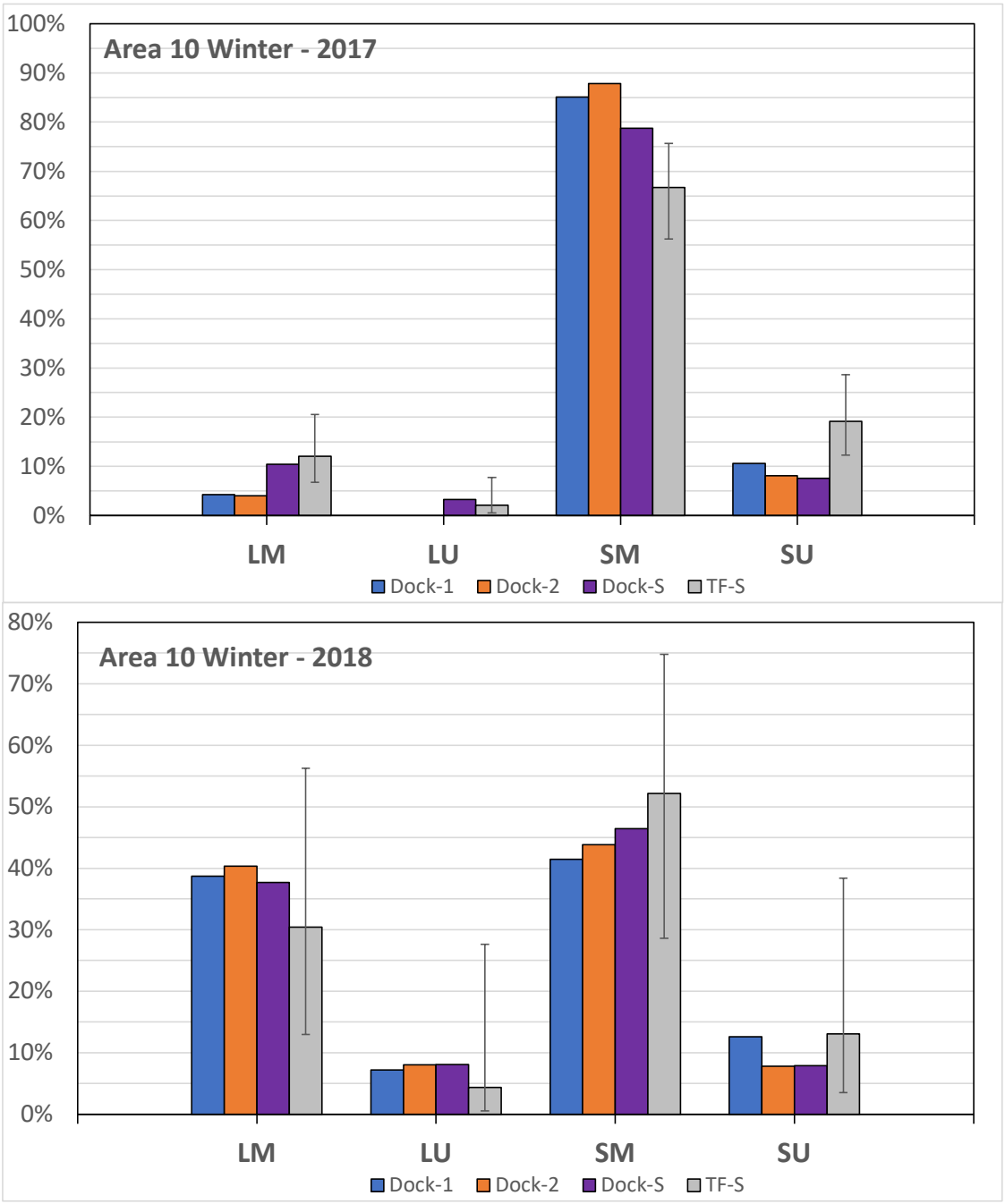


Figure B11. Comparison of the Dockside size|mark composition estimates for Area 10 winter.

APPENDIX C

Tables summarizing estimates of the size|mark composition of Chinook encounters in Puget Sound mark-selective fisheries from Dockside interview data collected during the first week of the season (Dock-1), Dockside interview data collected during the first and second weeks combined (Dock-2), end-of-season Dockside interview data (Dock-S), and the final post-season estimate of size|mark composition from the test fishery and/or VTR (TF/VTR) sampling programs. The number of boats interviewed, number of anglers represented by those interviews and reported number of encounters are shown for the Dockside data. The sample size (number of encounters) is shown for the TF/VTR data.

Table C1. Summary of size|mark composition estimates for Chinook encounters, and associated sample sizes, for summer mark-selective fisheries conducted in Puget Sound.

Marine Area	Season Year	Data Source	Encounter Size|Mark-Status Composition				Sample Size and Numbers Reported		
			LM	LU	SM	SU	Boats	Anglers	Encounters
05	Summer 2017	Dock-1	30.1%	13.0%	38.9%	18.1%	331	776	332
		Dock-2	20.4%	8.1%	52.7%	18.7%	642	1,494	935
		Dock-S	20.3%	13.5%	42.7%	23.6%	2,274	5,417	3,747
		VTR-S	14.8%	9.4%	50.5%	25.4%			406
05	Summer 2018	Dock-1	37.0%	21.5%	27.4%	14.1%	283	649	419
		Dock-2	32.6%	17.8%	35.1%	14.5%	606	1,384	950
		Dock-S	26.0%	19.2%	41.4%	13.4%	2,131	4,821	4,527
		VTR-S	20.2%	12.4%	46.7%	20.7%			1,128
05	Summer 2019	Dock-1	46.4%	23.1%	15.6%	15.0%	291	671	642
		Dock-2	40.8%	25.6%	16.6%	17.1%	681	1,570	1,087
		Dock-S	38.4%	29.2%	17.6%	14.7%	2,186	5,186	3,918
		VTR-S	31.8%	19.7%	28.0%	20.5%			132
07	Summer 2017	Dock-1	72.0%	15.1%	11.9%	0.9%	351	504	218
		Dock-2	63.8%	12.4%	20.8%	3.0%	706	1,149	630
		Dock-S	57.9%	12.4%	26.2%	3.4%	1,136	2,455	964
		TF-S	30.4%	21.7%	30.4%	17.4%			23
07	Summer 2018	Dock-1	64.2%	14.6%	16.8%	4.5%	410	723	268
		Dock-2	59.9%	13.1%	18.6%	8.4%	723	1,239	489
		Dock-S	53.3%	12.3%	24.4%	9.9%	1,052	2,266	900
		Beta Reg	52.8%	21.4%	18.4%	7.4%			27
07	Summer 2019	Dock-1	72.5%	15.8%	8.0%	3.7%	301	517	349
		Dock-2	64.6%	20.5%	11.0%	4.0%	571	1,143	556
		Dock-S	57.3%	21.5%	15.6%	5.5%	1,172	2,663	1,165
		TF-S	58.7%	23.9%	10.9%	6.5%			46
09	Summer 2017	Dock-1	49.6%	7.1%	36.2%	7.1%	1,136	2,546	1,354
		Dock-2	49.3%	7.5%	34.7%	8.5%	2,038	4,449	2,142
		Dock-S	46.6%	7.5%	37.2%	8.7%	2,262	4,977	2,331
		TF-S	31.6%	6.6%	50.0%	11.8%			76
09	Summer 2018	Dock-1	56.8%	10.8%	22.5%	9.9%	1,035	2,339	964
		Dock-2	59.5%	10.1%	21.7%	8.7%	1,926	4,328	1,809
		Dock-S	62.7%	9.3%	20.0%	8.0%	1,997	4,488	2,022
		TF-S	56.4%	9.0%	30.8%	3.8%			78
09	Summer 2019	Dock-1	70.7%	15.8%	8.5%	5.0%	1,275	2,905	840
		Dock-2	69.8%	16.4%	8.0%	5.8%	1,920	4,310	1,185
		Dock-S	69.8%	16.8%	7.6%	5.7%	2,218	4,967	1,325
		TF-S	75.0%	11.1%	11.1%	2.8%			36

Table C1. Summary of size|mark composition estimates for Chinook encounters, and associated sample sizes, for summer mark-selective fisheries conducted in Puget Sound (continued).

Marine Area	Season Year	Data Source	Encounter Size|Mark-Status Composition				Sample Size and Numbers Reported		
			LM	LU	SM	SU	Boats	Anglers	Encounters
10	Summer 2017	Dock-1	19.2%	9.6%	60.0%	11.2%	335	668	250
		Dock-2	22.6%	8.5%	56.5%	12.4%	693	1,401	434
		Dock-S	32.1%	13.6%	43.6%	10.6%	2,402	4,761	2,282
		TF-S	28.0%	8.7%	50.3%	13.0%			161
10	Summer 2018	Dock-1	41.9%	12.3%	32.5%	13.3%	568	1,180	406
		Dock-2	39.6%	10.7%	36.2%	13.5%	1,112	2,279	861
		Dock-S	52.3%	10.7%	29.0%	7.9%	4,031	8,422	3,415
		TF-S	47.2%	9.0%	34.0%	9.7%			144
10	Summer 2019	Dock-1	52.3%	16.9%	17.1%	13.7%	715	1,563	432
		Dock-2	53.2%	20.1%	13.6%	13.0%	1,265	2,757	675
		Dock-S	57.1%	19.3%	12.8%	10.8%	3,161	6,903	1,659
		TF-S	66.7%	18.8%	8.3%	6.3%			48
11	Summer 2017	Dock-1	36.8%	19.7%	28.9%	14.5%	239	405	76
		Dock-2	39.2%	19.2%	32.8%	8.8%	406	671	125
		Dock-S	24.1%	7.7%	52.2%	16.0%	5,330	9,604	4,069
		VTR-S	38.5%	11.0%	33.0%	17.6%			91
11	Summer 2018	Dock-1	53.7%	15.2%	27.0%	4.1%	325	535	341
		Dock-2	51.7%	11.8%	33.2%	3.4%	597	981	567
		Dock-S	43.6%	8.3%	41.5%	6.7%	5,905	10,592	3,855
		VTR-S	32.6%	11.6%	41.9%	14.0%			43
11	Summer 2019	Dock-1	75.4%	9.4%	13.1%	2.1%	450	857	191
		Dock-2	65.9%	12.1%	18.6%	3.4%	891	1,683	323
		Dock-S	54.7%	13.6%	23.2%	8.5%	4,700	9,073	1,524
		VTR-S	28.9%	34.2%	15.8%	21.1%			38

Table C2. Summary of size|mark composition estimates for Chinook encounters, and associated sample sizes, for winter mark-selective fisheries conducted in Puget Sound.

Marine Area	Season Year	Data Source	Encounter Size|Mark-Status Composition				Sample Size and Numbers Reported		
			LM	LU	SM	SU	Boats	Anglers	Encounters
06	Winter 2017	Dock-1	72.0%	7.2%	17.2%	3.6%	190	336	279
		Dock-2	72.4%	6.7%	18.0%	2.9%	207	424	416
		Dock-S	61.2%	8.4%	27.5%	2.9%	799	1,067	950
		VTR-S	54.4%	11.8%	30.9%	2.9%			68
06	Winter 2018	Dock-1	63.3%	9.0%	25.1%	2.5%	107	207	199
		Dock-2	63.0%	9.0%	25.1%	2.8%	112	216	211
		Dock-S	69.6%	6.8%	22.2%	1.4%	1,097	1,646	1,334
		VTR-S	64.3%	5.4%	17.9%	12.5%			56
07	Winter 2017	Dock-1	69.1%	5.5%	20.9%	4.5%	114	220	110
		Dock-2	59.2%	5.1%	26.5%	9.2%	223	449	294
		Dock-S	53.9%	11.6%	29.4%	5.2%	1,032	2,072	1,004
		TF-S	37.5%	14.8%	33.0%	14.8%			88
07	Winter 2018	Dock-1	63.5%	7.9%	21.4%	7.1%	97	234	126
		Dock-2	64.4%	11.1%	18.6%	6.0%	310	602	334
		Dock-S	65.7%	11.7%	18.4%	4.2%	1,238	2,515	1,216
		TF-S	47.8%	17.4%	23.2%	11.6%			138
8-1	Winter 2017	Dock-1	17.2%	0.0%	75.3%	7.5%	31	45	93
		Dock-2	13.3%	0.8%	80.0%	5.8%	41	66	120
		Dock-S	34.6%	5.7%	52.2%	7.5%	384	711	508
		VTR-S	38.3%	4.9%	43.2%	13.6%			81
8-1	Winter 2018	Dock-1	32.4%	5.9%	55.9%	5.9%	29	55	34
		Dock-2	31.4%	5.7%	54.3%	8.6%	32	63	35
		Dock-S	38.4%	5.6%	47.6%	8.4%	293	512	250
		VTR-S	46.7%	13.3%	33.3%	6.7%			45

Table C2. Summary of size|mark composition estimates for Chinook encounters, and associated sample sizes, for winter mark-selective fisheries conducted in Puget Sound (continued).

Marine Area	Season Year	Data Source	Encounter Size|Mark-Status Composition				Sample Size and Numbers Reported		
			LM	LU	SM	SU	Boats	Anglers	Encounters
8-2	Winter 2017	Dock-1	3.7%	0.8%	88.2%	7.3%	59	92	246
		Dock-2	3.3%	0.8%	90.3%	5.6%	88	152	359
		Dock-S	15.2%	3.8%	72.6%	8.5%	742	1,474	1,120
		VTR-S	38.3%	4.9%	43.2%	13.6%			81
8-2	Winter 2018	Dock-1	30.4%	4.1%	59.1%	6.4%	147	291	171
		Dock-2	25.8%	4.8%	62.2%	7.2%	205	423	209
		Dock-S	38.3%	5.8%	47.4%	8.6%	1,295	2,645	1,250
		VTR-S	46.7%	13.3%	33.3%	6.7%			45
09	Winter 2017	Dock-1	10.4%	1.0%	71.6%	16.9%	117	198	479
		Dock-2	12.3%	1.3%	70.5%	15.9%	186	330	742
		Dock-S	30.2%	5.0%	55.9%	8.9%	1,376	2,459	2,261
		TF-S	32.4%	12.0%	47.9%	7.7%			142
09	Winter 2018	Dock-1	51.8%	8.8%	33.3%	6.1%	96	198	114
		Dock-2	52.8%	7.4%	33.1%	6.7%	347	565	326
		Dock-S	48.7%	8.5%	36.8%	6.1%	1,840	3,607	2,002
		TF-S	58.2%	12.1%	23.4%	6.4%			141
10	Winter 2017	Dock-1	4.3%	0.0%	85.1%	10.6%	18	28	47
		Dock-2	4.1%	0.0%	87.8%	8.1%	26	41	74
		Dock-S	10.4%	3.3%	78.7%	7.6%	309	536	672
		TF-S	12.1%	2.1%	66.7%	19.1%			141
10	Winter 2018	Dock-1	38.7%	7.2%	41.4%	12.6%	81	167	222
		Dock-2	40.3%	8.0%	43.8%	7.8%	339	745	922
		Dock-S	37.7%	8.1%	46.4%	7.9%	385	836	993
		TF-S	30.4%	4.3%	52.2%	13.0%			23

APPENDIX D

Bar graphs comparing estimates of the size|mark composition of Chinook encounters in Puget Sound mark-selective fisheries for season total Dockside interview data, and bias-corrected season total Dockside estimates, to the final post-season estimate of size|mark composition from the test fishery and/or VTR sampling programs. Simultaneous 95% confidence intervals (Goodman 1965) are displayed for the TF/VTR estimates. Dock-S indicates dockside data collected for the entire season and Dock-BC indicates the bias corrected estimate based on the Dockside season total estimate.

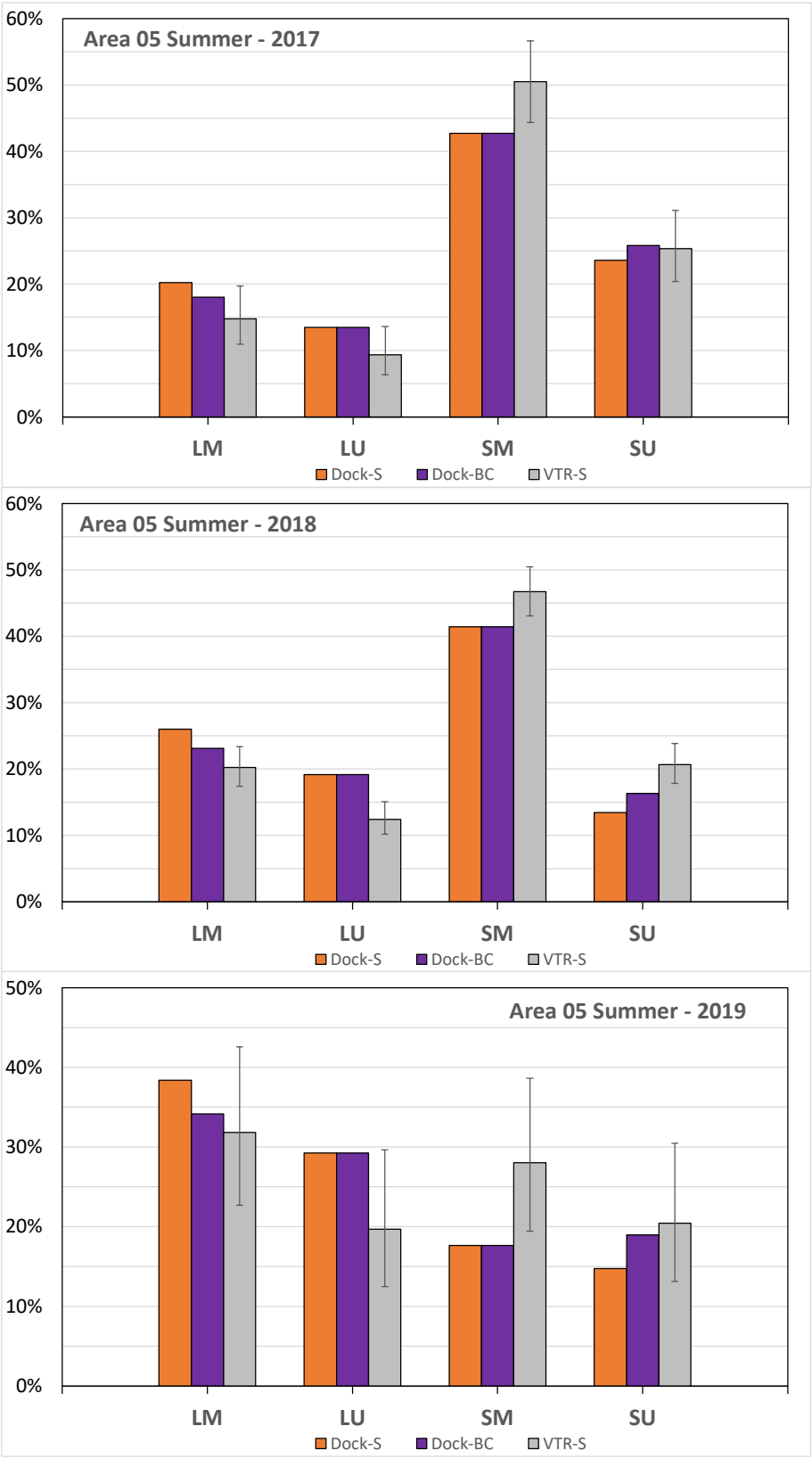


Figure D1. Comparison of size|mark composition estimates for Area 05 summer.

Figure D2. Comparison of size|mark composition estimates for Area 06 summer.

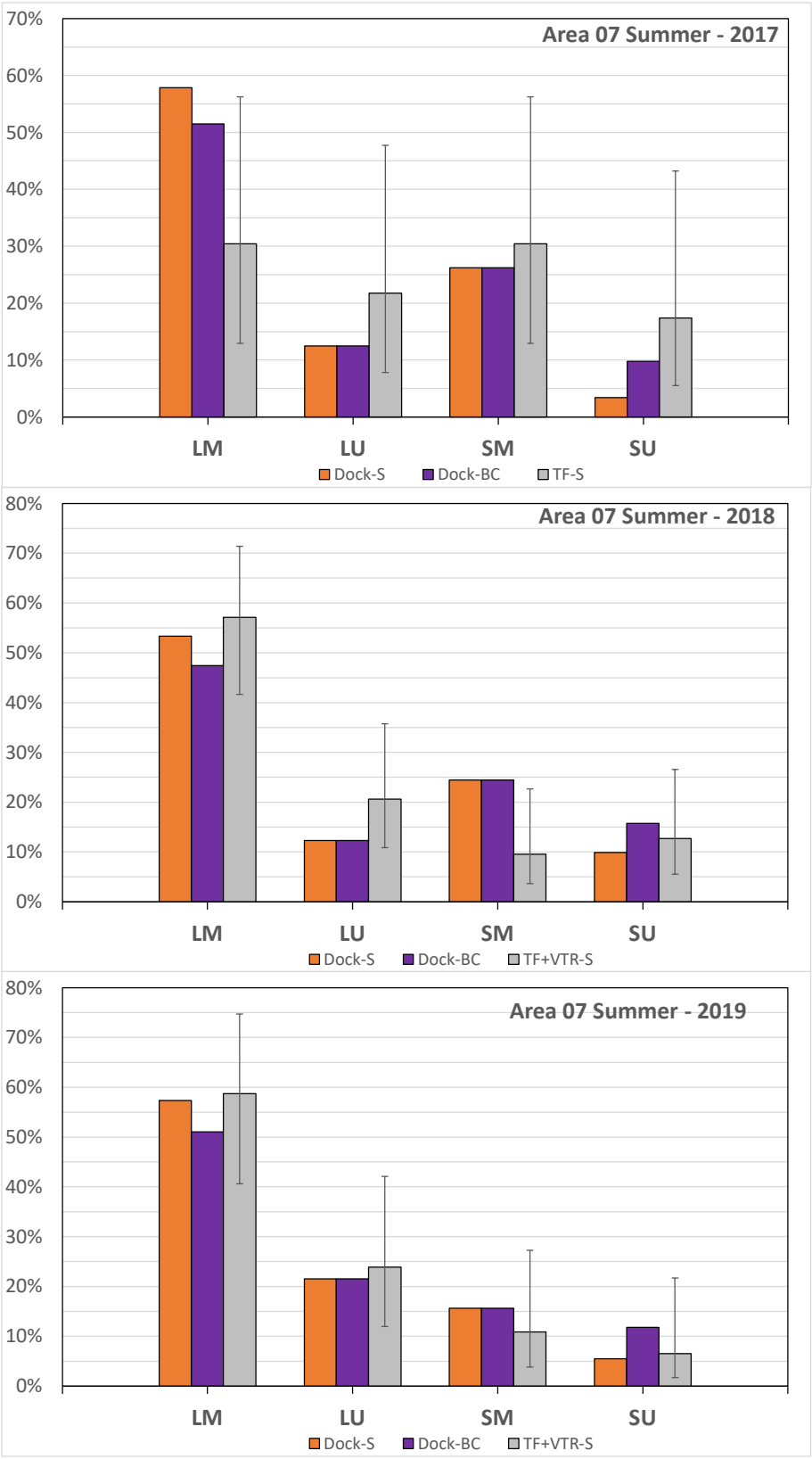


Figure D3. Comparison of size|mark composition estimates for Area 07 summer.

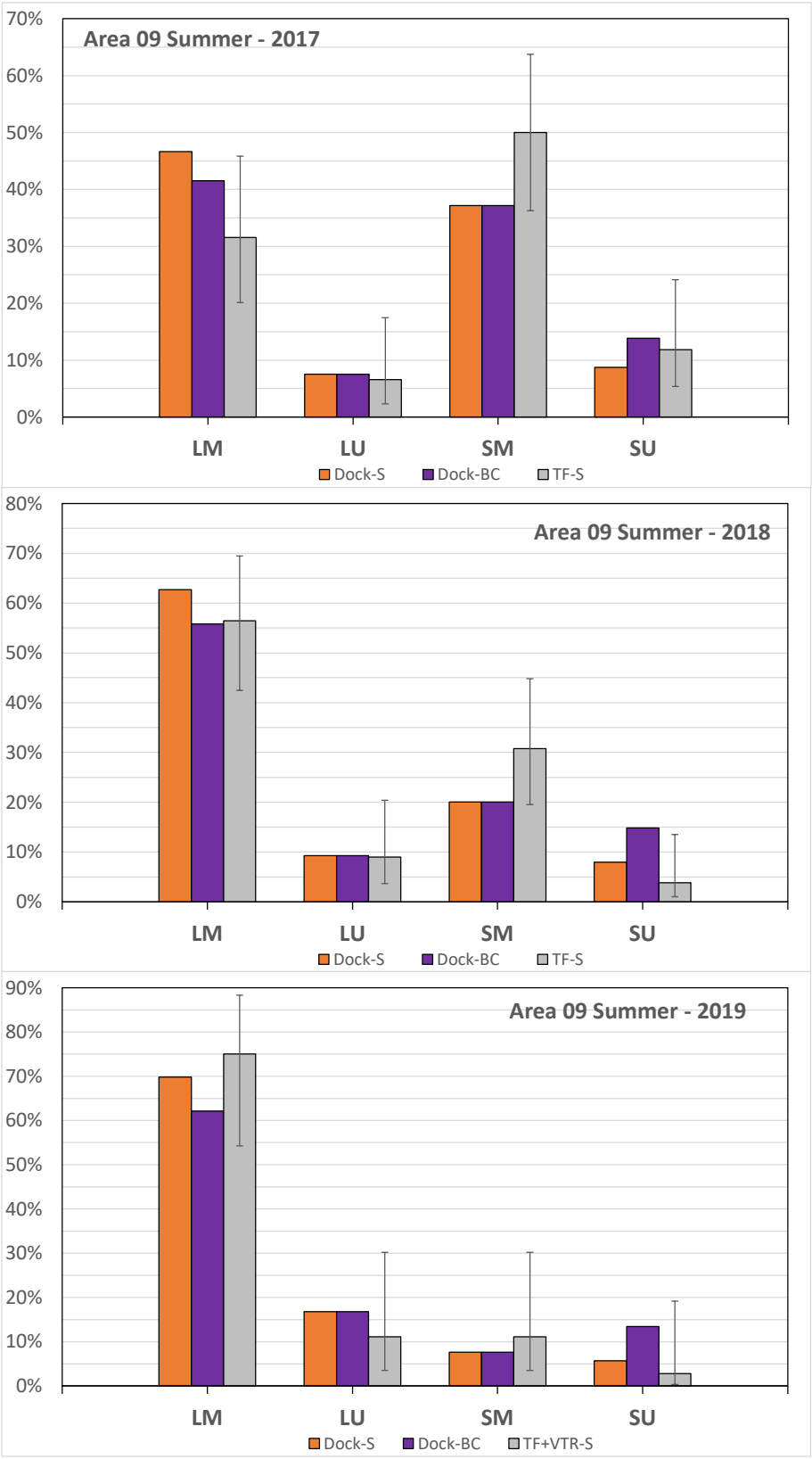


Figure D4. Comparison of size|mark composition estimates for Area 09 summer.

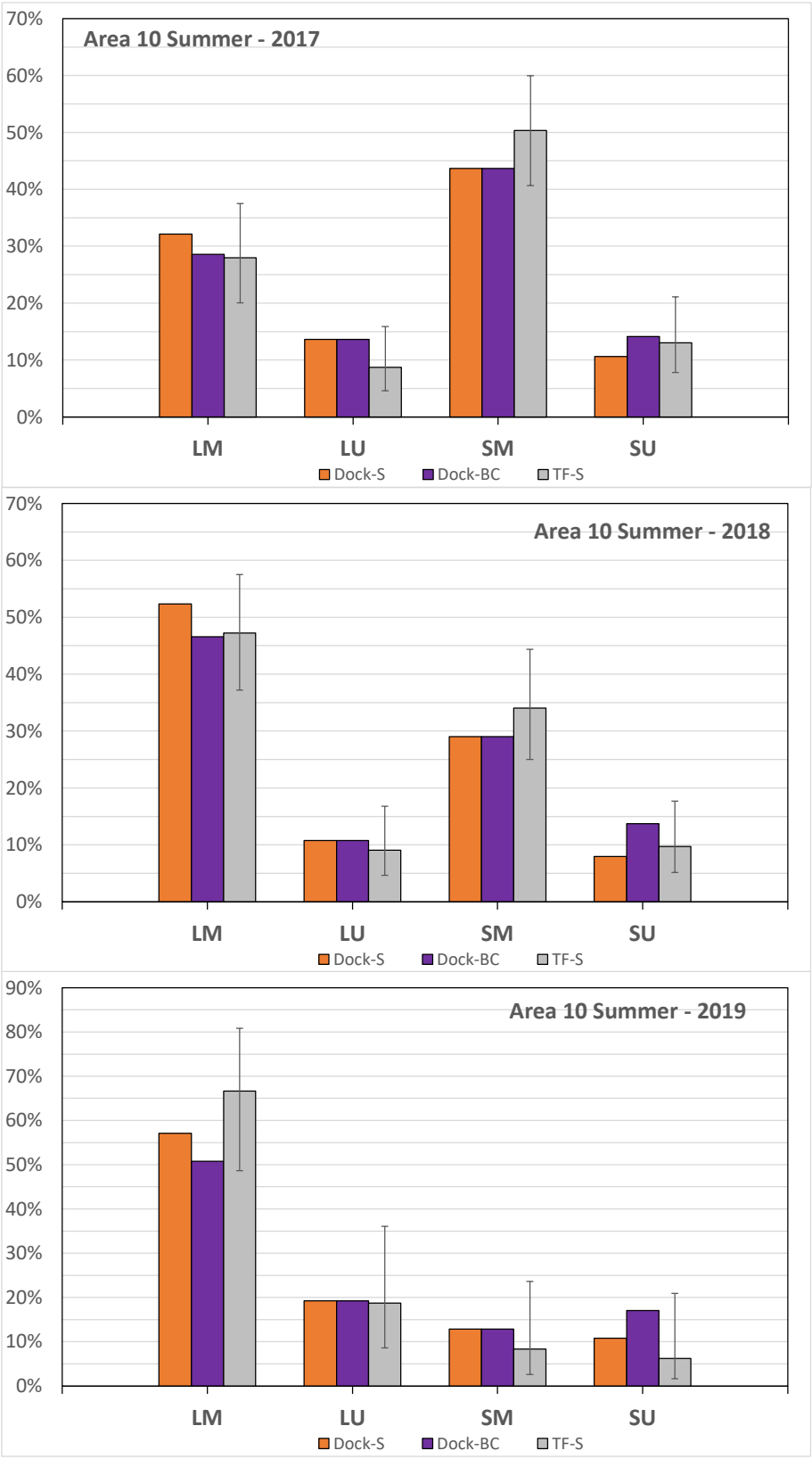
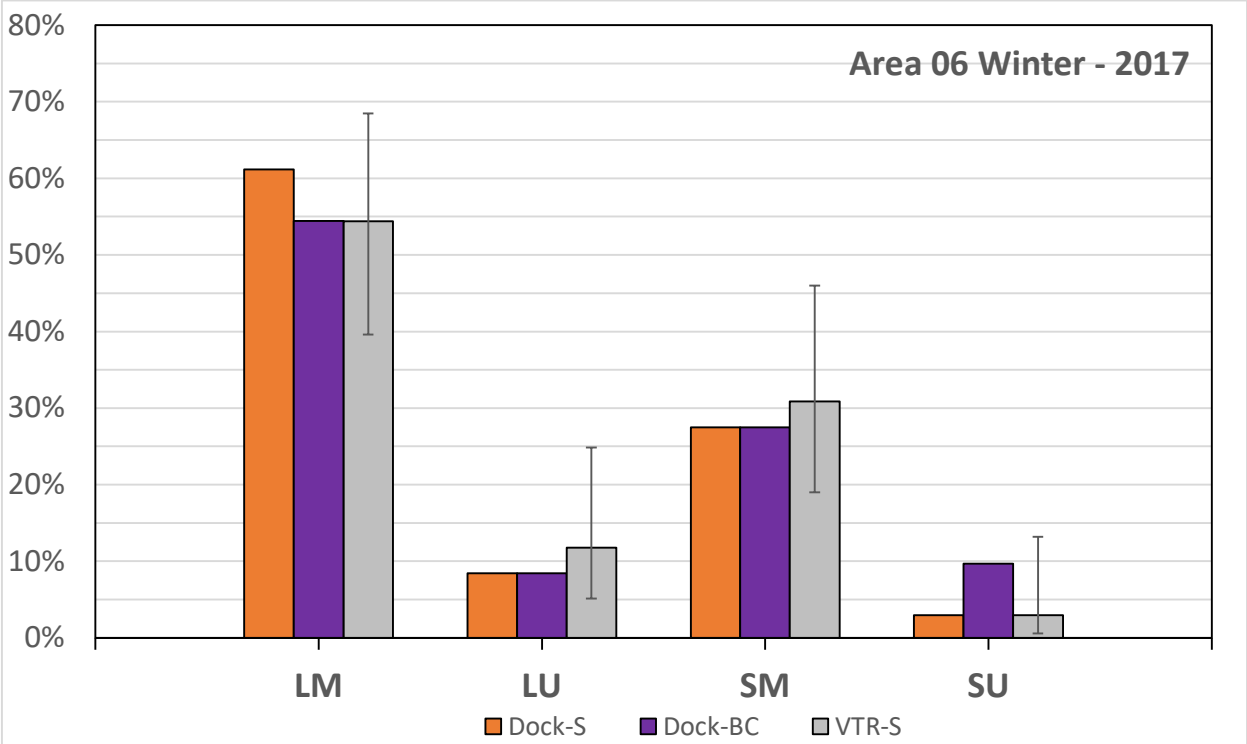


Figure D5. Comparison of size|mark composition estimates for Area 10 summer.

Figure D6. Comparison of size|mark composition estimates for Area 11 summer.



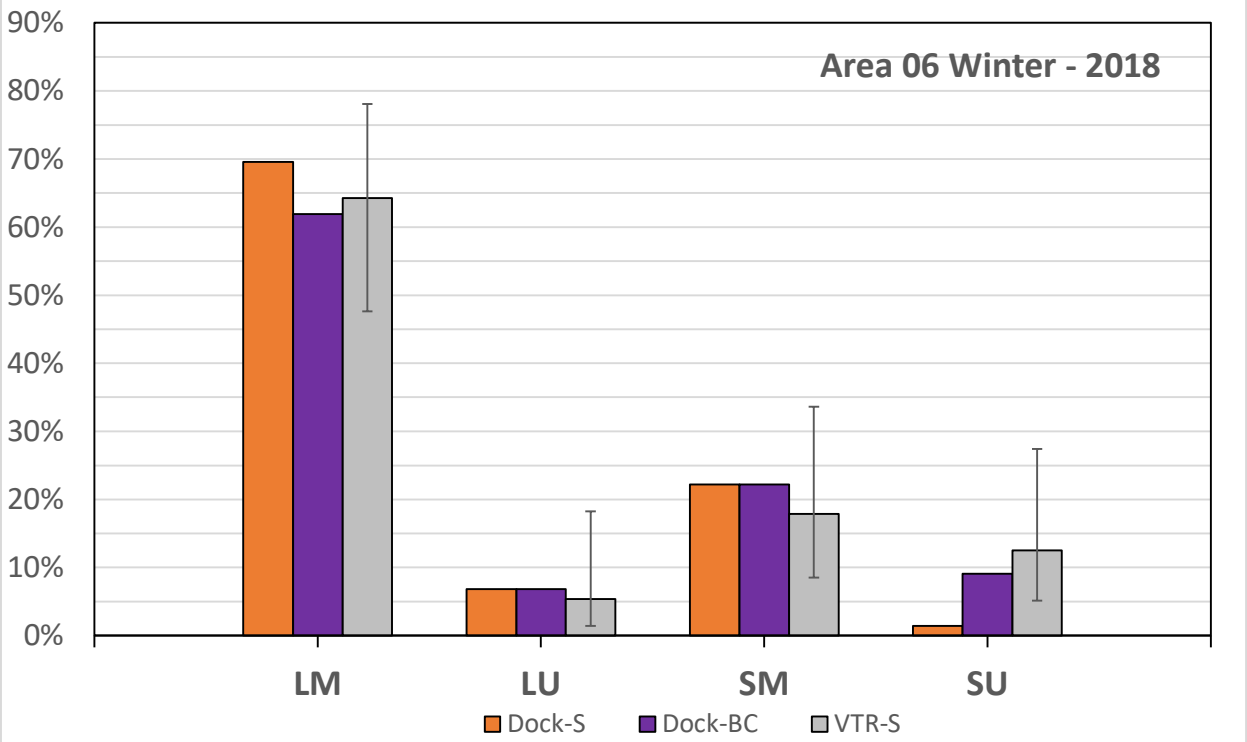
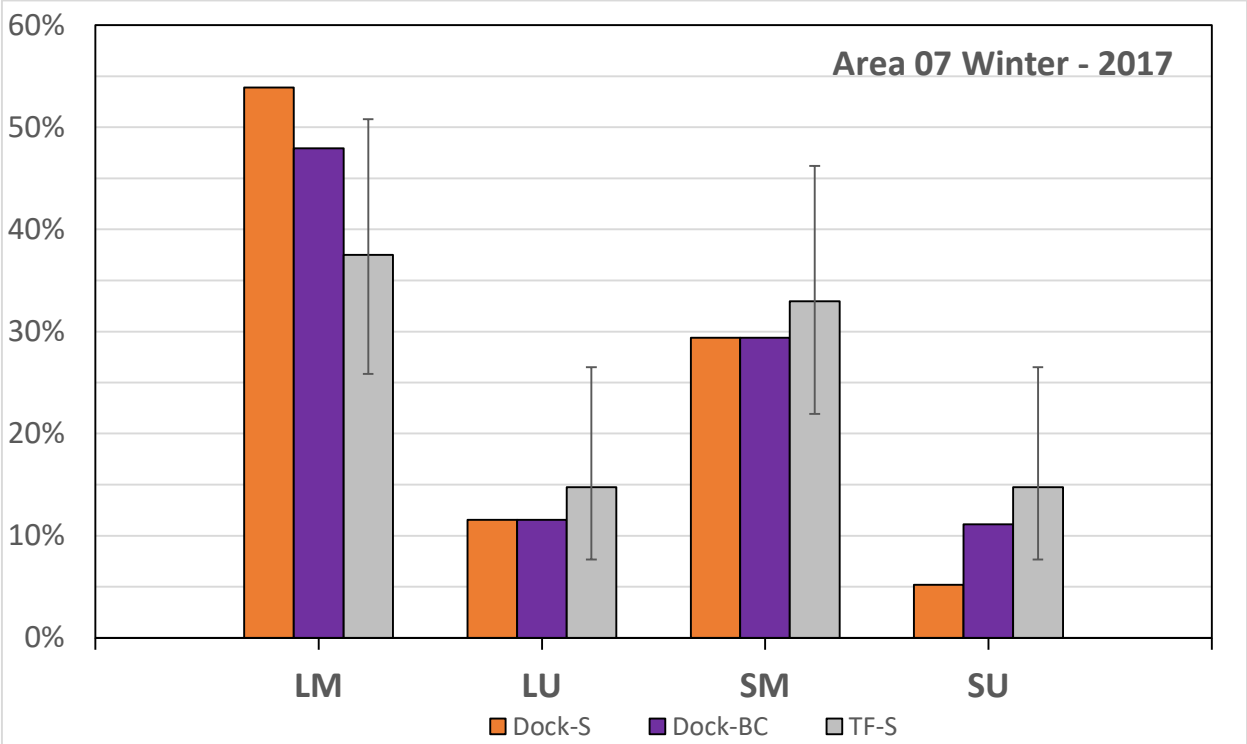


Figure D7. Comparison of size|mark composition estimates for Area 06 winter.



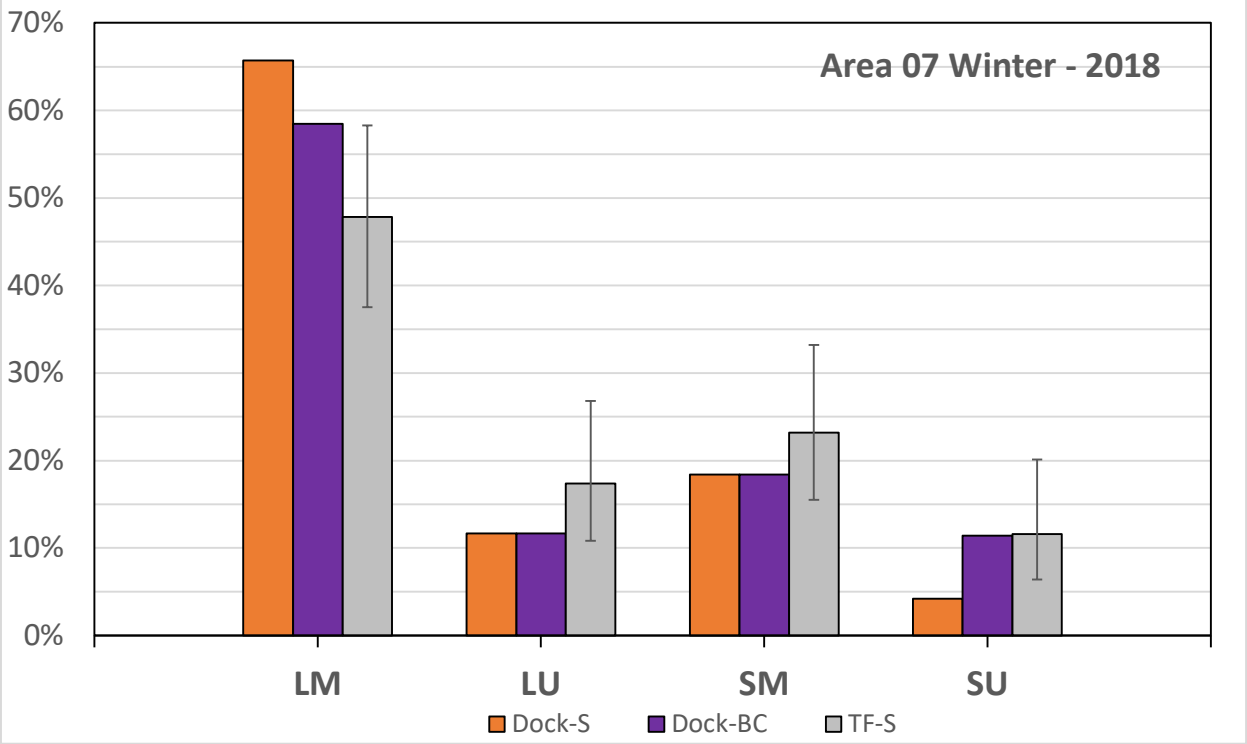
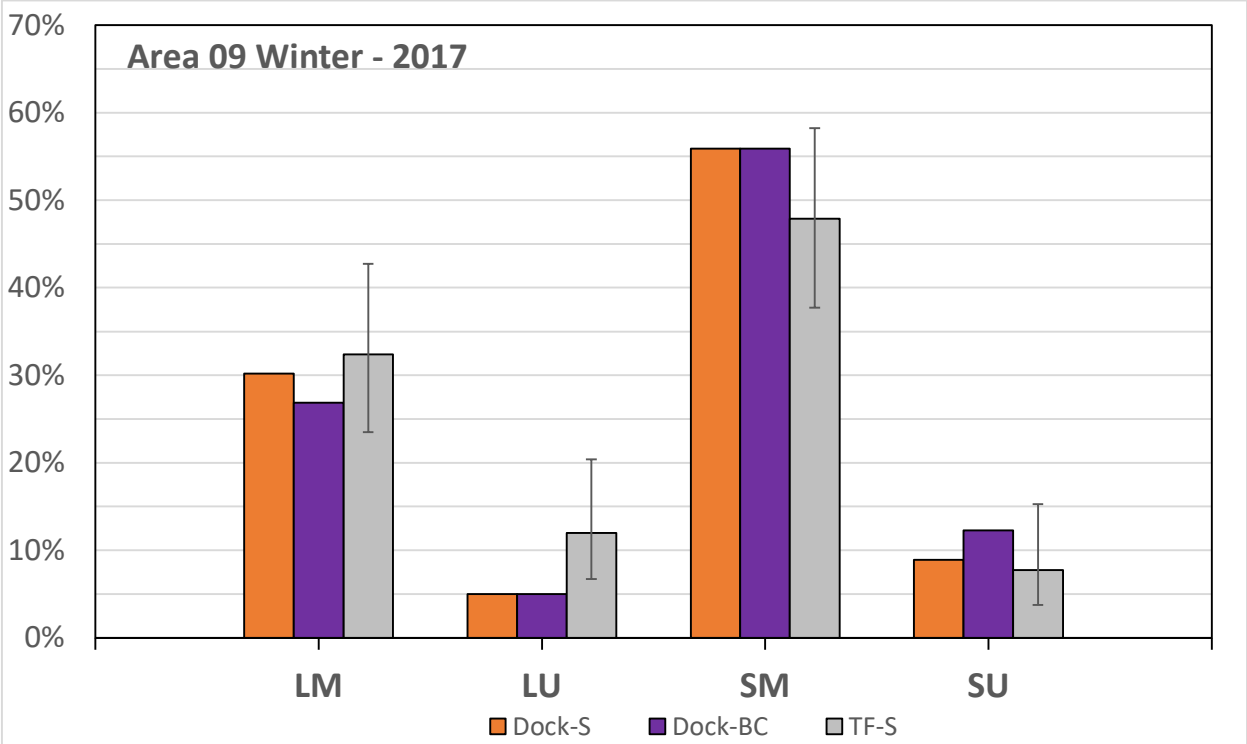


Figure D8. Comparison of size|mark composition estimates for Area 07 winter.



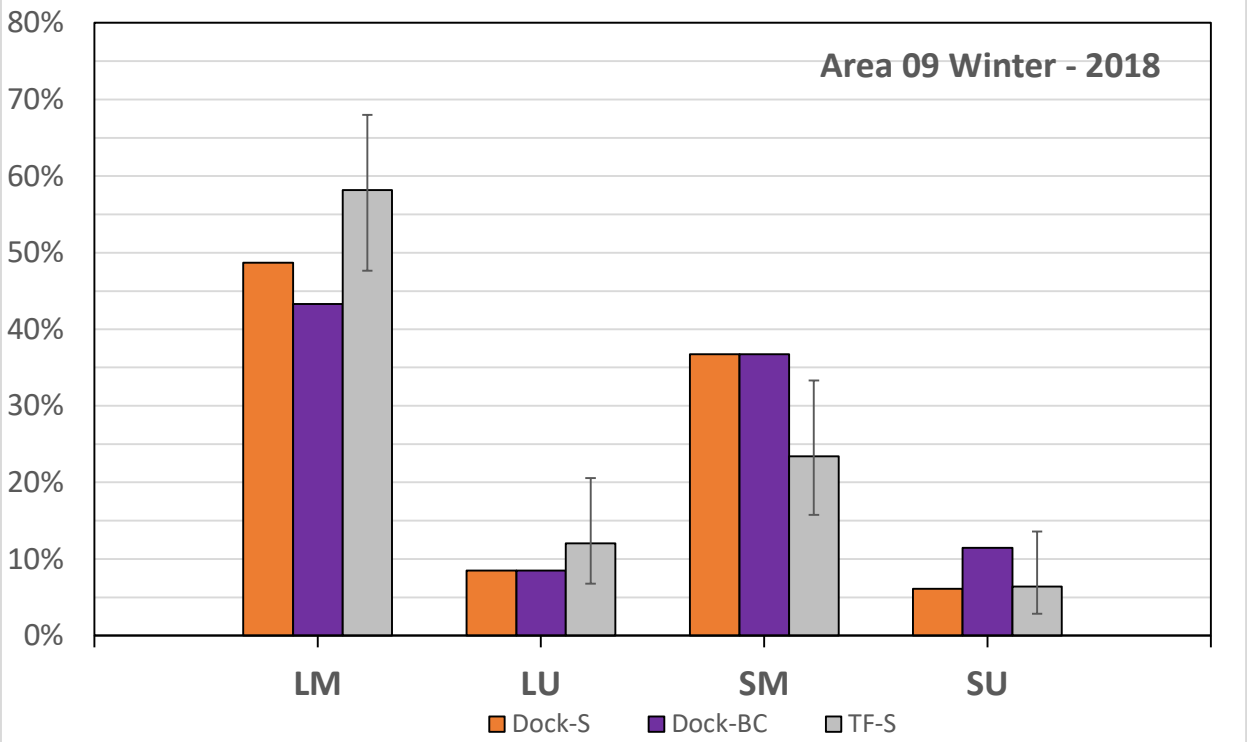


Figure D9. Comparison of size|mark composition estimates for Area 09 winter.

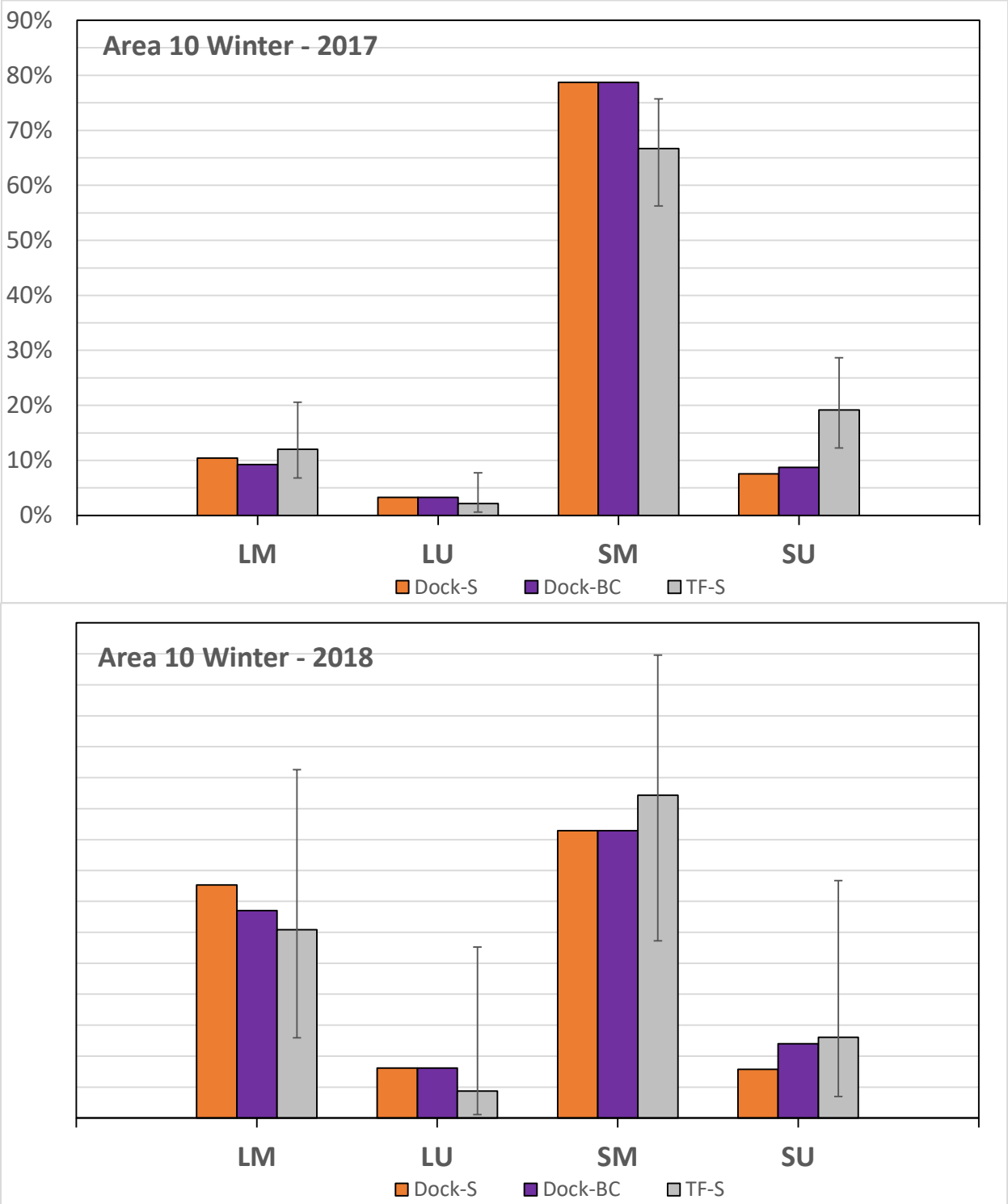


Figure D10. Comparison of size|mark composition estimates for Area 10 winter.