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Purse-Seine Length Frequencies Corrected for Selectivity Bias in Grab Samples Collected by Observers

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PURSE-SEINE LENGTH FREQUENCIES CORRECTED FOR SELECTIVITY BIAS IN GRAB SAMPLES COLLECTED BY OBSERVERS

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1. Estimation of the selectivity bias in grab samples

Lawson (2010) estimated the selectivity bias in grab samples collected by observers onboard purse seiners in the Western and Central Pacific by comparing paired grab and spill samples collected during 17 purse-seine trips taken during 2008–2010. Paired samples were collected from 254 sets, including 184 (72.4%) sets on schools associated with anchored FADs, 24 (9.4%) on drifting FADs, 28 (11%) on logs and 11 (4.3%) sets on unassociated schools.

The selectivity bias was estimated using the model developed in Lawson (2009):

$$n_{jk} = N_{jk} \cdot A_j + \varepsilon \tag{1}$$

$$= \frac{W_k \cdot T_{jk}}{\overline{w}_j} \cdot A_j + \varepsilon \tag{2}$$

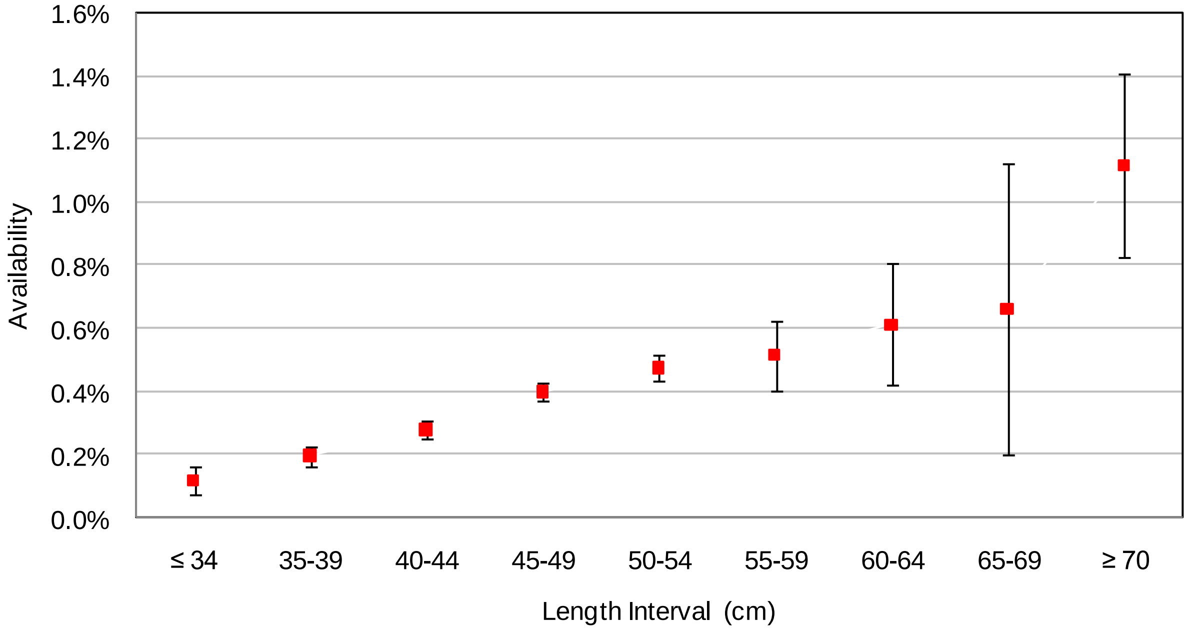
where n_{jk} is the number of fish in length interval j selected by a grab sampler from set k; N_{jk} is the "true" number of fish in length interval j in set k; A_j is the probability that a grab sampler will select a fish of length interval j, which can be considered as the *availability* of a fish to be selected; W_k is the total weight of set k; T_{jk} is the "true" proportion of fish of length interval j in set k, in terms of weight, determined from the spill sample taken from set k; $\overline{w}_j$ is the average weight of fish of length interval j; and ε is a random variable of mean zero.

The availability parameters, A_j in equation (1), were estimated for nine intervals of fish length: one interval for fish ≤ 34, seven intervals of 5 cm from 35 cm to 70 cm, and one interval for fish ≥ 70 cm. Table 1 and Figure 1 show that the estimates of availability increase with size; however, the relationship is obscured by the wide error bars for fish ≥ 55 cm, which are due to the lack of sufficient data.

Table 1. Estimates of availability for a model with 5 cm length intervals, with small fish and large fish grouped

Interval	Estimate	Std Error	t value	Pr(>|t|)
≤ 34	0.001186	0.000224	5.286590	0.00000014
35-39	0.001962	0.000156	12.536774	0.00000000
40-44	0.002794	0.000143	19.557551	0.00000000
45-49	0.003991	0.000142	28.155110	0.00000000
50-54	0.004752	0.000190	25.013712	0.00000000
55-59	0.005145	0.000562	9.159454	0.00000000
60-64	0.006121	0.000967	6.329040	0.00000000
65-69	0.006621	0.002301	2.877551	0.00405405
≥ 70	0.011163	0.001461	7.639209	0.00000000

Figure 1. Estimates of availability for a model with 5 cm length intervals, with small fish and large fish grouped



2. Correction of length frequencies for size selectivity bias

The estimates of availability can be used to correct the length frequencies determined from the grab samples as follows:

$$\hat{n}_{ijk} = \sum_i \sum_j n_{ijk} \cdot \frac{N_{ijk}}{\sum_i \sum_j N_{ijk}} \qquad (3)$$

$$= \sum_i \sum_j n_{ijk} \cdot \frac{\frac{n_{ijk}}{A_j}}{\sum_i \sum_j \frac{n_{ijk}}{A_j}} \tag{4}$$

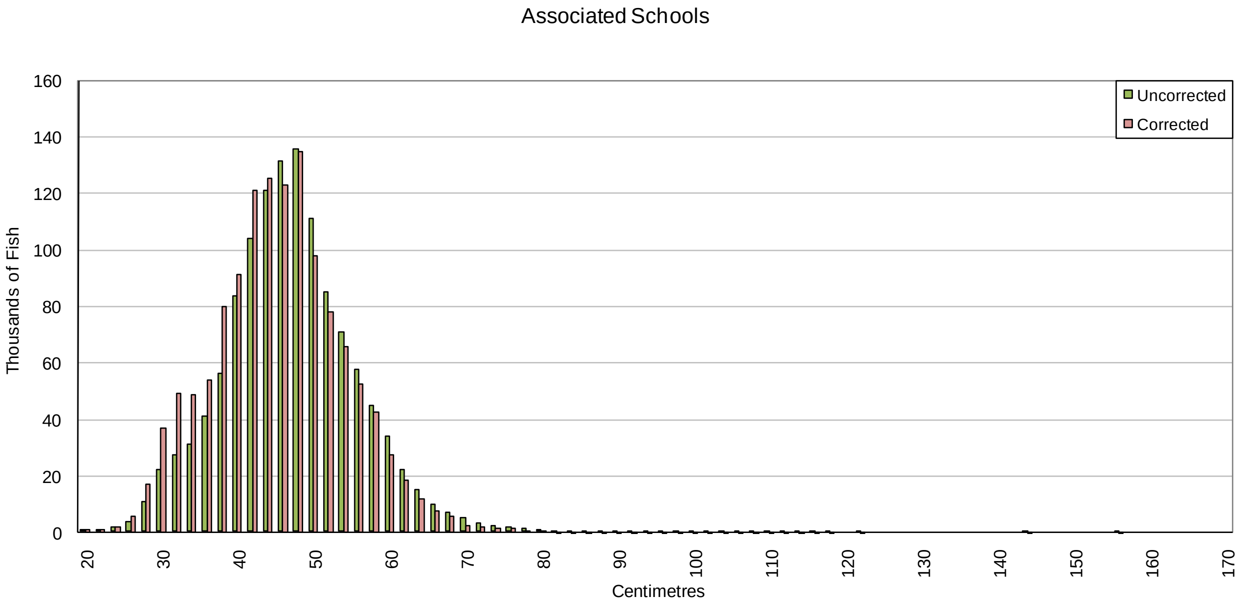
where $\hat{n}_{ijk}$ is the corrected number of fish of species i and length interval j in the samples from set k ; n_{ijk} is the uncorrected number of fish of species i and length interval j in the samples from set k ; N_{ijk} is the "true" number of fish of species i in length interval j in the samples from set k ; and A_j is the probability that a grab sampler will select a fish in length interval j . In equations (3) and (4), the length intervals can be of any magnitude — i.e., 1 cm intervals or 2 cm intervals — and are not constrained to be the same as those used to estimate the A_j in equation (2).

In equations (3) and (4), the total number of fish in the samples from a particular set, $\sum_i \sum_j n_{ijk}$, is applied to a corrected length frequency (in terms of proportions of numbers of fish) based on the estimates of availability, i.e., the right-hand part of the product in equations (3) and (4). Thus, the total of the corrected number of fish in the length frequency for a set is equal to the total of the uncorrected number of fish in the length frequency for that set. This has two effects. First, unlike the uncorrected numbers of fish, the corrected numbers of fish are not integers (and should therefore be treated accordingly). Second, there is an effect on the species composition (in terms of numbers of fish) within a set, such that the total number of fish in the corrected length frequency for skipjack increases, while those for yellowfin and bigeye decrease; this is because the availability of smaller fish (primarily skipjack) is less than for larger fish (primarily yellowfin and bigeye).

Equation (4) and the estimates of availability in Tables 1 were used to correct the length frequencies determined from grab samples collected during 1993–2010. The corrected grab samples were then aggregated into strata of year – quarter – area – school association, where the areas were either MULTIFAN-CL Areas 2 and 3 used in the assessments of skipjack or the MFCL Areas 3 and 4 used in the assessments of yellowfin and bigeye. The length intervals were 1 cm. The uncorrected and corrected length frequencies for skipjack, yellowfin and bigeye in MFCL Skipjack Areas 2 and 3 are shown in Figures 2–4. (The length frequencies for MFCL Yellowfin & Bigeye Areas 3 & 4 do not differ from those for MFCL Skipjack Areas 2 and 3 and so are not shown.)

The shapes of the length frequencies for yellowfin and bigeye in Figures 3 and 4 determined from samples taken from associated schools are quite similar, particularly for smaller fish, although there is no obvious reason why this should be the case.

Figure 2. Uncorrected and corrected length frequencies for skipjack



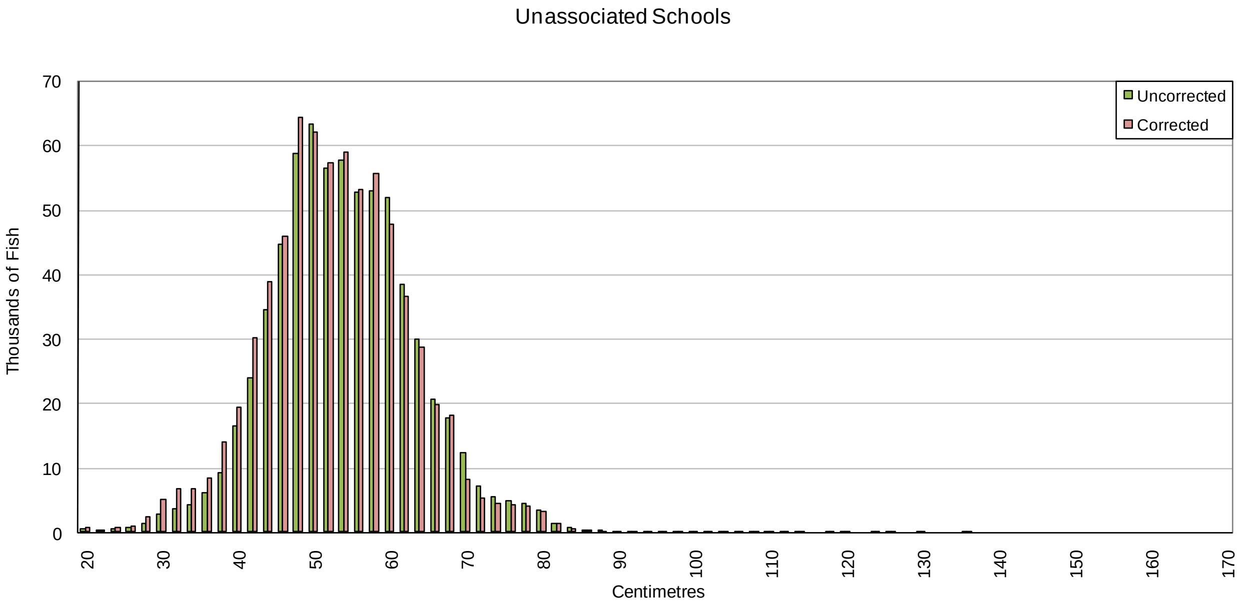
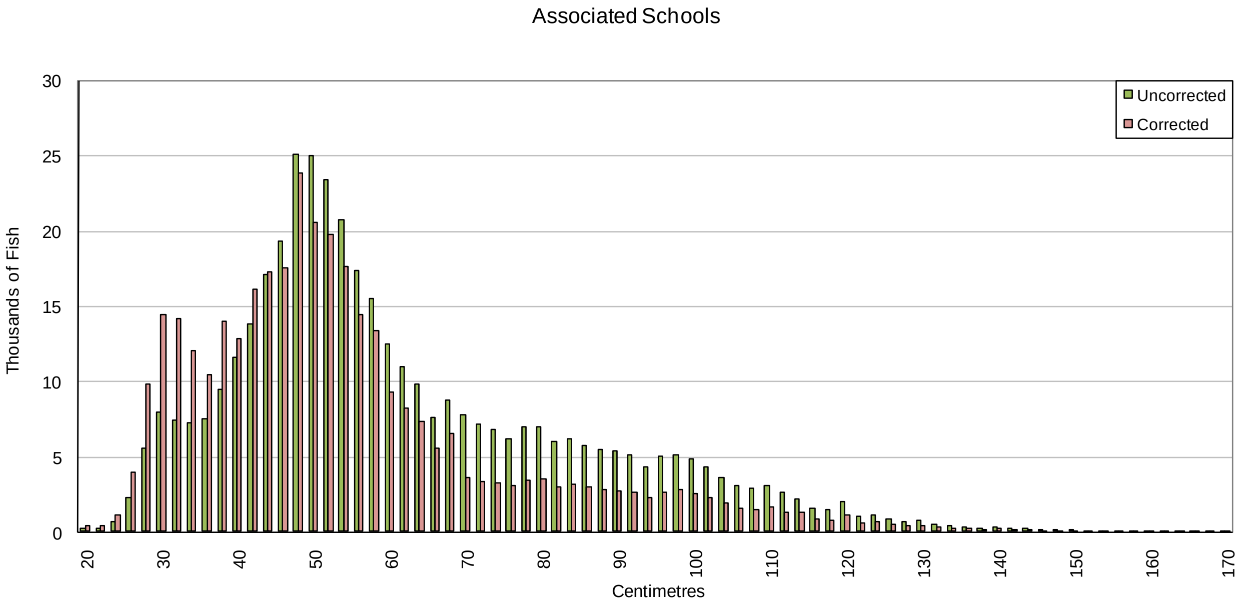


Figure 3. Uncorrected and corrected length frequencies for yellowfin



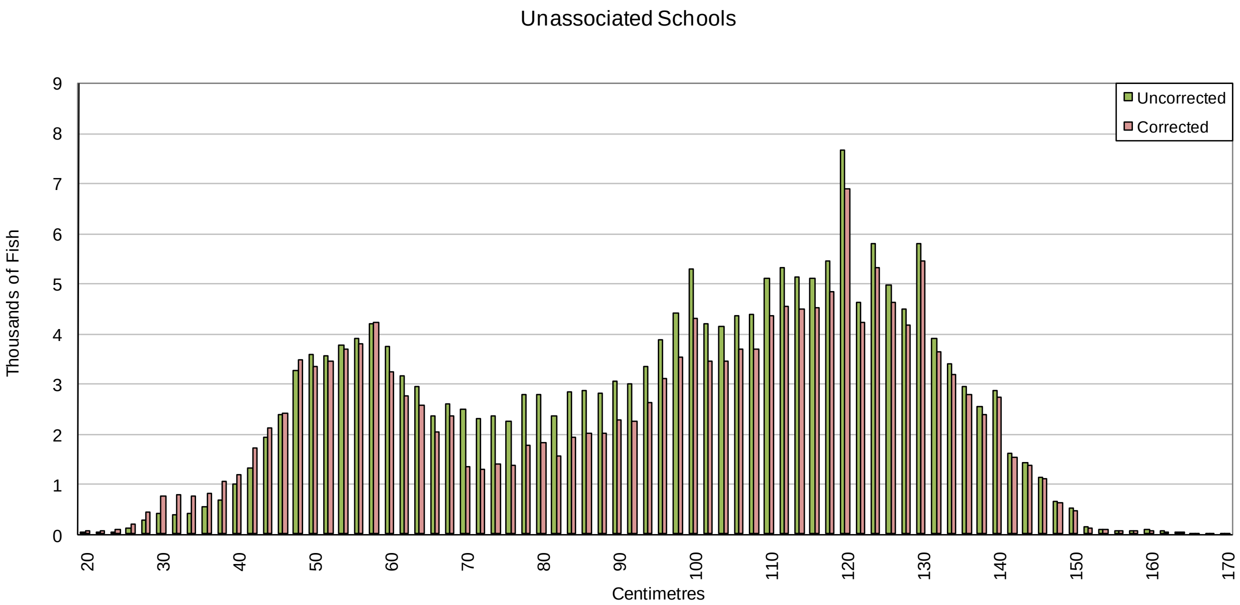
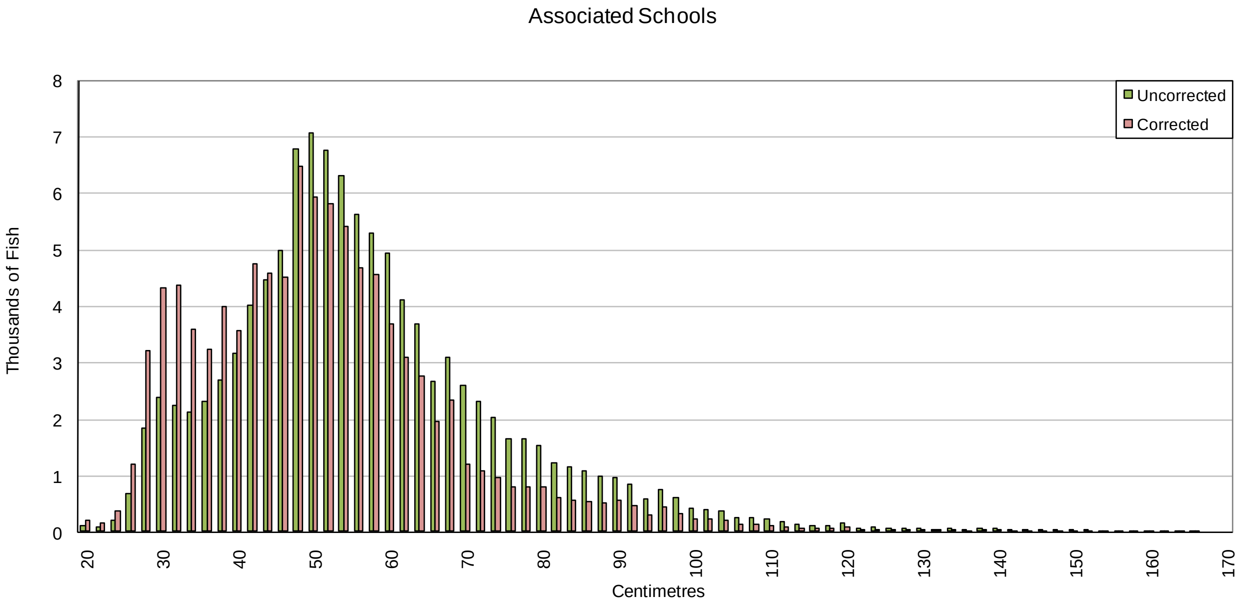
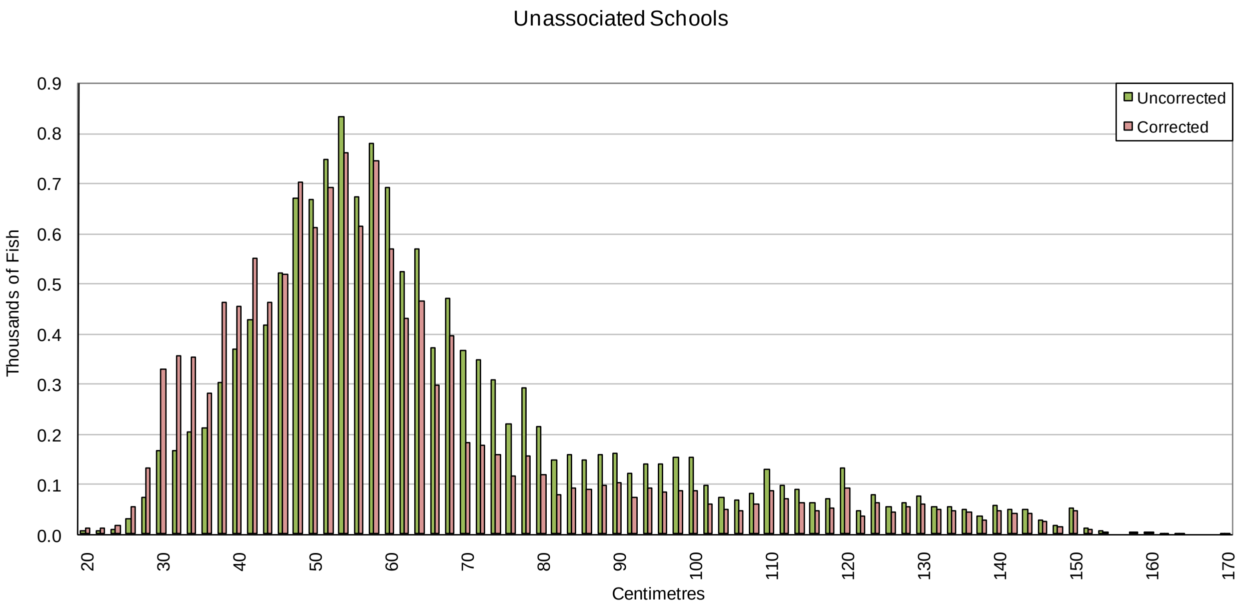


Figure 4. Uncorrected and corrected length frequencies for bigeye





The effect of the correction on the species composition (in terms of numbers of fish) is shown in Table 2. There are more skipjack in the corrected length frequency than in the uncorrected length frequency, while there are fewer yellowfin and bigeye.

Table 2. Number of fish in the length frequencies shown in Figures 2–4

Species	School Association	Numbers of Fish	
		Uncorrected	Corrected
Skipjack	Associated	1,237,406	1,307,009
	Unassociated	687,369	712,456
	Total	1,924,775	2,019,465
Yellowfin	Associated	413,904	354,814
	Unassociated	193,494	169,929
	Total	607,398	524,743
Bigeye	Associated	110,352	99,839
	Unassociated	14,847	13,325
	Total	125,199	113,164
Grand Total	Associated	1,761,662	1,761,662
	Unassociated	895,710	895,710
	Total	2,657,372	2,657,372

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