SAMPLING THE PROPORTION OF BIGEYE IN THE CATCH BY PURSE SEINERS IN THE WESTERN AND CENTRAL PACIFIC OCEAN

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INTRODUCTION

At the fourteenth meeting of the Standing Committee on Tuna and Billfish (SCTB), 9–16 August 2001, Bigelow (2001) reported differences in the sampling by port samplers and observers of the species composition of the catch taken by purse seiners in the western and central Pacific Ocean, determined from data held by the Oceanic Fisheries Programme (OFP) of the Secretariat of the Pacific Community. He found that for sets on schools associated with logs or drifting fish aggregation devices (FADs), the proportion of bigeye tuna determined from port sampling data was consistently higher than the proportion determined from observer data. The SCTB Statistics Working Group was therefore directed to examine these discrepancies by considering the accuracy of species identification and sampling protocols (Anon., 2002). This report examines these two aspects of the species composition sampling of purse-seine catches by port samplers and observers.

PORT SAMPLING DATA

Distribution of samples by year and port sampling programme

Table 1 presents the number of species composition samples taken from purse seiners by port samplers, by year and nationality of the sampling programme. In July 2002, the OFP held data for 10,592 port samples of species composition. The samples were taken from 1987 to 2002 by seven national programmes (Federated States of Micronesia, Japan, Kiribati, Marshall Islands, Papua New Guinea, Solomon Islands and the United States of America). About three-quarters of the samples (71.9 percent) were taken by the United States National Marine Fisheries Service (NMFS) in Pago Pago, American Samoa; these samples are all from United States purse seiners. The port sampling programme in the Marshall Islands, which began in 1998, accounts for 18.6 percent of the samples. The remaining 9.5 percent of the samples were taken in Papua New Guinea (3.7 percent), the Federated States of Micronesia (2.5 percent), Solomon Islands (1.4 percent), Japan (1.3 percent) and Kiribati (0.7 percent).

Percentage of samples containing yellowfin, but not bigeye, for port sampling programmes

In order to evaluate the quality of the species composition samples from the various sources, the percentage of samples containing yellowfin tuna, but not containing bigeye, were examined. Only sets on schools associated with logs or drifting FADs were considered, since these schools usually contain bigeye in association with juvenile yellowfin. The NMFS species composition samples are usually taken only when both bigeye and yellowfin are encountered while taking length samples; therefore, both length samples and species composition samples taken from the same well were examined to determine the presence of yellowfin and bigeye.

Table 2 presents the number of samples on log and drifting FAD schools that contain yellowfin, while Table 3 presents the percentage of samples that contain yellowfin, but that do not contain bigeye. Of the 2,812 wells sampled for lengths and species composition by NMFS, 14.5 percent contain yellowfin, but not bigeye. In contrast, the percentage of samples that contain yellowfin, but that do not contain bigeye, is lower for Japan, 4.1 percent (98 samples), and higher for the other programmes: 39.1 (23 samples) for the Federated States of Micronesia; 61.5 percent (13 samples) for Solomon Islands; and 75.3 percent (336 samples) for the Marshall Islands. (Sample sizes for Kiribati and Papua New Guinea are too small to obtain meaningful results.)

While a percentage of log and drifting FAD schools that contain yellowfin either do not contain bigeye or contain such small amounts of bigeye that they may not be detected by the port samplers,
the magnitude of the percentage probably depends on the area and time period fished and possibly vessel and gear attributes. Nevertheless, the percentages for the Solomon Islands and the Marshall Islands are sufficiently high as to suggest that bigeye identification in those programmes may be less reliable than for the programmes of the United States and Japan.

**Number of log schools and drifting FAD schools sampled by individual port samplers**

The quality of the species composition samples was further examined by considering the number of log and drifting FAD sets sampled by individual samplers from programmes other than NMFS and Japan, and the percentages of samples that contain yellowfin, but not bigeye. Table 4 presents the distribution of the number of samplers by the number of log and drifting FAD sets sampled. Of the 129 non-NMFS/Japan port samplers, 79 samplers (61.2 percent) have not sampled log or drifting FAD sets. Of the 50 samplers that have sampled log or drifting FAD sets, 25 samplers (50 percent) have sampled less than five sets. Only a small number of non-NMFS/Japan port samplers, 25 out of a total of 129 (19.4 percent), have had more than a small amount of experience sampling log and drifting FAD sets.

**Percentage of samples containing yellowfin, but not bigeye, for individual port samplers**

Table 5 shows that only five of the 25 non-NMFS/Japan samplers (20 percent) that have sampled five or more log or drifting FAD sets have percentages of sets that contain yellowfin, but not bigeye, that appear to be reasonable, i.e. less than 50 percent. The other 20 samplers have percentages that are much higher. Eight of these samplers (32 percent) have never recorded bigeye in species composition samples from log or drifting FAD sets.

**Subjective evaluation of port samplers**

The port samplers were subjectively evaluated by the OFP Fisheries Monitoring Supervisor, who is responsible for providing technical support for the port sampling programmes and observer programmes of SPC member countries and territories and who is thus familiar with the work of most port samplers in the region. Out of the total 129 port samplers, excluding the NMFS and Japanese samplers, only 19 (15 percent) were judged to be reliable samplers. Table 6 presents the number of reliable samplers by port sampling programme.

Five of the 19 port samplers judged to be reliable are included in the list of samplers (Table 5) that have sampled five or more log or drifting FAD sets. They correspond to the five samplers on the list with the lowest percentages of sets that contain yellowfin, but not bigeye, which indicates that the subjective evaluation is in accordance with the objective evaluation.

Training courses for port samplers in the Federated States of Micronesia, Marshall Islands and Papua New Guinea were held after the data analysed in this report were collected; hence, the reliability of the port samplers is expected to improve.

**Heterogeneity of trips with regard to school association**

The examination of species composition samples from log and drifting FAD sets may be complicated by well mixing, which occurs frequently on Korean and Taiwanese purse seiners. If extensive well mixing has taken place, then the well numbers that are recorded on the catch and effort logsheet for each set may not be appropriate and, hence, the school association assigned to each sampled well may be in error. One possible way of evaluating the extent of this problem is to examine the heterogeneity of school associations during a trip. If trips usually consist of a high percentage of sets of the same school association, then the problem may not be significant.
Information regarding the school associations during the trip was available for 3,397 out of a total of 10,455 non-Japanese port samples. (No information on the identity of the vessel was provided with the Japanese data, so the port samples could not be linked to logsheets.) The samples were screened to include only those from trips with five or more sets, which resulting in 2,234 trips. The percentage of sets during each trip was then determined for six school associations (unassociated, feeding on bait, log, drifting FAD, anchored FAD and marine mammal).

The proportion of trips for which a single school association represented 70, 80 or 90 percent or more of all sets was 74, 62 and 47 percent respectively. This suggests that well mixing is an important problem, but perhaps not as important as may have been expected, since almost half of all trips have the same school association for 90 percent or more of sets. For those trips, well mixing would not usually be expected to introduce errors in the school association attributed to a sample.

For United States vessels, the proportion of trips (n = 1,448 or 65 percent) for which a single school association represented 70, 80 or 90 percent or more of all sets was 73, 60 and 45 percent respectively. For Korean vessels, the proportion of trips (n = 376 or 17 percent) was 77, 64 and 49 percent respectively. For Taiwanese vessels, the proportion of trips (n = 266 or 12 percent) was 73, 63 and 46 percent respectively. Hence, the proportion of trips for which a single school association represented 70, 80 or 90 percent or more of all sets is consistent among the three fleets.

**NMFS species composition and samples**

The sampling protocol for NMFS species composition sampling is as follows (Coan & Yamasaki, 1990):

*Skipjack are usually unloaded separately since the price paid for this species by the canneries is different from that paid for yellowfin or bigeye. The prices paid for yellowfin and bigeye is the same, and consequently, the two species are often landed together and called yellowfin. In order to separate the reported unloading weight, when different species are being unloaded and reported together, species composition samples must be taken.*

*When taking a length-frequency sample, if more than one species is encountered, a species composition sample of 100 fish must be drawn. For example, when drawing yellowfin for a yellowfin length-frequency sample, the fifth fish drawn is a bigeye. Continue drawing 95 more fish noting the size and species. If the species cannot be determined from external characters, then the fish should be put aside and later identified by examination of the liver. If at the end of drawing 100 fish, there are 60 yellowfin, 10 black skipjack and 30 bigeye, a Length-Frequency Sampling Form is completed for the yellowfin and bigeye that were measured, and the sizes of the 10 black skipjack are noted on the Species Composition Form. If there are more bigeye still being unloaded, 20 more bigeye are drawn at random and recorded on the same Length-Frequency Sampling Form used to record the first 30 drawn. The bigeye drawn for the species composition sample are separated from those drawn to complete a fifty fish sample. If fish are unloaded by size groups and each size group contains mixed species, a 100 fish composition sample must be drawn from each size group.*

The above sampling protocol indicates that sampling for species composition is primarily directed towards bigeye and yellowfin. Table 7 presents several statistics for the NMFS species composition and length samples provided to SPC. The number of length samples with more than one species is 4,109, whereas the number of species composition samples is 2,645; hence, species composition samples have been taken for only 64 percent of length samples with more than one species. Species composition samples containing bigeye and yellowfin have been taken in 96 percent of instances.
when bigeye and yellowfin are encountered in a length sample. However, species composition samples containing skipjack have been taken in only 14 percent of instances when skipjack and bigeye are encountered in a length sample and only 10 percent of instances when skipjack and yellowfin are encountered.

There are many length samples for wells containing yellowfin, but no bigeye. Species composition samples containing yellowfin were taken in only 28 percent of these instances, confirming that the species composition samples are usually taken only when yellowfin and bigeye are encountered together in length samples.

The data provided by NMFS appear to be inconsistent insofar as there are 769 instances in which bigeye are present in the species composition sample, but not in the length sample. This may be because NMFS has not provided most of the bigeye length samples to SPC for which the sample size is small. Table 8 shows that only 3 percent of bigeye length samples have sample sizes of less than 5 fish, while 80 percent have 50 fish or more. Ignoring the small sample sizes is appropriate if the objective is to estimate the length frequency for individual sets, but the primary objective of the NMFS program is to estimate the length frequency for time-area strata.

**Number of reliable species composition samples by port sampling programme**

Table 9 presents the number of species composition samples taken by the reliable port samplers identified by the OFP Fisheries Monitoring Supervisor (see Table 6). Excluding unreliable samples, the total number of samples declines from 10,592 to 8,206 (77 percent). The number of non-NMFS/Japan samples declines from 2,839 to 453 (16 percent).

**Number of reliable species composition samples by vessel flag**

Table 10 presents the number of reliable species composition samples by vessel flag. The United States fleet accounts for 93 percent of all samples and has been covered consistently since 1988. A small number of samples are available for the Japanese fleet each year during 1995–2001. For the Korean and Taiwanese fleets, a relatively large number of samples are available for 1998 and 1999, but none or only a small number for other years. The fleets of Australia, the Federated States of Micronesia, Papua New Guinea, Solomon Islands and Vanuatu account for less than one percent of all samples. No reliable samples are available for the fleets of Kiribati, the Marshall Islands, Mexico, the Philippines, Russia and Spain.

**Number of reliable species composition samples by school association**

Table 11 presents the number of reliable species composition samples by school association. The samples primarily cover the United States fleet; hence changes in the distribution of the samples by school association closely follow changes in the fishing practices of the United States fleet. From 1988 to 1995, samples of unassociated schools are predominant, with a smaller number of samples taken from log schools. From 1996 to 2001, samples of schools associated with drifting fish aggregating devices (FADs) are predominant, especially in 1999 and 2000.

**Percentage of bigeye in yellowfin plus bigeye, in port samples, by school association**

Table 12 presents the percentage of bigeye in samples containing yellowfin plus bigeye, by school association. The percentage is low in unassociated schools and schools feeding on bait, 2.6 and 4.6 respectively. The percentage increases to 20.3 percent for log schools and increases further to 37.7 percent for schools associated with drifting FADs. The percentages for other and unknown
associations are intermediate, 11.3 and 24.4 respectively. The sample sizes for the remaining types of association are too small to obtain meaningful results.

The standard deviations for unassociated schools and schools feeding on bait are relatively small, whereas for log and drifting FAD schools, they are relatively large, which indicates that the percentage varies to a much greater degree in log and drifting FAD schools.

**Percentage of bigeye in yellowfin plus bigeye, in port samples, by school association, vessel flag and year**

The percentages of bigeye in samples containing yellowfin plus bigeye that are presented in Table 12 are dominated by samples covering the United States fleet. Variation in the percentage by vessel flag are examined in Tables 13–15 for unassociated, log and drifting FAD schools respectively.

In almost all instances, the numbers of samples for the Japanese, Korean and Taiwanese fleets are too small to draw comparisons between fleets for individual years. However, if only those percentages for all years combined that are based on 20 or more samples are considered, then the following comparisons can be made.

For unassociated schools, the percentage for all years combined is low for the United States fleet (2.5 percent), somewhat higher for the Korean and Taiwanese fleets (6.6 and 5.9) and much higher for the Japanese fleet (17.4).

For log schools, the percentage for all years combined is similar for the Japanese (21.9), Taiwanese (19.0) and United States (20.4) fleets.

For drifting FAD schools, the percentages for all years combined for the Japanese (29.8), Taiwanese (18.3) and United States (38.3) fleets are considerably different.

The sample sizes are low for the Japanese, Korean and Taiwanese fleets; however, these comparisons suggest that there may not be much variation among fleets for unassociated schools, except perhaps for the Japanese fleet, and log schools. For drifting FAD schools, however, there may be considerable differences, which may be related to the area and time period fished and possibly vessel and gear attributes.

**Percentage of bigeye in yellowfin plus bigeye, in port samples, by size of fish**

Table 16 presents the percentage of bigeye in samples containing yellowfin and/or bigeye, for small and large fish in unassociated schools (including schools feeding on bait), log schools and drifting FAD schools. The statistics in Table 16 are based on samples collected by NMFS for the United States fleet. Well tonnages corresponding to each sample were stratified by species and by size class. Small and large bigeye were defined to be fish smaller or larger than 72 cm and small and large yellowfin were defined to be fish smaller or larger than 78 cm. The average percentage of bigeye in yellowfin plus bigeye, for each size class, was determined by weighting the percentage for the species and size class in each sample by the well tonnage for the species and size class.

For unassociated schools, the percentage of bigeye in yellowfin plus bigeye for large fish is negligible (0.4), while for small fish, it is low (13.3). For log schools, the percentage is low (10.4) for large fish and moderate (25.3) for small fish. For drifting FAD schools, the percentage is moderate (30.4) for large fish and high (49.4) for small fish.
The percentage varies considerably among years, except for large fish in unassociated schools, for which the percentage is consistently low.

**OBSERVER DATA**

**Distribution of samples by year and observer programme**

Table 17 presents the number of sets sampled for species composition by observers onboard purse seiners, by year and observer programme. A total of 8,914 sets have been sampled by observers from 1993 to 2001, compared to 10,592 wells sampled by port samplers from 1987 to 2002 (Table 1). More than half of the observer samples (57.1 percent) were taken under the US Treaty observer programme. The observer programme in the Federated States of Micronesia accounts for 18.3 percent of the sets sampled. The remaining 24.6 percent of the samples were collected through the observer programmes of the Solomon Islands (7.7 percent), Papua New Guinea (7.5 percent), SPC/OFP (7.0 percent), the FSM Arrangement (2.4 percent) and Nauru (0.0 percent). The observer programmes of the US Treaty and the FSM Arrangement are managed by the Forum Fisheries Agency and utilise observers from FFA member countries.

**Percentage of samples containing yellowfin, but not bigeye, for observer programmes**

The quality of the species composition samples were examined by considering the percentage of samples from log and drifting FAD schools that contain yellowfin, but not bigeye. Table 18 presents the number of samples on log and drifting FAD schools that contain yellowfin, while Table 19 presents the percentage of samples that contain yellowfin, but not bigeye.

The SPC/OFP observers are the most experienced; hence, the percentage for the SPC/OFP observers, 32.6 (291 sets), should be considered the most reliable. In contrast, the percentage for observers of Solomon Islands is 54.5 (178 sets); for the US Treaty, 62.0 (2,863 sets); for the Federated States of Micronesia, 65.5 percent (704 sets); and for Papua New Guinea, 77.4 percent (257 sets). This suggests that the identification of bigeye by observers in the other programmes may be less reliable than for SPC/OFP observers.

**Number of log schools and drifting FAD schools sampled by individual observers**

Table 20 presents the number of log and drifting FAD sets sampled by individual observers. In contrast to the port samplers, of whom only 19 percent have sampled five or more log or drifting FAD sets, 81 percent of observers (122 out of a total of 151) have sampled five or more log or drifting FAD sets.

**Percentage of samples containing yellowfin, but not bigeye, for individual observers**

Of the 122 observers that have sampled five or more log schools or drifting FAD sets, only 45 (39 percent) have percentages of sets that contain yellowfin, but not bigeye, that appear to be reasonable, i.e. less than 50 percent. The other 77 observers (63 percent) have percentages that are higher than expected. Sixteen (13 percent) have never recorded bigeye in species composition samples from log or drifting FAD sets.

It would therefore appear that, in general, observers have had considerably more experience sampling log sets and drifting FAD sets than non-NMFS/Japan port samplers, and hence the quality of the species composition sampling by observers is somewhat better than the quality of the species
composition sampling by non-NMFS/Japan port samplers, although the quality of sampling varies considerably among observers.

**Subjective evaluation of observers**

The ability of observers to identify bigeye was subjectively evaluated by the OFP Fisheries Monitoring Supervisor, the FFA Observer Programme Manager and the Tuna Biologist at the National Oceanic Resource Management Authority of the Federated States of Micronesia. Table 21 presents the number of reliable observers and sets sampled, by country of residence of the observer. (Many observers have worked for both the US Treaty observer programme and their national programme; hence the statistics are not presented by observer programme.) The statistics are preliminary since information concerning the reliability of several observers is not yet available; observers whose reliability is unknown were considered to be ‘unreliable’ for the present analysis. There are a total of 151 observers, of which 83 (55 percent) were judged to be reliable. The total number of sets sampled is 8,914, of which 6,264 (70 percent) were judged to be reliably sampled for bigeye.

There are 121 observers that have sampled five or more log or drifting FAD sets; among them are 74 of the observers that were judged to be reliable. However, in contrast to port samplers, the observers that were judged to be reliable have percentages of sets that contain yellowfin, but not bigeye, that are evenly spread from zero to 100. Ten had percentages from 0 to 25; 21 from 25 to 50; 20 from 50 to 75; and 23 from 75 to 100.

The fact that (a) six of the observers that were judged to be reliable have not recorded any bigeye for log or drifting FAD sets, even though the number of sets that they sampled averages 23 and ranges from 10 to 46, and (b) ten of the observers that had percentages of less than 30 percent, but were not judged to be reliable, suggests that the subjective evaluation of observers may not be as accurate as the subjective evaluation of port samplers. If the subjective evaluation is incorrect and data from observers with low percentages but that were not judged to be reliable are excluded from analysis (and data from observers with high percentages but that were judged to be reliable are included), then the observer data remaining for analysis will under-estimate the catch of bigeye.

**Number of reliable species composition samples by vessel flag**

Table 22 presents the number of reliable species composition samples by vessel flag, according to the subjective evaluation of observers. The United States fleet accounts for 64 percent of all samples and has been covered consistently since 1994. The Taiwanese and Korean fleets account for 15 and 7 percent respectively; sampling for these fleets has been consistent over time, although the number of sets sampled in some years is small. The Japanese and Papua New Guinea fleets account for 4 and 3 percent, respectively, of sets sampled; sampling has been consistent over time, but the number of sets sampled each year has been small. Sampling of the fleets of the Federated States of Micronesia, Kiribati, the Philippines, Solomon Islands and Vanuatu has been sporadic. No sets have been sampled for the fleets of Australia, the Marshall Islands, Mexico, Russia and Spain.

**Number of reliable species composition samples by school association**

Table 23 presents the number of reliable species composition samples by school association (assuming that the subjective evaluation is correct and excluding samples from observers that were not judged to be reliable). As for the port samples, the observer samples primarily cover the United States fleet; hence changes in the distribution of the samples by school association closely follow changes in the fishing practices of the United States fleet. For 1994 and 1995, samples of
unassociated schools (including schools feeding on bait) are predominant, with a smaller number of samples taken from log schools. From 1996 to 1998, samples of schools associated with drifting fish aggregating devices (FADs) become increasingly important. From 1999 to 2001, samples of schools associated with drifting FADs represent 69 percent of all samples, whereas samples of unassociated schools and log schools represent 21 and 2 percent respectively.

**Percentage of bigeye in observer samples containing yellowfin plus bigeye, by school association**

Table 24 presents the percentage of bigeye in yellowfin plus bigeye, by school association, determined from data collected by observers that were subjectively evaluated as reliable. The percentage is low in unassociated schools and schools feeding on bait, 2.6 and 1.4 respectively (compared to 2.6 and 4.6 percent, respectively, for port samples). The percentage increases to 13.7 percent for log schools (compared to 20.3 percent for port samples) and increases further to 19.1 percent for schools associated with drifting FADs (compared to 37.7 percent for port samples). The percentage for anchored FADs, 18.0, is similar to the percentage for drifting FADs. The percentages for other and unknown associations are intermediate, 15.3 and 13.0 respectively (compared to 11.3 and 24.4 for port samples).

As for port samples, the standard deviations for unassociated schools and schools feeding on bait are relatively small, whereas for log, drifting FAD and anchored FAD schools, they are relatively large, which indicates that the percentage varies to a much greater degree in log, drifting FAD and anchored FAD schools.

The percentages of bigeye in yellowfin plus bigeye determined from data collected by observers that were subjectively evaluated to be reliable are considerably less than the percentages determined from data collected by port samplers for log schools and drifting FAD schools. However, it was suggested above that the subjective evaluation of observers may not be as accurate as the subjective evaluation of port samplers and that the result of excluding data collected by observers that were not judged to be reliable will be to under-estimate the amount of bigeye caught. The analysis was therefore repeated on the basis of an objective evaluation of observers. In this analysis, only data from observers who have sampled at least five log or drifting FAD sets and for whom the percentage of log or drifting FAD sets containing yellowfin, but not bigeye, was less than or equal to 50 were considered.

Table 25 presents the number of objectively-evaluated reliable observers and sets sampled, by country of residence of the observer. The number of objectively-evaluated reliable observers is considerably less than for the subjective evaluation, 47 (31 percent) compared to 83 (55 percent). There are 29 observers that have not sampled five or more log or drifting FAD samples, including one SPC observer, and so could not be evaluated. The number of sets that were reliably sampled, based on the objective evaluation, is 3,222 (36 percent), compared to 6,262 (70 percent) for the subjective evaluation.

Table 26 presents the percentage of bigeye in yellowfin plus bigeye, by school association, determined from data collected by observers that were objectively evaluated as reliable. Since data collected by observers that recorded bigeye in less than 50 percent of log or drifting FAD sets were excluded from the analysis, it is expected that the estimate of the percentage of bigeye in yellowfin plus bigeye in log or drifting FAD sets will be greater than for the subjective evaluation of reliability. The percentage for log schools for the objective evaluation is 30.1, compared to 13.7 for the subjective evaluation. For drifting FAD schools for the objective evaluation, it is 29.8, compared to 19.1 for the subjective evaluation.
The percentages for the objective evaluation are greater than for the subjective evaluation, as expected, although the difference between the percentages for log and drifting FAD schools is minor for the objective evaluation, whereas for the subjective evaluation (and for port samples), it is considerable. Compared to the percentages determined from port samples, the percentage of bigeye in yellowfin plus bigeye for log sets, determined from objectively-evaluated observers, is greater, 30.1 compared to 20.3, while for drifting FAD sets, it is less, 29.8 compared to 37.7.

**SAMPLING PROTOCOLS AND SAMPLE SIZES**

The NMFS port sampling protocol for species composition is to sample 100 fish if more than one species is encountered during a length sample. In practise, however, skipjack are usually ignored and only bigeye and yellowfin are included in the 100 fish sample (see *NMFS species composition and samples* above).

The protocol for non-NMFS port sampling programmes is to randomly select approximately five fish from every net that is unloaded from the well, regardless of the species. The protocol for observer programmes is to randomly select approximately five fish from every brail from the set, regardless of the species.

Figures 1 and 2 show the distributions of the number of bigeye plus yellowfin sampled in port samples and observer samples respectively. The distributions are noticeably different. Most (70 percent) of the NMFS port samples contain between 91 and 110 yellowfin plus bigeye, with only 11 percent of samples containing 50 yellowfin plus bigeye or less. In contrast, the size of the non-NMFS port samples is more evenly spread out, with a peak at 41–50 yellowfin plus bigeye and with 54 percent of samples containing 50 yellowfin plus bigeye or less.

The distribution for the observer samples is different from either of the distributions for port samples. The observer samples peak at 1–10 yellowfin plus bigeye (56 percent) and then decline continuously; 93 percent of the observer samples contain 50 yellowfin plus bigeye or less. The distribution for observer samples is the same as the distribution of the amount of yellowfin and bigeye caught per set and reported on logsheets.

**DISCUSSION**

Table 27 compares estimates of the percentage of bigeye in yellowfin plus bigeye determined from port sampling data and observer data. The differences between the percentages determined from the port samplers and the subjectively and objectively evaluated observers are considerable, particularly for log and drifting FAD sets. The differences may be due, in part, to the areas and time periods covered by the samples or to vessel and gear attributes. However, before the relationship between the percentage of bigeye in yellowfin plus bigeye and area, time period or vessel and gear attributes can be examined, the port sampling and observer data must be further evaluated for their reliability, using both objective and subjective criteria. This is now a high priority of the Statistics and Monitoring Section of the OFP, which will evaluate the data in collaboration with the port sampler and observer supervisors in the region.

The sampling protocols for the NMFS port samples, the non-NMFS port samples and the observer samples are different, such that the size of the observer samples is proportional to the amount of catch from the set, whereas the size of the NMFS port samples is constant. The size of the non-NMFS port samples is proportional to the amount of fish in the well, which may or may not be
proportional to the amount of catch from the set (or sets). However, if the sampling is truly random, then each of the protocols will result in unbiased samples. At present, there is no indication that the samples are not taken randomly, although this should be examined closely by the port sampler and observer supervisors.

REFERENCES


Figure 1. Distribution of number of bigeye and yellowfin sampled in port samples

Figure 2. Distribution of number of bigeye and yellowfin sampled in observer samples
Table 1. Number of species composition samples taken from purse seiners by port samplers, by year and sampling programme. Key: FM = Federated States of Micronesia; KI = Kiribati; MH = Marshall Islands; PG = Papua New Guinea; SB = Solomon Islands; US = United States.

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Table 2. Number of port samples of species composition from sets on logs and drifting FADs that contain yellowfin. Key: FM = Federated States of Micronesia; KI = Kiribati; MH = Marshall Islands; PG = Papua New Guinea; SB = Solomon Islands; US = United States.

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Table 3. Percentage of port samples of species composition from sets on logs and drifting FADs that contain yellowfin, but that do not contain bigeye. Key: FM = Federated States of Micronesia; KI = Kiribati; MH = Marshall Islands; PG = Papua New Guinea; SB = Solomon Islands; US = United States.

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Table 4. Distribution of the number of non-NMFS samplers by the number of log and drifting FAD sets sampled

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<th>%</th>
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### Table 5. Percentage of log or drifting FAD sets with yellowfin, but no bigeye, by individual non-NMFS/Japan port samplers that have sampled at least five log or drifting FAD sets

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<th>SAMPLER</th>
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<td>22.2</td>
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<tr>
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<td>50.0</td>
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<td>MH</td>
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<td>10</td>
<td>62.5</td>
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<tr>
<td>H</td>
<td>MH</td>
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<td>64.3</td>
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<td>MH</td>
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<td>75.0</td>
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Table 6. Number of reliable port samplers and species composition samples, excluding the NMFS and Japanese port sampling programmes

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<th>RELIABLE SAMPLERS</th>
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<td>SAMPLES</td>
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<tr>
<td>Marshall Islands</td>
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<tr>
<td>Papua New Guinea</td>
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<td>259</td>
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<tr>
<td>Solomon Islands</td>
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<td>143</td>
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<tr>
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Table 7. Statistics for NMFS species composition and port samples provided to SPC

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<td>Number of length samples</td>
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<tr>
<td>Species composition samples</td>
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<tr>
<td>Length samples with BET and SKJ</td>
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<tr>
<td>Above and species composition samples with SKJ</td>
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</tr>
<tr>
<td>Length samples with BET and YFT</td>
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</tr>
<tr>
<td>Above and species composition samples with BET</td>
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<tr>
<td>Above and species composition samples with YFT</td>
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<tr>
<td>Length samples with SKJ and YFT</td>
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<td>Above and species composition samples with SKJ</td>
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<td>Above and species composition samples with YFT</td>
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<td>Length samples with BET and no YFT</td>
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<td>Above and species composition samples with BET</td>
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<td>Length samples with YFT and no BET</td>
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<td>Above and species composition samples with YFT</td>
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<td>BET in spec comp sample, but not in length sample</td>
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<tr>
<td>SKJ in spec comp sample, but not in length sample</td>
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<tr>
<td>YFT in spec comp sample, but not in length sample</td>
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Table 8. Distribution of the number of wells sampled by the size of NMFS bigeye length samples

<table>
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<tr>
<td>5 TO 9</td>
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Table 9. Number of reliable species composition samples taken from purse seiners by port samplers, by year and sampling programme. Key: FM = Federated States of Micronesia; KI = Kiribati; MH = Marshall Islands; PG = Papua New Guinea; SB = Solomon Islands; US = United States.

<table>
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Key: AU = Australia; FM = Federated States of Micronesia; JP = Japan; KR = Korea; PG = Papua New Guinea; SB = Solomon Islands; TW = Taiwan; US = United States; VU = Vanuatu. No reliable samples are available for the fleets of Kiribati, the Marshall Islands, Mexico, the Philippines, Russia and Spain.

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Table 13. Percentage of bigeye in yellowfin plus bigeye in samples of unassociated schools

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Table 15. Percentage of bigeye in yellowfin plus bigeye in samples of drifting FAD schools

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Table 16. Number of samples and percentage of bigeye in yellowfin plus bigeye, by size of fish, in unassociated, log and drifting FAD schools, determined from NMFS samples for United States purse seiners

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<th>UNASSOCIATED LARGE</th>
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<th>LOG LARGE</th>
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<td>%</td>
<td>N</td>
<td>%</td>
<td>N</td>
<td>%</td>
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<td>0.00</td>
<td>0</td>
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<td>135</td>
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Table 17. Number of species composition samples taken from purse seiners by observers, by year and sampling programme. Key: FAOB = FSM Arrangement; FMOB = Federated States of Micronesia; NROB = Nauru; PGOB = Papua New Guinea; SBOB = Solomon Islands; SPOB = SPC; TTOB = US Treaty.

<table>
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<th>NROB</th>
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Table 18. Number of observer samples of species composition from sets on logs and drifting FADs that contain yellowfin. Key: FAOB = FSM Arrangement; FMOB = Federated States of Micronesia; NROB = Nauru; PGOB = Papua New Guinea; SBOB = Solomon Islands; SPOB = SPC; TTOB = US Treaty.

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Table 19. Percentage of observer samples of species composition from sets on logs and drifting FADs that contain yellowfin, but that do not contain bigeye. Key: FAOB = FSM Arrangement; FMOB = Federated States of Micronesia; NROB = Nauru; PGOB = Papua New Guinea; SBOB = Solomon Islands; SPOB = SPC; TTOB = US Treaty.

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Table 20. Distribution of the number of observers by the number of log and drifting FAD sets sampled

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<tr>
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Table 21. Number of reliable observers, based on a subjective evaluation, and species composition samples, by country

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<td>998</td>
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<tr>
<td>Secretariat of the Pacific Community</td>
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<td>551</td>
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</tr>
<tr>
<td>Tuvalu</td>
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<td>499</td>
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<tr>
<td>United States of America</td>
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<td>209</td>
</tr>
<tr>
<td>Vanuatu</td>
<td>2</td>
<td>188</td>
</tr>
<tr>
<td>Total</td>
<td>151</td>
<td>8,914</td>
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</table>
### Table 22. Number of reliable species composition samples taken from purse seiners, by year and fishing nation, according to a subjective evaluation of observers.

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<th>KR</th>
<th>PG</th>
<th>PH</th>
<th>SB</th>
<th>TW</th>
<th>US</th>
<th>VU</th>
<th>TOTAL</th>
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<td>38</td>
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<td>10</td>
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### Table 23. Number of reliable species composition samples taken from purse seiners, by year and school association, according to a subjective evaluation of observers.

<table>
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<th>YEAR</th>
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<th>UNASS</th>
<th>FEEDING</th>
<th>LOG</th>
<th>DRIFTING</th>
<th>ANCHORED</th>
<th>LIVE</th>
<th>WHALE</th>
<th>WHALE</th>
<th>SHARK</th>
<th>OTHER</th>
<th>TOTAL</th>
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<td>-</td>
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<td>-</td>
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<td>-</td>
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<td>-</td>
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<td>-</td>
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<td>171</td>
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<td>2</td>
<td>4</td>
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<td>3</td>
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<td>147</td>
<td>231</td>
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<td>2</td>
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<td>2</td>
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% 3.4 11.4 17.8 17.1 44.7 3.2 1.6 0.3 0.3 100.0
Table 24. Mean and standard deviation of the percentage of bigeye in bigeye plus yellowfin in samples taken by subjectively-evaluated reliable observers, by school association

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<tr>
<th>SCHOOL ASSOCIATION</th>
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<th>STANDARD DEVIATION</th>
</tr>
</thead>
<tbody>
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<td>8.7</td>
</tr>
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<td>13.7</td>
<td>23.6</td>
</tr>
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<td>27.2</td>
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<td>20.5</td>
</tr>
<tr>
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<td>84</td>
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<td>16.6</td>
</tr>
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<td>LIVE WHALE SHARK</td>
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<td>12.1</td>
<td>23.9</td>
</tr>
<tr>
<td>OTHER</td>
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Table 25. Number of objectively-evaluated reliable observers, by country

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<th>RELIABLE OBSERVERS</th>
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</thead>
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<td>Niue</td>
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<tr>
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</tr>
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<td>Tokelau</td>
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<tr>
<td>Tonga</td>
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<tr>
<td>Tuvalu</td>
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<td>499</td>
</tr>
<tr>
<td>United States of America</td>
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<td>209</td>
</tr>
<tr>
<td>Vanuatu</td>
<td>2</td>
<td>188</td>
</tr>
<tr>
<td>Total</td>
<td>151</td>
<td>8,914</td>
</tr>
</tbody>
</table>
Table 26. Mean and standard deviation of the percentage of bigeye in yellowfin plus bigeye in samples taken by objectively-evaluated reliable observers, by school association

<table>
<thead>
<tr>
<th>SCHOOL ASSOCIATION</th>
<th>N</th>
<th>MEAN</th>
<th>STANDARD DEVIATION</th>
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</thead>
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<tr>
<td>UNASSOCIATED</td>
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<td>13.5</td>
</tr>
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<td>32.9</td>
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<td>24.0</td>
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<td>27.7</td>
</tr>
<tr>
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Table 27. Percentage of bigeye in yellowfin plus bigeye, by school association, for port sampling data and subjectively and objectively evaluated observer data

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<th>OBSERVER DATA</th>
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