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COMPARISON OF THE SPECIES COMPOSITION OF CATCHES BY PURSE SEINERS IN THE WESTERN AND CENTRAL PACIFIC OCEAN DETERMINED FROM OBSERVER AND OTHER TYPES OF DATA

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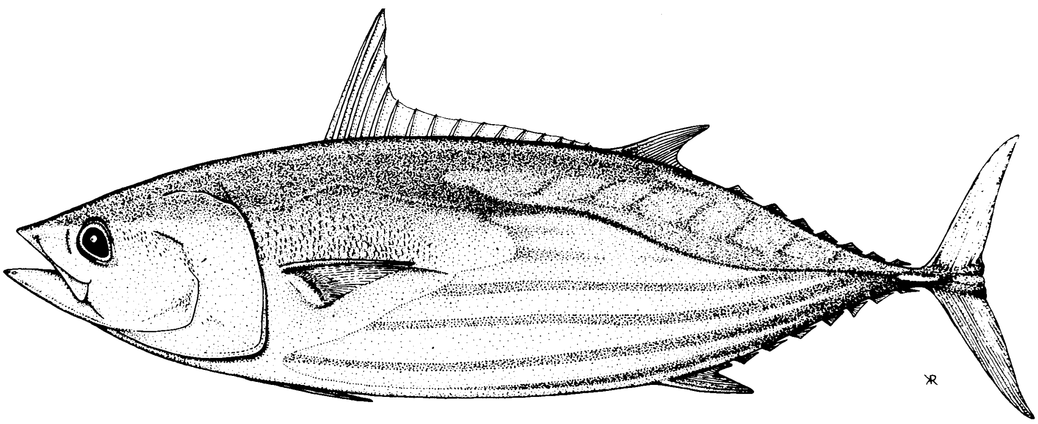

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INTRODUCTION

Purse seiners operating in the Western and Central Pacific Ocean (WCPO) target skipjack tuna (*Katsuwonus pelamis*), yellowfin tuna (*Thunnus albacares*) and bigeye tuna (*Thunnus obesus*). According to catch estimates compiled by the SPC Oceanic Fisheries Programme (OFP) and published in the SPC Tuna Fishery Yearbook, the species composition of purse-seine catches in the WCPO during 1970–2003 was 75.8% skipjack, 22.3% yellowfin and 2.0% bigeye (Lawson 2004).

Purse-seine catches were less than 100,000 tonnes until 1979, then increased throughout the 1980s and 1990s; during 2002 and 2003, the catch was 1.2 million tonnes (Figure 1). According to the SPC Tuna Fishery Yearbook, skipjack accounted for 60.7% of the catch during the 1970s. The proportion of skipjack increased to 73.4% and 75.6% during the 1980s and 1990s respectively, and was 80.2% during 2000–2003 (Figure 2).

The catch estimates compiled by the OFP are usually determined from operational catch and effort data recorded on logsheets and from receipts for unloadings to canneries or transshipments to reefer vessels. However, catches of bigeye are usually recorded on logsheets and unloadings receipts as yellowfin, since juvenile bigeye and yellowfin are difficult to distinguish and prices paid by canneries for small bigeye and yellowfin are usually the same. Therefore, port sampling data and observer data have been used to obtain more accurate estimates of catches of bigeye and yellowfin. Statistical analyses of the relationship between the proportion of bigeye in the combined catches of yellowfin and bigeye (‘yellowfin plus bigeye’) and variables such as school association, time period, geographic area and vessel nationality have been conducted by Bigelow (2001), Crone & Coan (2002) and Lawson (2003, 2005).

While the mis-identification of bigeye as yellowfin in purse-seine data has long been recognised, it has been widely assumed that the amounts of skipjack and ‘yellowfin plus bigeye’ recorded on logsheets and unloading receipts are unbiased. This assumption, however, has not been examined using observer data. This paper presents estimates of the purse-seine species composition determined from observer data and compares the estimates to those determined from other types of data.

SOURCE OF OBSERVER DATA

At the time of writing, the OFP held species composition data for 8,587 purse-seine sets in the WCPO sampled from 1993 to 2004 by observers from SPC and the national observer programmes of SPC member countries and territories. For the purposes of the present analysis, the data were screened in the following order:

- There were 2,044 samples for which the school association was unknown. Since including a school association category of ‘unknown’ in the multivariate analysis would almost certainly decrease the information content of the data, in regard to school association, these samples were not used.
- There were 475 samples from ‘skunk sets’, which were defined as those for which the catch was less than or equal to 2.5 tonnes. Since these samples may not have been representative of the entire school, they were not used.
- There were 94 sets for which the total number of skipjack, yellowfin and bigeye sampled was less than 10; these small samples were not used since they may not be representative of the species composition of the set.

- There were 1,546 samples that were not used because the species composition data were evaluated to be of poor quality.

After screening, there were 4,428 samples covering 1995–2003. The number of the remaining samples, by year and school association, by year and quarter, by year and MULTIFAN-CL skipjack areas ‘5’ and ‘6’ (Figure 3), and by year and flag, are presented in Tables 1–4 respectively.

SPECIES COMPOSITION OF PURSE-SEINE CATCHES

Proportion of skipjack in purse-seine catches determined from observer data

Tables 5–8 present the proportion of skipjack in purse-seine catches, by year and school association, by year and quarter, by year and area, and by year and flag respectively. The proportions refer to the weight of fish in the sample. Sampled lengths of fish have been converted to kilograms using the weight-length parameters in the footnote[1]. For each stratum in Tables 5–8, the proportion of skipjack in the catch is the average of the proportions determined for each sample, weighted by the total catch per set.

The proportion of skipjack in purse-seine catches determined from all samples for 1995–2003 is 55.4%. The average annual proportion is somewhat lower, 52.8%, because of the low value for 1995, 30.4%, which is based on only 71 samples.

For school fish (i.e., unassociated schools or schools feeding on baitfish), the proportion of skipjack for 1995–2003 was 66.3%, while for schools associated with logs and drifting FADs, the proportion of skipjack was lower, 46.4% and 46.0% respectively.

The proportion of skipjack was somewhat variable among quarters: 54.5%, 59.3%, 50.3% and 48.5% for the first, second, third and fourth quarters respectively.

The proportion of skipjack was almost the same for MULTIFAN-CL areas ‘5’ and ‘6’, 53.3% and 55.5% respectively.

The proportion of skipjack was variable among fishing nations, ranging from 41.8% for Papua New Guinea to 62.8% for the Republic of Korea.

Comparison of the species composition determined from operational catch data held by the OFP to the species composition determined from observer data

Table 9 compares the proportion of skipjack in the catch by purse seiners, as determined from observer data and logsheet data. The observer data and logsheet data were grouped into strata of school association, year, quarter, area and flag, and the average percentage of skipjack in the catch was determined for each stratum and type of data. The average percentage of skipjack for each stratum and type of data was calculated by weighting the percentage for each set by the total catch per set. Only strata for which at least ten sets were both observed and recorded on logsheets were included in the analysis; hence, the strata for both types of data were equally distributed among each of the variables.

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[1]
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Length-weight parameters for skipjack: 1.30330E-5,  3.044000
Length-weight parameters for yelowfin: 1.90800E-5,  2.977619
Length-weight parameters for bigeye:   2.34684E-5,  2.975750
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It can been seen from Table 9 that the average proportion of skipjack determined from logsheet data is 78.3%, while for observer data, the average proportion is 53.5%. The proportion determined from logsheet data is consistently higher than the proportion determined from observer data, although the magnitude of the discrepancy ranges widely among values of the variables. The smallest discrepancy, 7.8%, is for unassociated schools, while the largest (excluding the comparison for 1995, for which there is only one stratum) is 39.2% for schools associated with logs.

Comparison of the species composition determined from unloadings data held by the OFP to the species composition determined from observer data

Table 10 compares the proportion of skipjack in the catch by purse seiners, as determined from observer data and unloadings data. The observer data and unloadings data were grouped into strata of year and flag, and the average percentage of skipjack in the catch was determined for each stratum and type of data. The average percentage of skipjack for each stratum and type of data was calculated by weighting the percentage for each set by the total catch per set and for each trip unloaded by the total amount unloaded per trip. Only strata for which there were at least ten sets observed and one trip unloaded were included in the analysis; hence, the strata for both types of data were equally distributed among each of the variables.

It can been seen from Table 10 that the average proportion of skipjack determined from unloadings data is 76.9%, while for observer data, the average proportion is 56.5%. For some values of year and flag, data are available for only one or two strata, and the estimated proportions of skipjack for these values may be unreliable. For values with more than two strata, the average difference in the proportion of skipjack determined from observer data and unloadings data is 20.5%.

Comparison of the species composition determined from port sampling data held by the OFP to the species composition determined from observer data

According to the observer data, the proportion of skipjack in the purse-seine catch in the WCPO during 1995–2003 has been about 55%, while according to logsheet data and unloadings data, the proportion has been 75%–80%. It is possible that the proportion of skipjack reported in unloadings data and logsheet data is biased, perhaps because small skipjack, yellowfin and bigeye may not be distinguished on the basis of price by the fishing companies and canneries. Port sampling data, which, like observer data, are collected by samplers trained in species identification under a standard random-sampling protocol, should not be subject to such a bias.

Table 11 compares the proportion of skipjack in the catch by purse seiners, as determined from observer data and port sampling data. The observer data and port sampling data were grouped into strata of school association, year and flag, and the average percentage of skipjack in the catch was determined for each stratum and type of data. The average percentage of skipjack for each stratum and type of data was calculated by weighting the percentage for each set by the total catch per set and for each port sample by the total catch per set. Only strata for which there were at least three sets observed and three wells sampled in port were included in the analysis; hence, the strata for both types of data were equally distributed among each of the variables.

It can been seen from Table 11 that the average proportion of skipjack determined from port sampling data is 72.5%, while for observer data, the average proportion is 57.3%. For associated sets, the proportions are 64.4% and 47.8% for port sampling data and observer data respectively. For unassociated sets, the proportions are 83.9% and 70.7% for port sampling data and observer data respectively.

Comparison of the distribution of size of fish determined from port sampling data and observer data

The proportion of skipjack in the purse-seine catch estimated from port sampling data (72.5%) is greater than the proportion estimated from observer data (57.3%). To examine this discrepancy in greater detail, length frequencies for the two types of data were compared. Figures 4 and 5 show the length frequencies for associated schools deterrmined from observer data and port sampling data respectively, while Figures 6 and 7 show the length frequencies for unassociated schools deterrmined from observer data and port sampling data respectively. The strata and samples that were used to determine the length frequencies in Figures 4–7 are the same as those that were used to compare the observer data to the port sampling data in Table 11. Hence, the sum of the percentage of skipjack over all length increments in each figure is equivalent to the appropriate value in Table 11 (e.g., in Figure 4, which shows the length frequency for associated schools determined from observer data, the sum of the percentage of skipjack over all length increments is 47.8%).

Figures 4 and 5 show that for associated schools, the ranges of lengths for each species and the general shapes of the length frequencies determined from observer data and port sampling data are similar. Figures 6 and 7 show the same for unassociated schools. For each school type, the main differences are the relative proportions of skipjack, yellowfin and bigeye, with less skipjack and more yellowfin and bigeye in the length frequencies determined from observer data.

Table 12 presents the proportions in observed and port sampled catches of each species, by size class, for associated and unassociated schools. According to the observer data, 25.8% of fish in associated schools and 27.3% of fish in unassociated schools are greater than 80 cm, while according to the port sampling data, the proportions are less, 18.5% and 14.2% respectively. Both types are data are consistent in that fish greater than 80 cm are almost entirely yellowfin or bigeye, with only a neglible amount of skipjack. The overall difference in the proportion of skipjack in the purse-seine catch is therefore due primarily to larger amounts of large yellowfin and, to a lesser extent, large bigeye, in the observer data, compared to the port sampling data.

Comparison of the species composition determined from Final Out-Turn reports to the species composition determined from observer data, for the United States fleet

A final source of data that can be used to estimate the species composition of the purse-seine catch for the United States fleet are the Final Out-Turn (FOT) reports that each vessel must provide under the terms of the US treaty and which record the amounts unloaded by the vessel and received by the canneries.

The discrepancy between the species compositions determined from port sampling data and observer data (discussed above) is primarily due to a greater amount of large yellowfin and bigeye (> 80 cm) in the observer data. The FOT statistics for skipjack, yellowfin and bigeye are broken down into five size classes: 0–3 lbs, 3–4 lbs, 4–7.5 lbs, 7.5–20 lbs and 20–60 lbs. An 80 cm yellowfin and a 75 cm bigeye each weigh about 20 lbs. Table 13 therefore compares three categories of species composition and size: (a) skipjack, (b) yellowfin and bigeye < 20 lbs and (c) yellowfin and bigeye ≥ 20 lbs. The proportions of these three species/size categories determined from the FOT reports — i.e., 74.2%, 10.0% and 15.9% respectively — are similar to those for all fleets determined from the port sampling data (Table 12) — i.e., 72.5%, 11.3% and 16.2%. The proportions determined from the observer data for all fleets (Table 12) — i.e., 57.3%, 16.6% and 26.0% — are different from both the port sampling data and the FOT reports.

Species composition for purse-seine fleets in other ocean areas

Table 14 presents the species composition for purse-seine catches in the Eastern Pacific Ocean, the Atlantic Ocean and the Indian Ocean during 1995–2003; the proportions of skipjack were 33.3%, 43.1% and 52.1% respectively. The proportion of skipjack in the WCPO based on observer data, 55%, is similar to the species composition for the Indian Ocean, but larger than for the Eastern Pacific and the Atlantic. The proportion of skipjack in the WCPO determined from logsheeet data, unloadings data and port sampling data, 70%–80%, is much larger than for the other ocean areas.

Simulation of bias in observer samples

At present, it cannot be determined whether the discrepancy between the species compositions based on observer data and other sources of data are the results of bias in the observer data or in the other sources of data. However, it would still be of interest to determine the level of bias in observer sampling that would be required to explain the discrepancy. In this regard, observer sampling of a set on an associated school and a set on an unassociated school were simulated.

For both the associated set and the unassociated set, the catch per set was 30 tonnes, the average level. The distribution of the catch per set by species and length interval determined from port sampling data (Figures 5 and 7) were applied. The numbers of fish in the set were 10,856 and 10,951 for the associated and unassociated sets respectively. Samples of 60 fish were drawn, which represents the average sample size for 30 tonne sets. For random sampling, the probability of selecting a fish is $\frac{1}{N}$, where N is the number of fish in the set. In the simulations, the probability of selecting a large (> 80 cm) yellowfin or bigeye was varied from $\frac{1}{N}$ to $\frac{4}{N}$, while the probability of sampling all other fish was normalised, such that the sum of the probabilities for all fish in the set was equal to 1.0. The maximum probability of sampling large yellowfin and bigeye, i.e. $\frac{4}{N}$, is equal to four times the random probability. For each level of probability, sampling of 1000 sets was simulated and the average percentage of the weight of skipjack in each sample was calculated.

Figure 8 presents the results of the simulations. For the associated set, the estimate of the proportion of skipjack in the catch declined from 65% for random sampling to 41% for the maximum bias. The proportion of skipjack that has been determined from actual observer data for associated sets, i.e. 48%, corresponds to a bias of 3.0 times the random probability. For the unassociated set, the estimate of the proportion of skipjack in the catch declined from 85% for random sampling to 62% for the maximum bias. The proportion of skipjack that has been determined from actual observer data for unassicated sets, i.e. 71%, corresponds to a bias of 2.6 times the random probability.

For the associated set, the average number of large yellowfin and bigeye in the 1000 simulated samples is 2.0 fish for random sampling and 5.7 fish for bias of 3.0 times the random probability. For the unassociated set, the numbers of large yellowfin and bigeye corresponding to random sampling and bias of 2.6 times the random probability are 1.0 fish and 2.4 fish respectively.

DISCUSSION

According to the catch estimates compiled for the SPC Tuna Fishery Yearbook, which are based primarily on logsheet data and unloadings data, the proportions of skipjack, yellowfin and bigeye in the purse-seine catch during 1995–2003 was 78.1%, 19.7% and 2.2% respectively and average catches of skipjack, yellowfin and bigeye were 833,950 tonnes, 209,907 tonnes and 23,420 tonnes respectively.

According to the observer data, the proportions of skipjack, yellowfin and bigeye in the purse-seine catch during 1995–2003 were 55.4%, 35.8% and 8.8% respectively. If the proportions based on the observer data are applied to the average of the total catches for 1995–2003 that are reported in the Yearbook, then the average catch of skipjack would be revised downwards to 591,271 tonnes and the average catches of yellowfin and bigeye would be revised upwards to 382,432 tonnes and 93,648 tonnes respectively. That is, the catch of skipjack would be revised downwards by 29.1%, the catch of yellowfin would be revised upwards by 82.2% and the catch of bigeye would be revised upwards by 299.9%.

The catch estimates in the preceding paragraph, based on observer data, do not take into account the relationship between the species composition and school association, year, quarter, area or flag. Of these variables, the effect of school association is the most important. The species composition based on observer data for unassociated schools is 68.2% skipjack, 30.4% yellowfin and 1.4% bigeye. For associated schools, the species composition based on observer data is 47.8% skipjack, 39.1% yellowfin and 13.1% bigeye. Applying these proportions to the average annual catch from unassociated schools (41.6% of the average annual catch) and associated schools (58.4% of the average annual catch) during 1995–2004 gives average annual catches of skipjack, yellowfin and bigeye of 600,754 tonnes, 378,343 tonnes and 88,180 tonnes respectively. That is, the catch of skipjack would be revised downwards by 28.0%, the catch of yellowfin would be revised upwards by 80.2% and the catch of bigeye would be revised upwards by 276.5%. While these revisions are more precise, they are still similar to those which do not take explicit account of school association.

Revisions of the estimates of catches by purse seiners in the WCPO, based on the species composition determined from observer data, would therefore result in large changes to the estimates. Furthermore, revisions of the input catch data for the MULTIFAN-CL assessments of skipjack, yellowfin and bigeye, based on the species composition determined from observer data, would almost certainly have major impacts on those assessments. The crucial question is, therefore, How accurate and reliable are the species composition data collected by observers?

Unfortunately, there is no simple answer at present. Each element in the discussion is debatable, as we see in the following points:

- The observer data should be considered accurate and reliable because the observers are well-trained technicians. However, the basic level of skills is quite low compared to observers in other areas, such as the Eastern Pacific, and many observers in the WCPO have not undergone sufficient debriefing to improve their sampling skills.
- The observer data used in this study have been evaluated and screened for data quality, so they should be considered accurate and reliable. However, certain elements of the evaluation of data quality are highly subjective.
- The species composition based on the observer data is more consistent with those of other ocean areas. However, the species compositions for the other ocean areas are themselves variable, with the proportion of skipjack ranging from 33.3% for the Eastern Pacific to 52.1% for the Indian Ocean.
- The logsheet data, unloadings data and FOT reports may be subject to bias related to the fact that small skipjack and yellowfin have the same economic value. However, the comparison of the port sampling data and the observer data indicates that the main difference is the presence of more large yellowfin in the observer data. The difference is not, therefore, related to the mis-identification of small fish in the logsheet, unloadings and FOT reports.

Further to the first bullet point above, it is questionable whether the sampling of purse-seine catches by observers has been truly random. The sampling protocol is to randomly select five fish in every brail taken from the set. However, it could be that the observers have a tendancy to pick larger fish and, if so, this could account for the higher proportion of yellowfin in the species composition determined from observer data.

On the other hand, the simulation studies presented above indicate that the bias towards selecting large yellowfin and bigeye would have to be two to three times the random probablity, such that, for associated sets, an average of 5.7 large yellowfin and bigeye would have to be selected, rather than 2.0 fish, and, for unassociated sets, an average of 2.4 large yellowfin and bigeye would have to be selected, rather than 1.0 fish. While the sampling by some observers could be subject to such high levels of bias, it is doubtful that these levels are representative of the average bias over all observers.

In any case, some consideration should be given to evaluating the randomness of both observer samples and port samples.

REFERENCES

Anonymous. 2003. Report of the Fifth Meeting of the Tuna Fishery Data Collection Committee. Secretariat of the Pacific Community, Noumea, New Caledonia and Forum Fisheries Agency, Honiara, Solomon Islands. 138 pp.

Bigelow, K. 2001. Estimation of bigeye catches by purse seiners. Working Paper SWG–8. Fourteenth Meeting of the Standing Committee on Tuna and Billfish, 9–16 August 2001, Noumea, New Caledonia. Secretariat of the Pacific Community, Noumea, New Caledonia. 13 pp.

Crone, P.R. & A.L. Coan, Jr. 2002. Sampling design and variability associated with estimates of species composition of tuna landings for the U.S. purse seine fishery in the central-western Pacific Ocean (1997–2001). Working Paper SWG–9. Fifteenth Meeting of the Standing Committee on Tuna and Billfish, 22–27 July 2002, Honolulu, Hawaii, United States of America. National Marine Fisheries Service, La Jolla, California, United States of America. 9 pp.

Hampton, J. 2002. Stock assessment of bigeye tuna in the western and central Pacific Ocean. Working Paper BET–1. Fifteenth Meeting of the Standing Committee on Tuna and Billfish, 22–27 July 2002, Honolulu, Hawaii, United States of America. Secretariat of the Pacific Community, Noumea, New Caledonia. 36 pp.

Hulbert, S.H. 1984. Pseudoreplication and the design of ecological field experiments. Ecol. Mono. 54: 184–211.

Lawson, T.A. 2002a. Sampling of the proportion of bigeye in the catch by purse seiners in the Western and Central Pacific Ocean. Oceanic Fisheries Programme Internal Report No. 48. Secretariat of the Pacific Community, Noumea, New Caledonia. 25 pp.

Lawson, T.A. 2002b. SPC Tuna Fishery Yearbook, 2001. Secretariat of the Pacific Community, Noumea, New Caledonia. 170 pp.

Lawson, T.A. 2003. Analysis of the proportion of bigeye in ‘yellowfin plus bigeye’ caught by purse seiners in the Western and Central Pacific Ocean, based on observer data. Oceanic Fisheries Programme Internal Report No. 49. Secretariat of the Pacific Community, Noumea, New Caledonia. 22 pp.

Lawson, T.A. 2004. SPC Tuna Fishery Yearbook, 2003. Secretariat of the Pacific Community, Noumea, New Caledonia. 178 pp.

Lawson, T.A. 2005. Update on the proportion of bigeye in 'yellowfin plus bigeye' caught by purse seiners in the Western and Central Pacific Ocean. Working Paper WCPFC–SC1 WP–4, First Meeting of the Scientific Committee of the Western and Central Pacific Fisheries Commission, Noumea, New Caledonia, 8–19 August 2005. Oceanic Fisheries Programme, Secretariat of the Pacific Community, Noumea, New Caledonia. 11 pp.

Snedecor, G.W. & W.G. Cochran. 1989. Statistical Methods (8th Edition). Iowa State University Press, Ames, Iowa.

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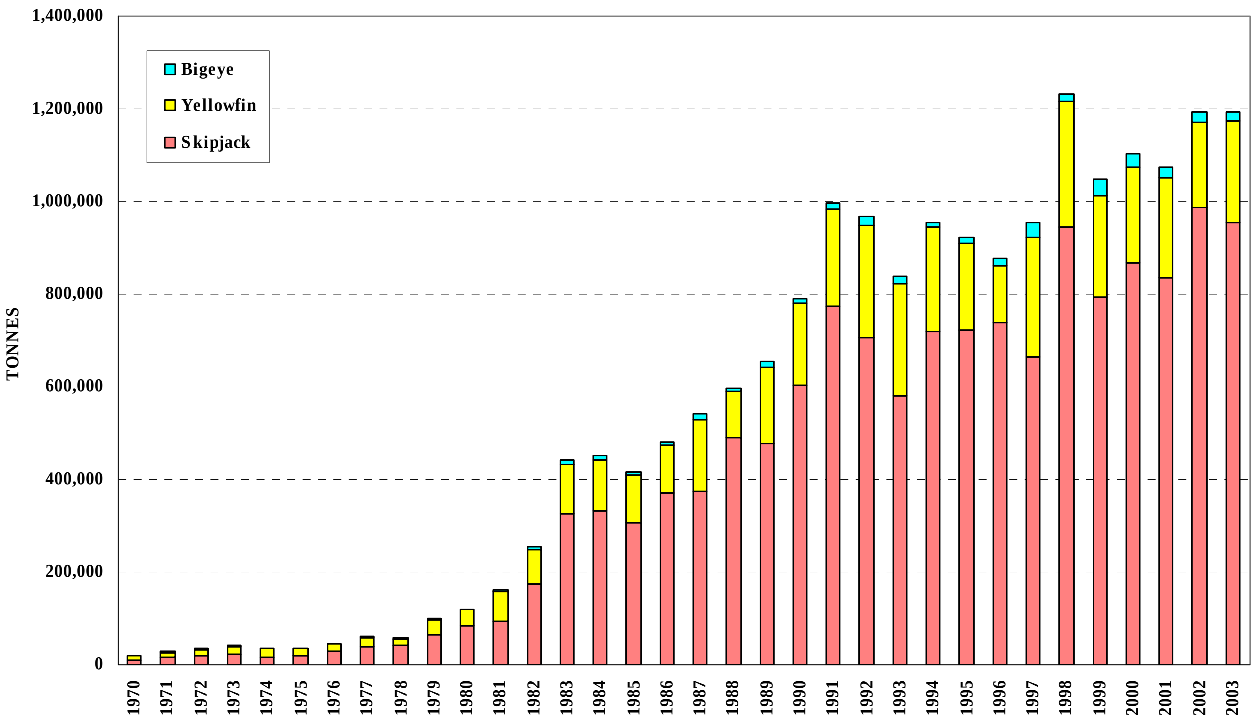

Figure 1. Purse-seine catches in the Western and Central Pacific Ocean, according to the SPC Tuna Fishery Yearbook

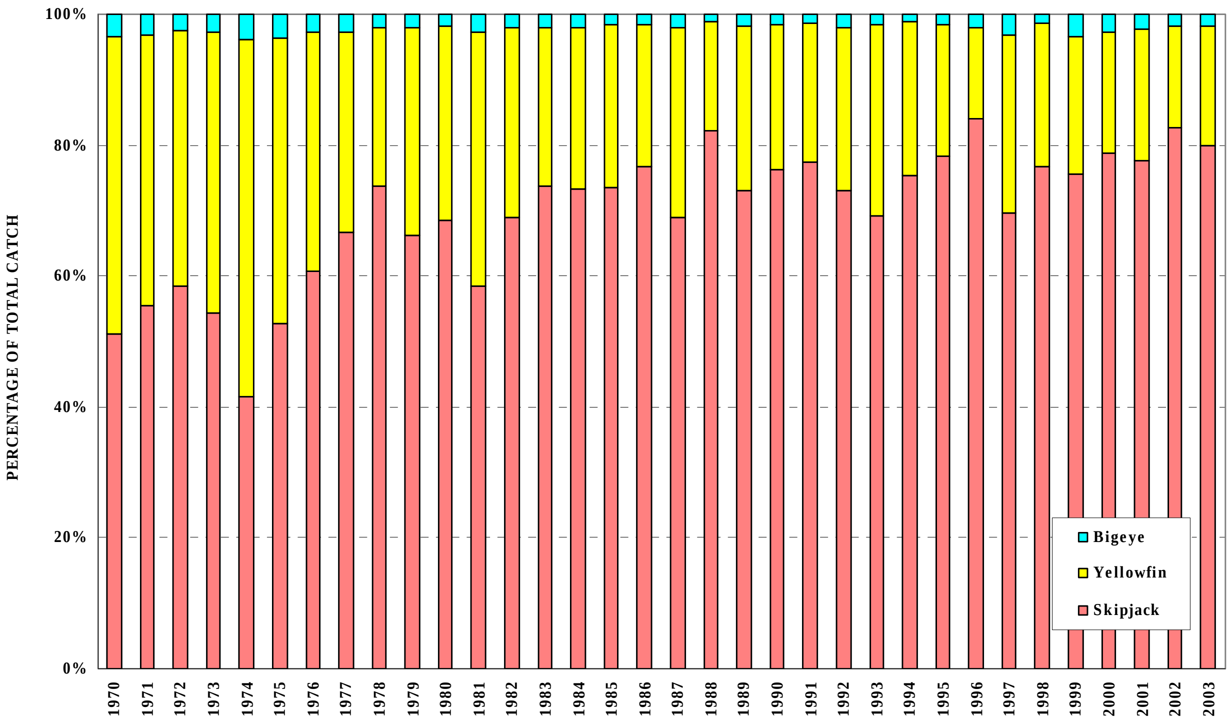

Figure 2. Species composition of purse-seine catches in the Western and Central Pacific Ocean, according to the SPC Tuna Fishery Yearbook

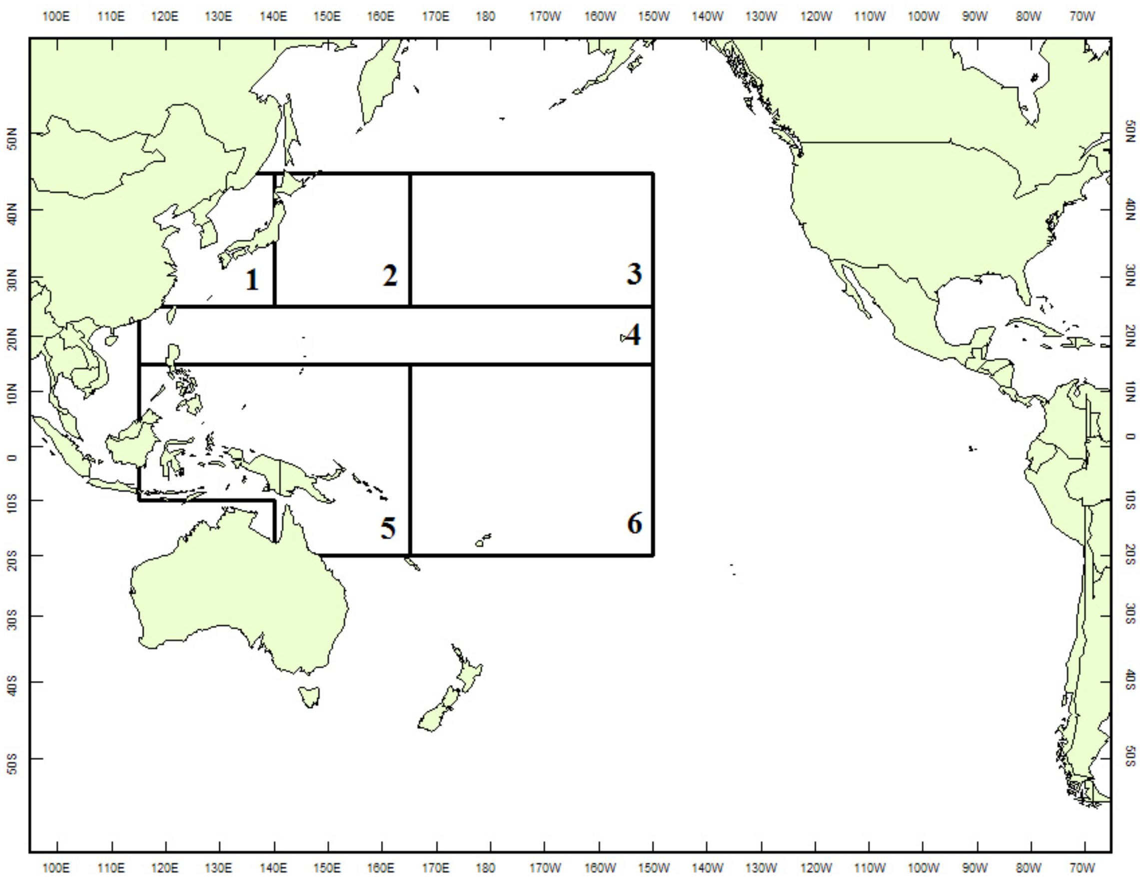

Figure 3. Areas used in the MULTIFAN-CL assessment of skipjack

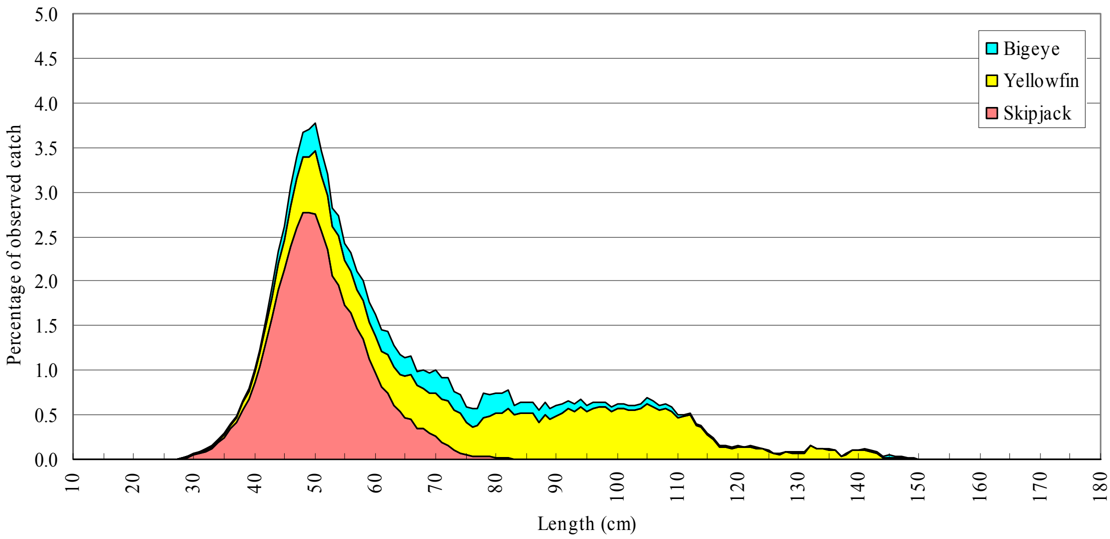

Figure 4. Length frequency for associated schools determined from observer data

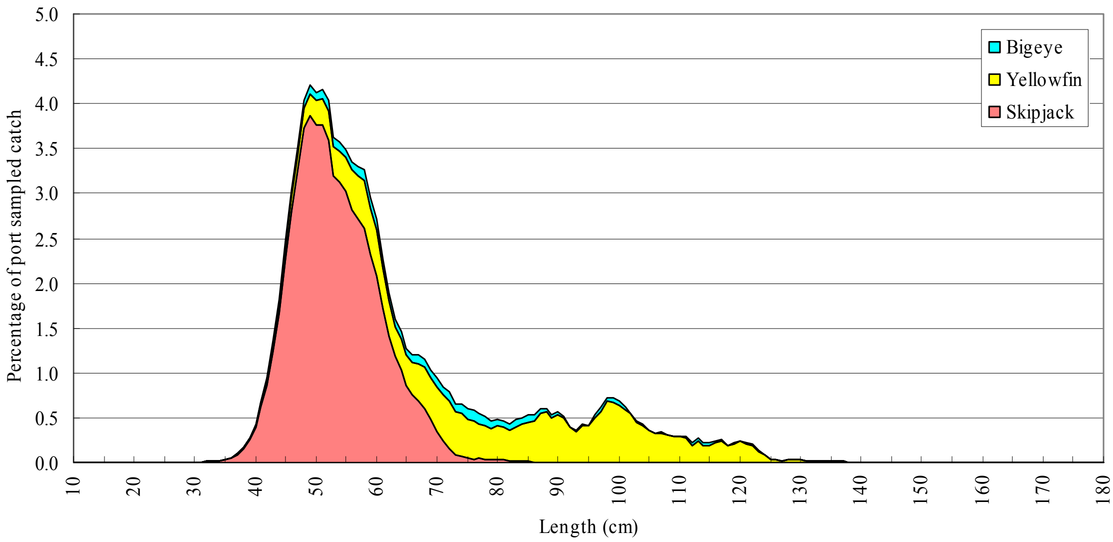

Figure 5. Length frequency for associated schools determined from port sampling data

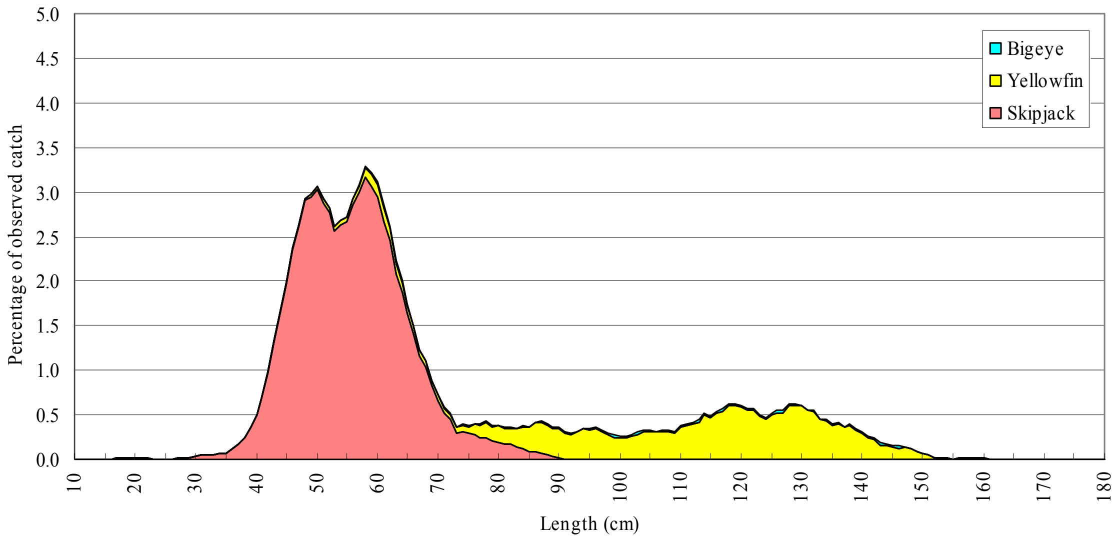

Figure 6. Length frequency for unassociated schools determined from observer data

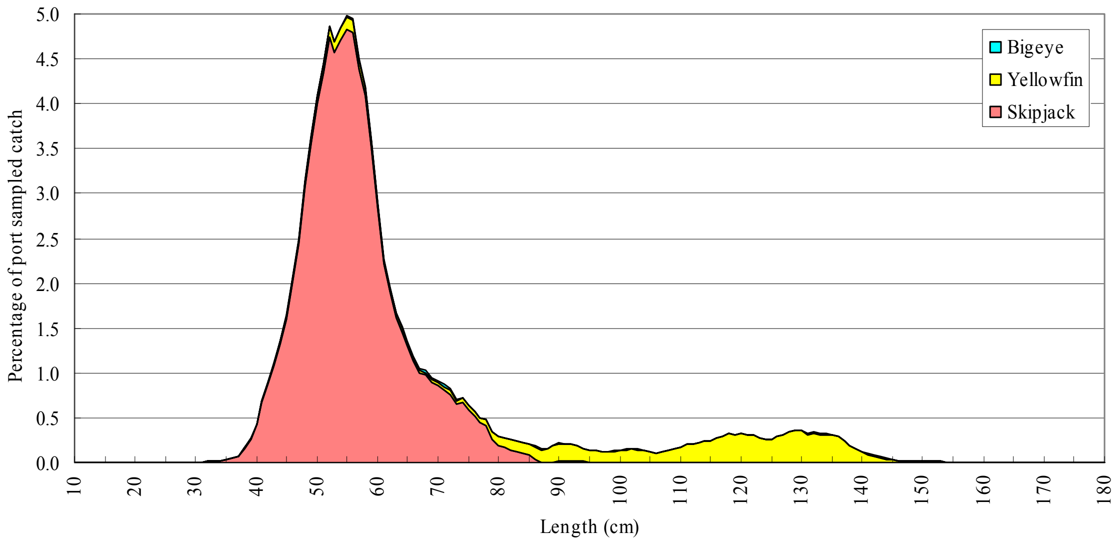

Figure 7. Length frequency for unassociated schools determined from port sampling data

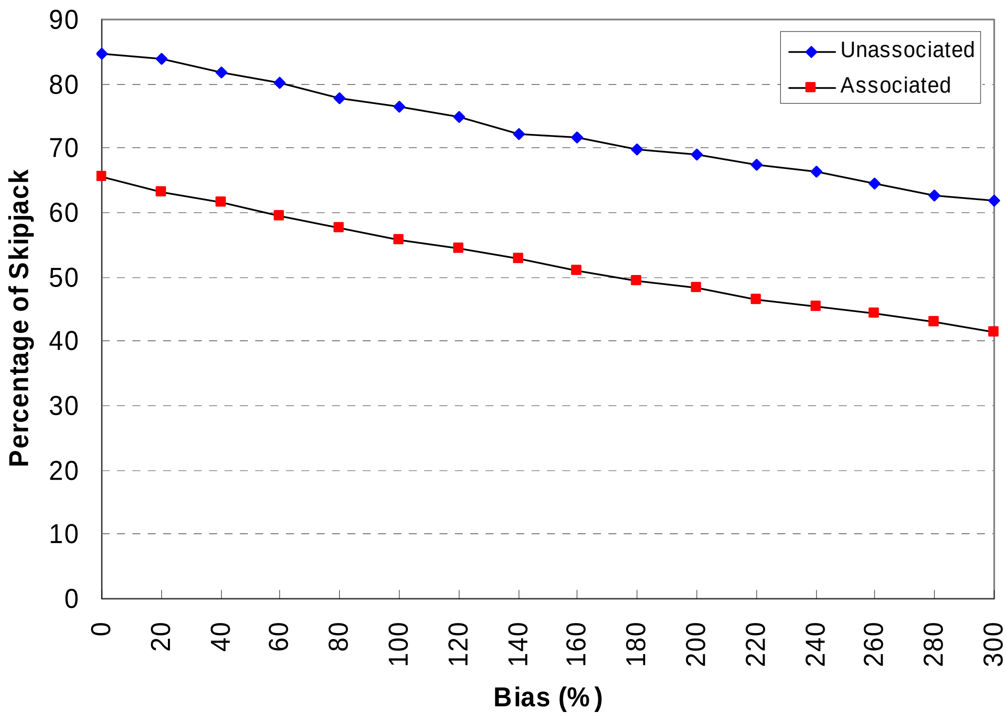

Figure 8. Relationship between bias in observer sampling (percentage increase in probability of selecting large yellowfin and bigeye) and estimates of the percentage of skipjack in the catch, for simulated sampling of sets on an associated school and an unassociated school

Table 1. Number of species composition samples collected by observers from purse seiners, by year and school association. Key: LOG: Drifting log, debris or dead animal; FAD: Drifting raft, FAD or payao; SCHOOL: unassociated or feeding on baitfish.

YEAR	LOG	FAD	SCHOOL	TOTAL	%
1995	43	8	20	71	1.6
1996	174	22	157	353	8.0
1997	121	67	84	272	6.1
1998	287	129	403	819	18.5
1999	27	322	138	487	11.0
2000	32	432	176	640	14.5
2001	82	454	325	861	19.4
2002	264	236	347	847	19.1
2003	45	18	15	78	1.8
TOTAL	1,075	1,688	1,665	4,428	100.0
%	24.3	38.1	37.6	100.0	

Table 2. Number of species composition samples collected by observers from purse seiners, by year and quarter

YEAR	Q1	Q2	Q3	Q4	TOTAL	%
1995	1	23	35	12	71	1.6
1996	36	70	156	91	353	8.0
1997	134	51	26	61	272	6.1
1998	219	352	206	42	819	18.5
1999	97	167	156	67	487	11.0
2000	165	235	143	97	640	14.5
2001	167	308	254	132	861	19.4
2002	196	274	181	196	847	19.1
2003	72	3	0	3	78	1.8
TOTAL	1,087	1,483	1,157	701	4,428	100.0
%	24.5	33.5	26.1	15.8	100.0	

Table 3. Number of species composition samples collected by observers from purse seiners, by year and skipjack area (Figure 1)

YEAR	SKJ AREA		TOTAL	%
	2	3		
1995	71	0	71	1.6
1996	352	1	353	8.0
1997	259	13	272	6.1
1998	436	383	819	18.5
1999	214	273	487	11.0
2000	268	372	640	14.5
2001	188	673	861	19.4
2002	347	500	847	19.1
2003	65	13	78	1.8
TOTAL	2,200	2,228	4,428	100.0
%	49.7	50.3	100.0	

Table 4. Number of species composition samples, containing yellowfin and bigeye, collected by observers from purse seiners, by year and fishing nation. **Key: FM: Federated States of Micronesia, JP: Japan, KR: Republic of Korea, PG: Papua New Guinea, PH: Philippines, SB: Solomon Islands, TW: Chinese Taipei, US: United States of America, VU: Vanuatu.**

YEAR	FM	JP	KR	PG	PH	SB	TW	US	VU	TOTAL	%
1995	21	10	4	7	–	–	29	–	–	71	1.6
1996	8	13	87	7	13	–	215	–	10	353	8.0
1997	–	23	72	2	40	–	110	9	16	272	6.1
1998	5	33	134	37	1	4	366	219	20	819	18.5
1999	–	14	73	14	–	9	78	280	19	487	11.0
2000	34	41	93	34	–	–	89	349	–	640	14.5
2001	49	50	55	5	31	5	96	570	–	861	19.4
2002	–	45	29	135	170	13	93	362	–	847	19.1
2003	–	–	–	3	8	–	–	67	–	78	1.8
TOTAL	117	229	547	244	263	31	1,076	1,856	65	4,428	100.0
%	2.6	5.2	12.4	5.5	5.9	0.7	24.3	41.9	1.5	100.0	

Table 5. Percentage of skipjack in purse-seine catches, based on observer data, by year and school association. Key: LOG: Drifting log, debris or dead animal; FAD: Drifting raft, FAD or payao; SCHOOL: unassociated or feeding on baitfish.

YEAR	LOG	FAD	SCHOOL	ALL
1995	24.6	23.9	43.6	30.4
1996	47.8	44.4	81.6	61.9
1997	41.9	35.4	58.8	44.7
1998	46.2	51.7	55.3	51.4
1999	49.1	45.9	62.2	49.8
2000	63.0	44.4	75.0	53.5
2001	43.1	55.3	66.9	59.7
2002	48.5	56.9	80.1	64.6
2003	53.2	56.4	73.1	59.6
AVERAGE	46.4	46.0	66.3	52.8

Table 6. Percentage of skipjack in purse-seine catches, based on observer data, by year and quarter

YEAR	Q1	Q2	Q3	Q4	ALL
1995	0	25.0	38.9	30.2	30.4
1996	54.6	74.6	56.9	63.4	61.9
1997	57.8	43.2	39.4	22.6	44.7
1998	30.3	58.9	53.6	66.4	51.4
1999	56.5	41.2	54.0	54.8	49.8
2000	45.7	55.9	45.5	66.2	53.5
2001	63.4	62.0	58.5	50.7	59.7
2002	68.3	72.8	55.6	57.4	64.6
2003	59.5	100.0	–	25.2	59.6
AVERAGE	54.5	59.3	50.3	48.5	52.8

Table 7. Percentage of skipjack in purse-seine catches, based on observer data, by year and skipjack area (Figure 1)

YEAR	SKJ AREA		ALL
	5	6	
1995	30.4	–	30.4
1996	61.6	100.0	61.9
1997	46.4	22.1	44.7
1998	54.4	48.1	51.4
1999	53.9	47.2	49.8
2000	66.0	44.2	53.5
2001	57.2	60.4	59.7
2002	47.5	72.1	64.6
2003	62.0	50.1	59.6
TOTAL	53.3	55.5	52.8

Table 8. Percentage of skipjack in purse-seine catches, based on observer data, by year and fishing nation. Key: FM: Federated States of Micronesia, JP: Japan, KR: Republic of Korea, PG: Papua New Guinea, PH: Philippines, SB: Solomon Islands, TW: Chinese Taipei, US: United States of America, VU: Vanuatu.

YEAR	FM	JP	KR	PG	PH	SB	TW	US	VU	ALL
1995	42.9	37.6	33.3	16.8	–	–	25.5	–	–	30.4
1996	35.2	71.1	53.4	56.8	72.1	–	66.5	–	65.3	61.9
1997	–	35.3	71.3	58.1	34.6	–	29.5	65.5	42.8	44.7
1998	44.2	40.0	55.4	42.8	59.4	72.6	47.2	52.8	74.8	51.4
1999	–	28.2	56.6	53.0	–	44.6	64.8	45.9	51.8	49.8
2000	61.1	64.4	72.5	58.1	–	–	70.3	40.4	–	53.5
2001	52.7	51.7	79.4	15.4	47.9	58.7	51.1	60.8	–	59.7
2002	–	51.2	80.4	50.4	41.8	58.0	67.9	76.3	–	64.6
2003	–	–	–	25.2	56.8	–	–	62.4	–	59.6
AVERAGE	47.2	47.4	62.8	41.8	52.1	58.5	52.9	57.7	58.7	52.8

Table 9. Comparison of the percentage of skipjack in purse-seine catches determined from observer data and logsheet data. Only school association – year – quarter – area – flag strata for which at least ten sets were observed and recorded on logsheets have been included.

Variable	Value	Number of Strata	Observer Data	Logsheet Data	Difference
All	All	113	53.5	78.3	24.8
School association	Logs	35	43.8	83.0	39.2
	Drifitng FADs	34	46.3	78.3	32.0
	Unassociated	44	66.9	74.7	7.8
Year	1995	1	23.9	91.7	67.8
	1996	11	64.2	91.2	27.0
	1997	10	42.0	77.3	35.2
	1998	23	48.6	74.8	26.3
	1999	11	49.4	74.0	24.6
	2000	15	56.9	78.9	22.0
	2001	13	57.1	74.3	17.2
	2002	27	56.5	79.2	22.7
	2003	2	58.4	81.5	23.1
Quarter	Q1	29	49.9	76.9	27.1
	Q2	37	55.3	82.2	26.9
	Q3	26	52.0	76.8	24.8
	Q4	21	57.3	75.4	18.1
Area	5	72	52.6	78.4	25.8
	6	41	55.2	78.2	23.0
Flag	Federated States of Micronesia	3	40.5	64.3	23.8
	Japan	3	44.3	80.4	36.1
	Republic of Korea	20	64.7	79.5	14.8
	Papua New Guinea	8	46.8	79.8	33.0
	Philippines	12	40.8	67.1	26.4
	Solomon Islands	0	–	–	–
	Chinese Taipei	31	52.1	82.0	29.9
	United States of America	33	56.0	79.7	23.7
	Vanuatu	3	58.0	71.2	13.2

Table 10. Comparison of the percentage of skipjack in purse-seine catches determined from observer data and unloadings data. Only year – flag strata for which there are at least ten observed sets and one unloading have been included.

Variable	Value	Number of Strata	Number of Sets Observed	Number of Trips Unloaded	SKJ % – Observer Data	SKJ % – Unloadings Data	Difference
All	All	37	3997	3418	56.5	76.9	20.4
Year	1995	2	50	384	34.2	78.1	43.9
	1996	4	325	452	64.3	87.6	23.2
	1997	4	238	613	44.6	74.0	29.5
	1998	5	776	695	54.6	68.8	14.2
	1999	5	464	427	54.4	71.5	17.1
	2000	5	599	262	60.5	79.1	18.6
	2001	5	801	260	58.4	79.9	21.5
	2002	6	677	229	64.0	79.0	15.0
	2003	1	67	96	62.4	71.5	9.1
Flag	Federated States of Micronesia	3	104	28	52.2	83.5	31.3
	Japan	1	45	1	51.2	100.0	48.8
	Republic of Korea	7	543	635	67.0	80.0	13.0
	Papua New Guinea	4	220	56	51.1	83.2	32.1
	Philippines	3	84	191	51.5	72.9	21.4
	Solomon Islands	1	13	1	58.0	49.9	-8.1
	Chinese Taipei	8	1076	1664	52.9	78.7	25.8
	United States of America	6	1847	814	56.4	73.8	17.3
	Vanuatu	4	65	28	58.7	65.2	6.5

Table 11. Comparison of the percentage of skipjack in purse-seine catches determined from observer data and port sampling data. Only school association – year – flag strata for which at least three sets were observed and three wells were sampled in port have been included.

Variable	Value	Number of Strata	Number of Sets Observed	Number of Sets Sampled in Port	SKJ % – Observer Data	SKJ % – Port Sampling Data	Difference
All	All	24	2,131	302	57.3	72.5	15.2
School association	Associated	14	1,341	124	47.8	64.4	16.6
	Unassociated	10	790	178	70.7	83.9	13.2
Year	1995	0	–	–	–	–	–
	1996	1	36	35	78.3	80.7	2.4
	1997	1	37	22	82.9	57.2	-25.7
	1998	4	500	39	51.8	78.4	26.6
	1999	1	271	11	45.7	40.1	-5.6
	2000	0	–	–	–	–	–
	2001	7	564	79	50.5	70.6	20.2
	2002	8	668	100	65.8	76.2	10.5
	2003	2	55	16	41.3	72.6	31.3
Flag	Federated States of Micronesia	0	–	–	–	–	–
	Japan	0	–	–	–	–	–
	Republic of Korea	8	291	145	68.8	83.4	14.5
	Papua New Guinea	3	45	19	32.4	76.1	43.7
	Philippines	2	166	23	41.9	32.3	-9.7
	Solomon Islands	0	–	–	–	–	–
	Chinese Taipei	6	555	84	56.1	83.0	26.9
	United States of America	5	1,074	31	61.6	56.7	-4.9
	Vanuatu	0	–	–	–	–	–

Table 12. Percentages of observed and port sampled catches, by school association, species and size class

	Observer Data				Port Sampling Data			
	Skipjack	Yellowfin	Bigeye	Total	Skipjack	Yellowfin	Bigeye	Total
	Associated Schools							
< 80 cm	47.7	18.0	8.5	74.2	64.2	13.8	3.5	81.5
>= 80 cm	0.1	22.3	3.4	25.8	0.2	17.1	1.3	18.5
Total	47.8	40.3	11.9	100.0	64.4	30.8	4.8	100.0
	Unassociated Schools							
< 80 cm	69.6	2.8	0.3	72.7	82.9	2.3	0.5	85.8
>= 80 cm	1.1	25.0	1.2	27.3	1.0	13.0	0.2	14.2
Total	70.7	27.8	1.5	100.0	83.9	15.3	0.8	100.0
	Associated and Unassociated Combined							
< 80 cm	56.8	11.6	5.0	73.4	72.1	9.0	2.3	83.4
>= 80 cm	0.5	23.5	2.5	26.6	0.4	15.4	0.8	16.6
Total	57.3	35.1	7.6	100.0	72.5	24.4	3.1	100.0

Table 13. Species composition for United States purse seiners determined from Final Out-Turn reports

Year	Skipjack		Yellowfin & Bigeye < 20 lbs		Yellowfin & Bigeye > 20 lbs		Total
	Tonnes	%	Tonnes	%	Tonnes	%	Tonnes
1994	60,342	65.0	13,927	15.0	18,510	20.0	92,779
1995	111,399	81.1	11,211	8.2	14,814	10.8	137,424
1996	113,137	79.6	13,564	9.5	15,369	10.8	142,070
1997	73,428	62.5	14,266	12.1	29,796	25.4	117,490
1998	108,814	77.2	8,043	5.7	24,163	17.1	141,020
1999	124,286	77.1	18,503	11.5	18,394	11.4	161,183
2000	96,338	73.3	10,158	7.7	24,946	19.0	131,442
2001	70,854	74.4	11,171	11.7	13,172	13.8	95,197
2002	83,037	75.2	7,597	6.9	19,859	18.0	110,493
2003	58,689	72.5	9,063	11.2	13,193	16.3	80,945
2004	43,971	69.7	9,378	14.9	9,777	15.5	63,126
Total	944,295	74.2	126,881	10.0	201,993	15.9	1,273,169

Table 14. Species composition (%) for purse-seine fisheries in other ocean areas during 1995–2003

Ocean Area	Skipjack	Yellowfin	Bigeye
Eastern Pacific Ocean	33.3	58.1	8.5
Atlantic Ocean	43.1	46.5	10.4
Indian Ocean	52.1	39.8	8.1
Average	42.8	48.2	9.0