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# Estimates of Precision and Sampling Biases Associated with SBT Catch Estimates from the CSIRO/RIMF Monitoring System

**T. Polacheck**

**T. Patterson**

**T.L.O. Davis**

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# Estimates of Precision and Sampling Biases Associated with SBT Catch Estimates from the CSIRO/RIMF Monitoring System

T. Polacheck, T. Patterson and T.L.O. Davis

**Abstract**

This paper examines the uncertainties associated with sampling errors and possible biases in the representiveness of sampling associated with the CSIRO/RIMF catch monitoring of SBT landed in Benoa, Bali. Bootstrap variance and confidence intervals were calculated by random re-sampling with replacement either at the landing or vessel level. The results suggest that the estimates of annual SBT exported and total catch have been estimated with reasonable precision with the estimated CV always less than 9% for any of the annual estimates. Also the recent declines in sampling fraction have not had a large effect on the estimated precision of the annual SBT catches and the overall level of sampling has been sufficient to provide relatively precise estimates.

Given that processors were not sampled randomly and that there has been apparent temporal trends in the relative proportion of vessels using the main two processors that have been sampled, there is a potential for bias in either the overall estimate or trends in the estimates if the vessels using different processors are not representative of vessels landing their catch in Bali. Meaningful randomisation estimates of the variances associated with the sample of actual processors were not possible because the fact that the bulk of the sampling only came from two processors. As an alternative, a number of characteristics were examined by processor to get an indication of the amount of variability that exists among the processors that were sampled and to see if there are any consistent differences over time. Comparison of the annual estimates of SBT landed based on landings that occurred either at SSU or at PSB were similar for 1994 and 1995, but diverged subsequently. The analyses suggest that there could be unknown and changing biases in the estimates. These stem from:

1. Administrative constraints that limited sampling primarily to two processors;
2. Changes in the relative proportion of catches being landed at these two processors;
3. Differences in the proportion of SBT caught by vessels unloading their catches at different processors;
4. Differences in the proportion of tunas being exported;
5. Changes over time in the above proportions.

Given the lack of information and data from other processors at the time of monitoring, it is not possible to determine if and how the above factors could have induced biases into the overall estimates of SBT landings.

## Introduction

CSIRO Divison of Marine Research and the Research Institute of Marine Fisheries of Indonesia (RIMF) began a collaborative research program to monitor the catches of southern bluefin tuna caught by longline vessels operating out of Indonesia. As discussed in Davis and Andamari (2003), this program involved sampling catches from selected processors in Benoa, Bali and estimation of a raising factor to obtain estimates of the total SBT catch landed in Benoa. This program has produced estimates of monthly and annual catch of SBT land in Benoa from 1993-2001. The estimates have been used in stock assessments to provide estimates of the total SBT landing in Indonesia, based on the presumption that little SBT was landed in other ports in Indonesia. The estimated annual catches have ranged from 720 to 2160 t (dressed weight) and have constituted a significant fraction of the global SBT catch. The Indonesian SBT fishery occurs on the only known spawning ground and the catches are primarily of older fish (e.g. the majority are estimated to have been over 20 years of age when caught). This combined with the estimated magnitude has meant that these catches have significant implications for the international management of the SBT resource and on recovery strategies for the stock.

Since the catch estimates produced by the CSIRO/RIMF program are based on a sampling of the full catch (i.e. they are not derived from a complete census), there are uncertainties which are associated with sampling errors and possible biases associated with the representativeness of sampling. To date, there has been no quantitative assessment or formal analyses of how uncertainties resulting from the sampling aspects of this program translate into uncertainties in the overall catch estimates. The current paper provides results of bootstrap and related analyses designed to address the uncertainties associated with some of the sampling aspects of the program.

In considering the uncertainties associated with the overall catch estimates, it is important to emphasize that the sampling of the SBT catch in Indonesia was originally initiated to collect biological materials (gonads and otoliths) and this remained one of the primary objectives of the overall project. The estimation of the catch developed as an added objective from the data that were being collected. In addition, administrative constraints on sampling meant that it was not possible to conduct sampling at all processors. Access to two processors (Sari Segara Utama and Perikanaan Samodra Besar) was only possible on a routine basis throughout the 1993-2001 period. Two processing rooms were monitored at Sari Segara Utama, although the landings were not distinguished by the rooms which were operated by Gilontas Indonesia and Pahala Bahari. Large amounts of effort were directed at expanding the sampling base, but were thwarted by recruitment of unsuitable staff and lack of cooperation by some processors. However, it was possible to sample additional processors on a limited basis in some years.

## Material and Methods

Davis and Andamari (CCSBT-ICM/0304/6) provide a detailed description of the CSRIO/RIMF catch monitoring program. The program involves sampling individual vessel landings at selected processors. The basic data collected for estimating the total

SBT landings from Benoa are the catch weight of SBT, yellowfin and bigeye categorized into export and reject grades. The total SBT catch is then estimated based on the sample of SBT observed raised by an estimate of the fraction of the total catch observed. The raising factor that has been used is an estimate of the total weight of tunas observed exported. This is derived from the total weight of tunas (SBT, yellowfin and bigeye) exported assembled by Dinas divided by the total weight of tunas observed exported by CSIRO/RIMF enumerators. The details of the estimation procedure are documented in Davis and Andamari (CCSBT-ICM/0304/6) and issues with respect to the raising factor are discussed in Davis and Andamari (CCSBT-ICM/0304/7). Thus, the two key components in the estimator are the total weight of SBT sampled and the fraction of all tunas that was estimated to have been exported.

The estimation of SBT landings is based on the assumption that the landings sampled constitute a representative (or random) sample of landings in Benoa and that the observed proportion of total tuna exported is a representative (or random) sample of the exported proportions from all landings. It is these aspects of the estimator that are investigated in the current paper. As noted above, most of the sampling over the period from 1992 to 2001 was done at two processors because of administrative constraints which limited wider access. The longline fishery and processing arrangements have also evolved over time. It is important to distinguish between processors and fishing companies/fishing vessels. A mixture of fishing companies and vessels use an individual processor's facilities. However, a processor can also be a fishing company that owns its own fleet of vessels. Initially, there were limited processing facilities in Bali and a large fraction of the tuna being landed was processed at PSB. Subsequently, the amount of tuna being processed at this processor declined as both the size of the fleet and the number of processors increased. Many vessels that initially used PSB for processing changed processors over time. By 1997, only a small number of vessels besides those directly owned by PSB were using the PSB processing facilities[1]. Vessels generally used a single processor for an extended period of time. Overall, the data were only collected from most vessels from only a single processor –particularly within any given year (Figure 1 and 2)[2].

Operational aspects of the longline fishery in Bali have also evolved over time. In particular, initially each vessel landed its catch separately after a voyage generally of 1 to 2 weeks. Subsequently, there has been an increasing use of carrier vessels to transport catches after a few days from a group of cooperating vessels operating in the same area. This meant that the fishing vessels did not have to return to port to land their catches. However, the catches were almost always still identifiable to an individual vessel when landed at a processor, although there are some instances in the data where the catch is only attributable to a small group of vessels. Thus, the number of landing per vessel and the number of landing sampled has increased markedly.

[1] Note that the PSB owned vessels are treated differently in the estimation of the SBT catch because a complete record of their catch was available and their fishing practices were considered to be sufficiently distinct so as not to be considered representative. Thus, the PSB vessels are treated as a separate component or strata which do not contribute to the variance/uncertainty in the overall estimate.
[2] It is not uncommon for vessels to change their name and in particular a large number of vessels changed their name as part of a re-registration process in 1995. In most cases, no unique identifier was available. As such, the apparent number of vessels is greater than the actual number and the number of processors in which a vessel has been sampled may be under estimated. In the latter case, this would have to be associated with a name change.

However, this does not represent a concomitant increase in the number of vessels or in sampling effort.

The estimator of SBT catches also assumes that the enumerated total weight of tuna by Dinas is an accurate reflection of the total weight of tunas exported. In the current paper, the Dinas statistics are taken as given and no attempt is made to consider how uncertainty in them translates into the overall estimates of total catch (see discussion). This is because the Dinas statistics are meant to constitute a complete census of all exports from Bali. Thus, there are no sampling characteristics associated with them. As with any census, there are possible errors in the Dinas statistics due to potential mistakes in the compilation of the statistics (missed records, double counting, addition errors, etc). Such errors could possibly introduce a bias but no information in the basic sampling data provide any basis for assessing this (see Davis and Andamari, CCSBT-ICM/0304/7). Unless, there was a systematic temporal trend in the errors, such errors would not induce any bias in the overall trends, but could result in the estimates being over or under estimates.

The estimation of SBT catch is based on multi-stage sampling involving a sampling of landing within vessels and vessels within processors. To gain some insight how the variability at these different sampling levels may be contributing to the uncertainty in the overall estimates, bootstrap variance and confidence intervals were calculated by random re-sampling with replacement either at the landing or vessel level. These bootstrap estimates were done on a monthly level for landings and an annual basis for vessels. Thus, in the case where a landing was considered the basic sampling unit, a bootstrap sample was constructed by randomly sampling with replacement all sampled landings in a year until the number in the bootstrap sample equalled the actual number of landings that were observed. In the case where the vessels was the primary sampling unit, a bootstrap sample was constructed by randomly sampling with replacement all sampled vessels in a year and including all of that vessels data as one member in the bootstrap sample. The number of vessels in an individual bootstrap replicate equalled the actual number of vessels for which data had been collected. In this case, the number of landing varies, representing the variability among vessels in the number of landings. For each of the bootstraps, a 1000 bootstrap replicates were generated and the mean, coefficient of variance and 95% confidence intervals were calculated for the estimated total SBT landings in Bali.

Due to the increase in the number of vessels and processors in the Bali fishery and a decline in the actual number of non-PSB vessels using the PSB processing facilities, the actual sampling coverage has declined in recent years. To obtain an indication of the sensitivity of the results to differing sampling levels, a Monte-Carlo sub-sampling of the data from 1996 was undertaken. 1996 was chosen as this was the year with the broadest coverage in terms of the fleet and processors. Sub-sampling was done by selecting a random percentage of the actual vessels from which data were collected in 1996. This sub-sample was then used to calculate an annual estimate of the SBT landings in Bali. At each sampling level considered, this procedure was repeated 1000 times. The mean, standard deviation and coefficient variation were then calculated.

It was not possible to conduct any meaningful randomisation estimates of the variances associated with the sample of actual processors. This is due to the fact that the bulk of the sampling only came from two processors. As an alternative, we have examined a number of characteristics by processor to get an indication of the amount of variability that exists among the processors that were sampled and to see if there are any consistent differences over time.

Note that in all of the bootstrap and sub-sampling results, catches from actual PSB vessels were excluded in the re-sampling and their catch was added into the final estimates. This follows the procedure that has been done in the past and reflects the fact that the catch statistics for the PSB vessels are complete and appear to come from a different fishing strategy from the rest of the fleet. Also, in results for landings from the PSB processor, catches by PSB vessels have been excluded.

## Results and Discussion

**Bootstrap Confidence Intervals**
Figure 3 and 4 provide the bootstrap results for the estimate of the annual total SBT exported from Bali and the total SBT landings when the re-sampling unit in the bootstrap procedure was an individual landing. These figures compares the mean of the 1000 bootstrap replicate estimates with the actual estimate based on all of the data. Also, shown in these figures are the 95% confidence intervals for the annual estimates. Figures 5 and 6 provide similar results, except the basic re-sampling unit in the bootstrap procedure was an individual vessel. Comparison of the mean of the bootstrap estimates with the actual estimates indicates that they are highly consistent. Thus, they never differ by more then a small percent. This indicates that there is little statistical bias in the estimates.

Comparison of Figures 3 and 4 with Figures 5 and 6 suggest that most of the variability in the overall estimate is due to the variability among landings within vessels and that there is only a small additional variance component due to the variability among vessels once the variability in individual landings is accounted for. The difference bootstrap confidence intervals based on vessels as the basic sampling unit are only slightly wider than those based on landings as the sampling unit. The estimated coefficients of variation of the estimates of total catch increases between 0.5 and 2.5% when using vessels as the sampling unit compared to using landings (Table 1).

Overall, the bootstrap results suggest that the estimates of annual SBT exported and total catch have been estimated with reasonable precision (Figures 3-6). Thus, the estimated CV is always less than 9% for any of the annual estimates. Although the estimate sampling coverage in terms of the proportion of the Dinas exported total tuna that were sampled have varied with a declining trend in recent years (Figure 7). However, the overall estimated sampling fraction has always been greater then 9% and the recent declines have not had a large effect on the estimated precision of the annual SBT catches. This indicates that overall the level of sampling has been sufficient to provide relatively precise estimates.

**Sub- Sampling Results**
Figure 8 provides the results of the Monte-Carlo sub-sampling of the 1996 data indicated that the decline in the precision of the estimates of total SBT catches would be relatively small as sampling effort in terms of the number of vessels decrease. As

long as sampling effort in terms of the number of vessels remained above 100 the CV in the estimates of total catch would be expected to remain less than 20% (Figure 9). It is only if the sampling effort decreases to less than 33% of that in 1996 would one expect large and substantial decreases in the precision of the estimates. These sub-sampling results further confirm the bootstrap results that the sampling coverage in all years has been sufficient to provide reasonably precise estimates of the total SBT catches. The changes in sampling coverage over time, particularly the decreases in the more recent years, would not have been expected to have increased the variance associated with the estimates.

**Differences Among Processors**

As noted above the limited number of processors that have been routinely sampled because of administrative constraints means that it is not possible to undertake formal randomisation analyses of how sampling variability at this level may be inducing uncertainty into the overall estimates. Nevertheless, given that variability among landings appears to be the main component of the overall variance in the estimates of SBT catches, it would not be expected that sub-sampling at different processors would have a large effect on the overall precision of the estimates. Only very limited and anecdotal information exists on landing, buying and marketing practices. However, several companies and fish buyers use the same processing facility. The limited information that was available and initial analyses did not provide any indication that systematic differences would be expected at different processors. However, given that processors were not sampled randomly and that there has been apparent temporal trends in the relative proportion of vessels using the main two processors that have been sampled, there is a potential bias in either the overall estimate or trends in the estimates if the vessels using different processors are not representative of vessels landing their catch in Bali.

Nevertheless, there exists a large decline between 1995 and 1997 in the amount of export grade tuna from PSB as a proportion of the total Dinas export statistics, while over the same period the amount of export grade tuna from SSU as a fraction of the total Dinas statistic has been relatively constant (Figure 10). In other words, the realized relative sampling effort from SSU in terms of all exported tuna and its contribution to the overall estimate of SBT landed has increased. This largely reflects the changes in the amount of tuna being processed at the two different facilities and not changes in sampling effort or strategy. As such, the decline in relative sampling effort at PSB appropriately reflects the declining contribution of landings at PSB to the overall catch of tuna in Bali.

To investigate whether there were systematic differences among the vessels that landed at each of the processors, we calculated estimates of the total estimated SBT landed in a month using only the data sampled from a single processor. Figure 11 shows the results of these calculations for the period from November 1995 through June 1998. This was the period in which the most number of processors were sampled. There is substantial variation on the monthly estimate of total Bali SBT landings based only on the data from a single processor. While the relative rank of the monthly estimates varies among processors, there is a tendency for the estimates from a particular processor to be somewhat higher or lower. In particular the estimates from SSU tend to be greater than those from PSB (Figure 11 and 12). The differences between the monthly PSB and SSU estimates are more pronounced for the estimates of SBT exports than for the estimates of total SBT landings (Figure 13). The differences in the total SBT landing are less evident before the substantial decline in the use of the PSB processing facility in 1996, although some differences appear to have always existed (Figure 12). Comparison of the annual estimates of SBT landed based on landings that occurred either at SSU or at PSB were similar for 1994 and 1995, but diverged subsequently (Figure 14)[3].

The generally consistent difference in the monthly estimates of SBT landing for SSU and PSB could stem from the vessels that landed at PSB catching proportionally less SBT in their catch, from a difference in grading of tunas as export quality (i.e. a greater proportion of the landings at PSB being graded for export would result in lower raising factor) or a combination of both. Comparison of the proportion of the landed catch which was SBT between PSB and SSU indicates that the proportion at SSU tended to be greater (Figure 15). There was also some tendency for the proportion of all tunas graded as exported quality to be somewhat greater at PSB than at SSU, but to a lesser extent (Figure 16). There appears to be little relationship between the proportion of SBT landed in a month and the proportion of all tunas exported, except perhaps when low levels of SBT are landed at PSB (Figure 17). Additionally, the proportion of SBT being landed at PSB appears to have declined after 1996 (Figure 18-19) in association with the declining use of this facility. All of this suggests that the primary source of the difference in the estimates is that vessels landing at PSB tend to catch proportionately less SBT and that the vessels that continued to land at PSB tended to be ones that catch less SBT. The reason for this difference is unknown, but could be associated with the difference in fishing strategies among different fishing companies and/or buy and export practices among the tuna buyers at the two different processors.

## General Discussion

The above analyses suggest that the sampling intensity in terms of vessels or landings has always been sufficient to provide reasonably precise estimates of the total SBT landings in Bali (i.e. coefficient of variations of less than 9%). However, the analyses suggest that there may be unknown and changing biases in the estimates. These stem from:

1. Administrative constraints that limited sampling primarily to two processors;
2. Changes in the relative proportion of catches being landed at these two processors;
3. Differences in the proportion of SBT caught by vessels unloading their catches at different processors;
4. Differences in the proportion of tunas being exported;
5. Changes over time in the these proportions.

Given the lack of information and data from other processors at the time of monitoring, it is not possible to determine if and how the above factors may have induced biases into the overall estimates of SBT landings. For the two processors sampled, the data could be expected to provide reasonably representative sampling of

[3] Note that part of the large difference in the annual estimates in 1997 is due to the lack of any sampling from PSB between July and November.

the catches being landed at each of the processors given the generally high and continuos levels of sampling. Thus, the main concern is the extent to which the landings at either SSB or PSB processors may be representative of the landings at other processors. The fact that there has been substantial decline in the catches being landed at PSB and that the vessels that continue to land at PSB appear to have been ones with lower levels of SBT in their catch suggests that any trend based on the landings at PSB would be negatively biased (i.e. under estimate the relative catches in recent years).

It should be noted that there has been a somewhat of a decline in the proportion of tuna graded as export quality and a much larger decline in the proportion of SBT graded as export quality (Figure 20). In terms of SBT it is not clear what the source of the trend has been. It is more likely to reflect marketing factors than changes in quality of fish being landed (i.e. time from catches to unloading have actually been reduced with the introduction of carrier vessels). Anecdotal information indicates that there has been increasing reluctance and problems in exporting SBT (which may have increased as the result of the trade information scheme). While such a trend, by itself, in theory would not induce any bias in the estimator of SBT landing in Bali, it would result in a decrease in the SBT seen in import statistics. Moreover, this trend also highlights another potential important source of bias in the estimate of SBT landings. The SBT landing estimates are based on the assumption that all SBT tuna graded as export quality are actually exported. However, not all tuna graded as export quality are in fact exported (e.g. some goes directly to service the tourist sashimi restaurants in Indonesia). Anecdotal information from some processors on this has not been fully consistent. However, the information supplied suggests that at least in some cases a substantial amount of the tuna graded as export quality are in fact not exported.

In 2002, a number of past administrative constraints have been over come and sampling in Bali has been expanded to include all processors. Some initial results from the recently expanded sampling program tends to confirm that substantive differences among processors may exist – particularly in the proportion of SBT being landed (Table 2). Given the changing nature of the tuna fishery and processing in Bali, it is not clear how one might apply any results from this wider sampling to provide retrospective estimates. Finally, to the extent possible, it is important to achieve representative sampling across all processor is important to ensure unbiased estimates.

Table 1: Comparison between the use of individual landings or vessels on the estimated coefficient of variation for the mean from the bootstrap procedure.

| | SBT Exported | | Total SBT Catch | |
|---|---|---|---|---|
| Year | Landings | Vessel | Landing | Vessel |
| 1993 | 8.62 | 10.10 | 6.86 | 8.35 |
| 1994 | 6.49 | 7.05 | 5.69 | 6.29 |
| 1995 | 6.29 | 6.86 | 5.42 | 6.17 |
| 1996 | 5.10 | 6.90 | 4.77 | 6.44 |
| 1997 | 4.89 | 5.43 | 4.15 | 4.63 |
| 1998 | 6.98 | 8.07 | 6.39 | 7.97 |
| 1999 | 4.27 | 6.12 | 3.55 | 5.10 |
| 2000 | 6.91 | 8.71 | 6.60 | 8.94 |
| 2001 | 7.13 | 8.52 | 4.38 | 5.05 |

Table 2: Observed percent of SBT in landed catch from different processors and the percent of all tuna that was graded as export quality from the first six months of the expanded IOTC sampling program in the latter half of 2002.

| Processor | % SBT processed | % of tunas graded as export quality |
|---|---|---|
| BK | 13.46 | 58.57 |
| BMM | 2.41 | 48.48 |
| BNWM | 4.62 | 60.11 |
| BT | 1.15 | 55.65 |
| BTS | 5.04 | 60.78 |
| CS | 3.68 | 69.64 |
| HSL | 0.70 | 46.82 |
| IMS | 8.02 | 54.73 |
| JK | 1.79 | 66.68 |
| PSB | 4.82 | 55.51 |
| SSU * | 1.07 | 55.73 |
| GI | 16.49 | 59.28 |
| Grand Total | 4.70 | 58.88 |

*In this table, SSU processes landings mainly from its own boats, which formed only part of the landings processed under the SSU category in the CSIRO/RIMF catch monitoring. Thus they are not comparable with previous years. The two processing rooms monitored at SSU under the old scheme were Gilontas Indonesia (GI) and Pahala Bahari. GI processed landings of many fishing companies then, but many of these left over time, and during the IOTC monitoring in late 2002 on which this table is based, they processed few landings other than from their own vessels. GI processing currently does not exist, the fishing company boats now processing at Hentri Jaya in 2003. Pahala Bahari no longer operates.

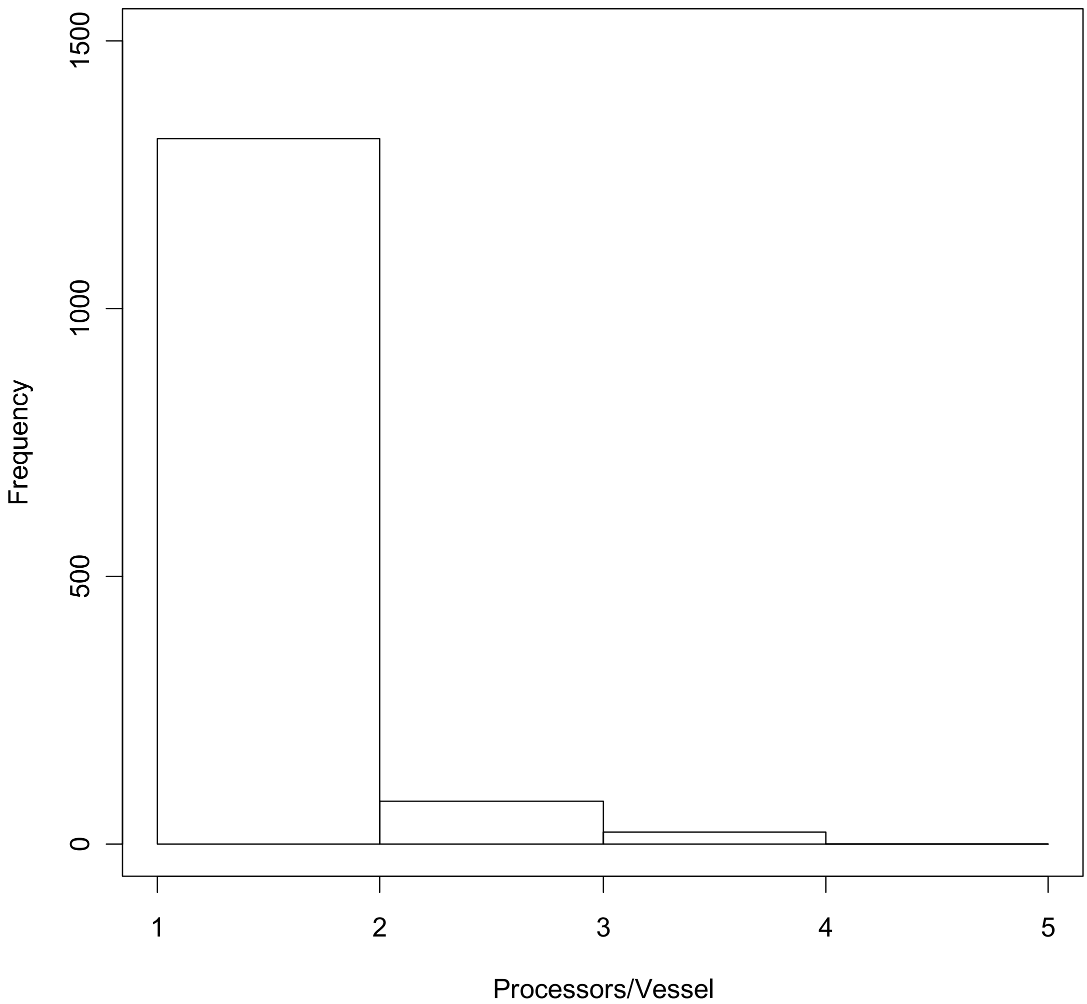



Figure 1: Frequency distribution of the number of processors visited by each vessel from which landing data were collected over the nine year period from 1993 to 2001. Note that because of name changes that there is double counting of some vessels.

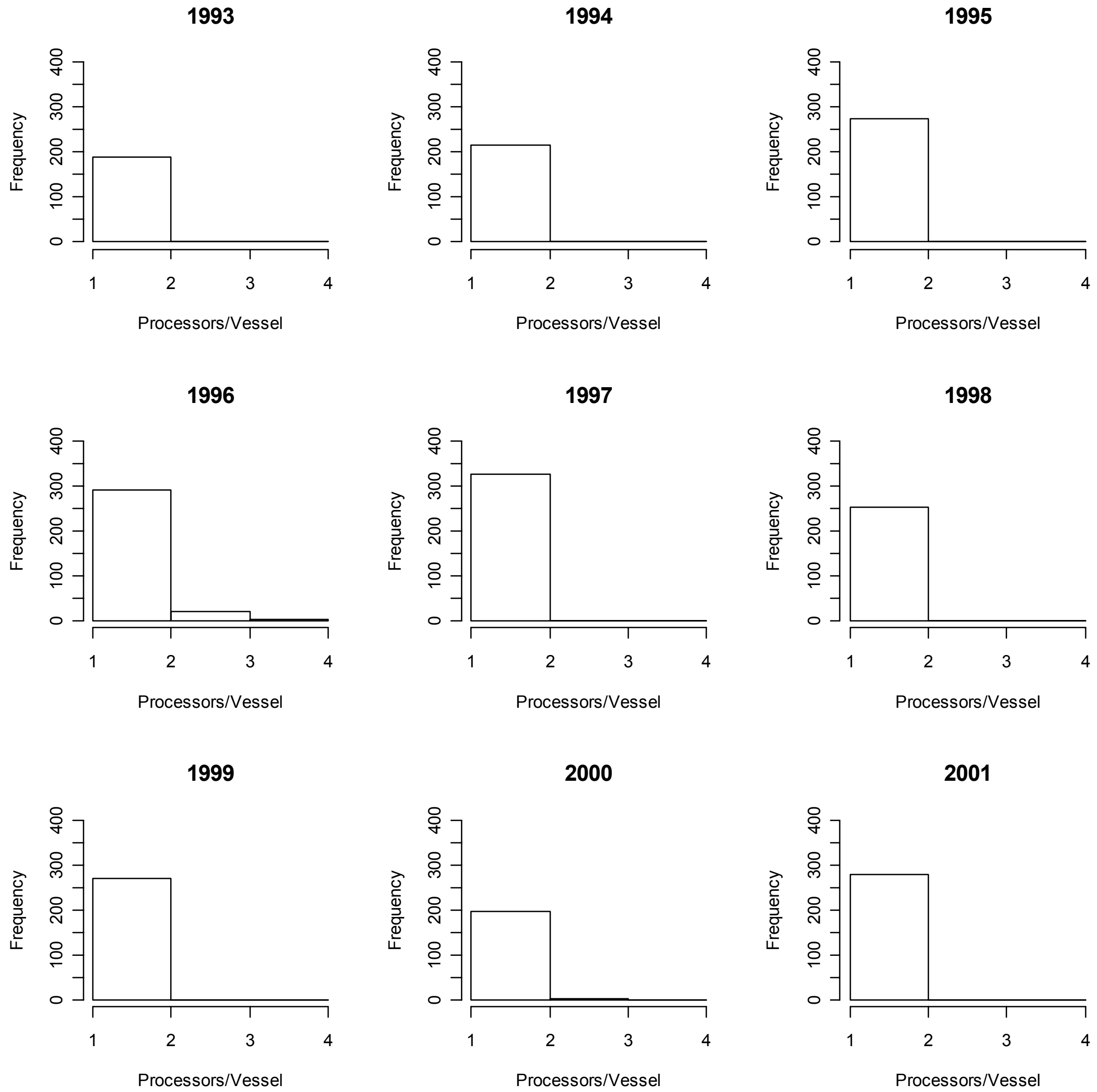



Figure 2: Frequency distribution of the number of processors visited by each vessel from which landing data were collected within any given year.

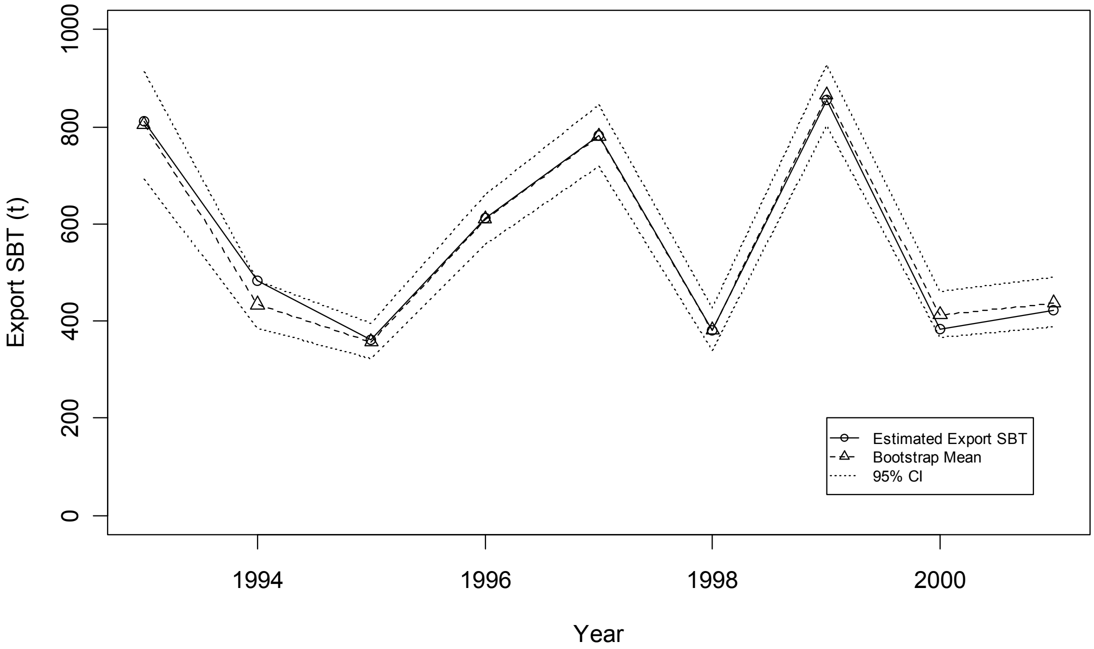



Figure 3. Bootstrap results for the estimated total SBT exported from Bali when the re-sampling unit was an individual landing. Shown are the mean and 95% confidence interval for the bootstrap results as well as the actual estimate based on the full data set.

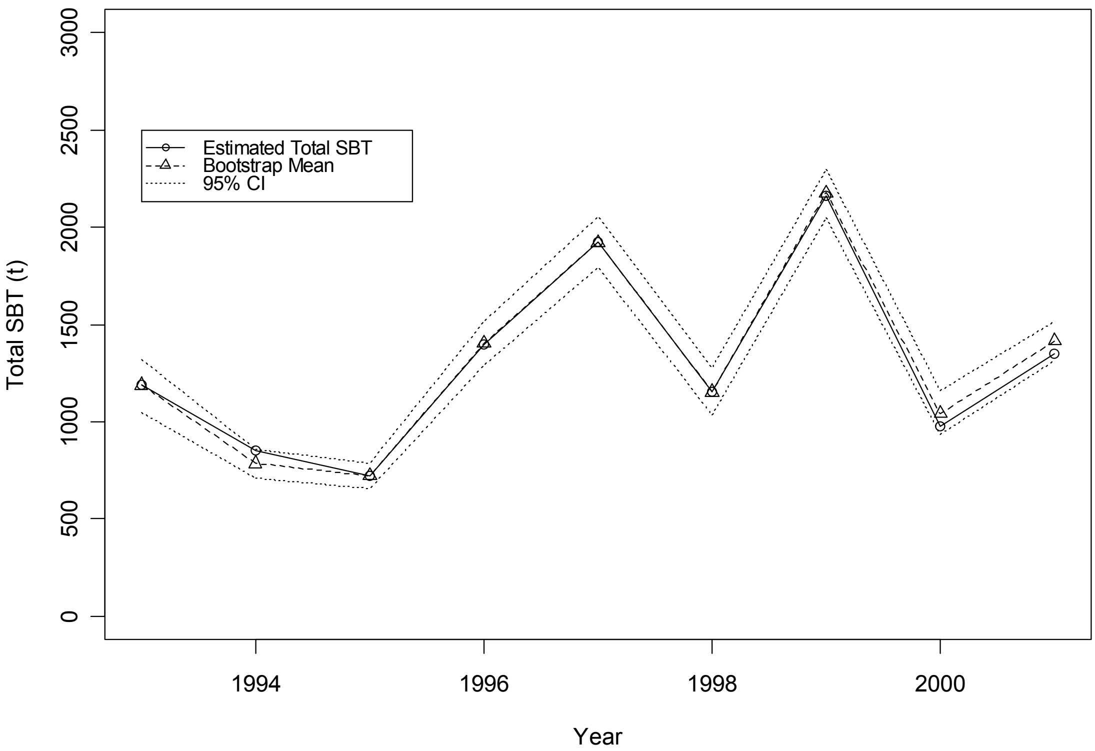



Figure 4: Bootstrap results for the estimated total SBT landed in Bali when the re-sampling unit was an individual landing. Shown are the mean and 95% confidence interval for the bootstrap results as well as the actual estimate based on the full data set.

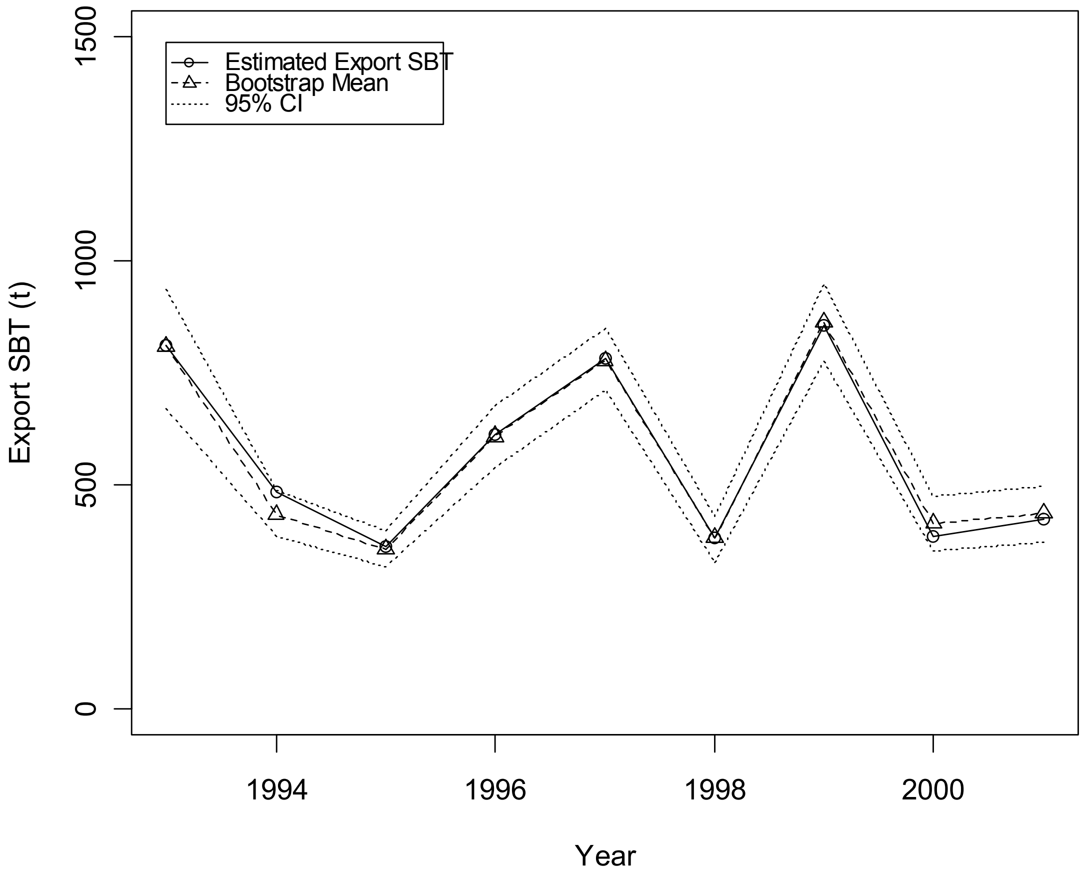



Figure 5: Bootstrap results for the estimated total SBT exported from Bali when the re-sampling unit was an individual vessel. Shown are the mean and 95% confidence interval for the bootstrap results as well as the actual estimate based on the full data set.

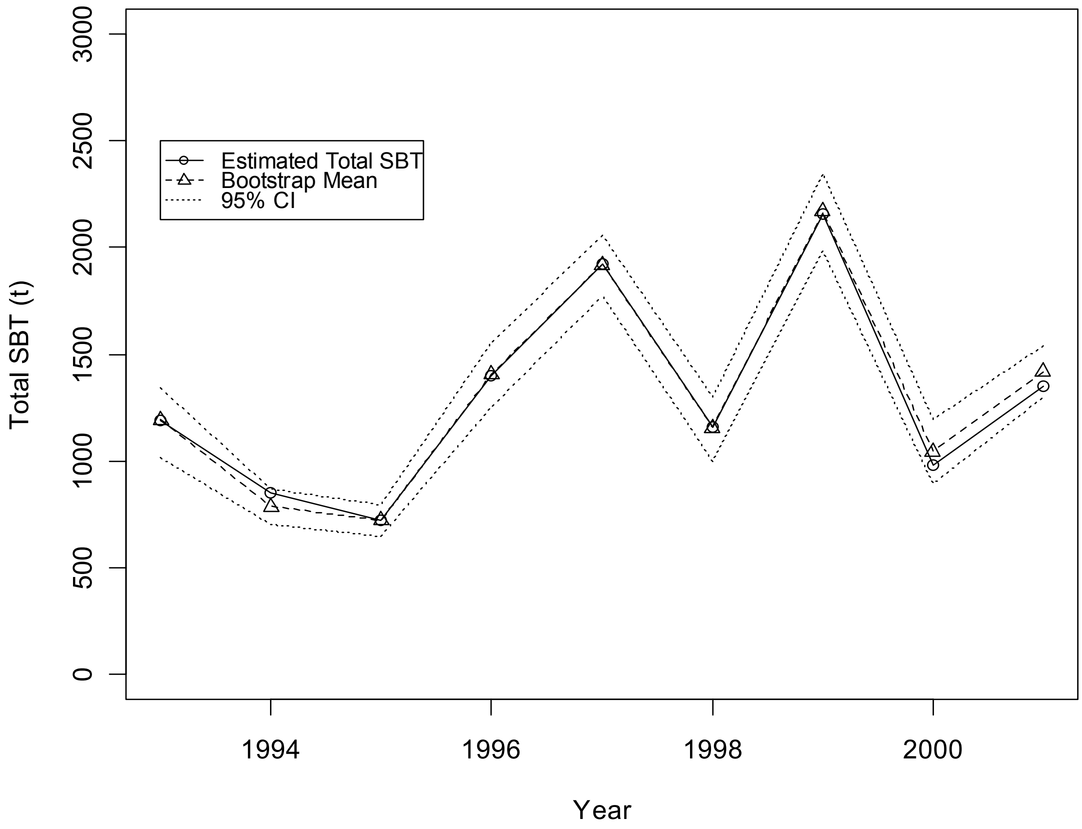



Figure 6: Bootstrap results for the estimated total SBT landed in Bali when the re-sampling unit was an individual vessel. Shown are the mean and 95% confidence interval for the bootstrap results as well as the actual estimate based on the full data set.

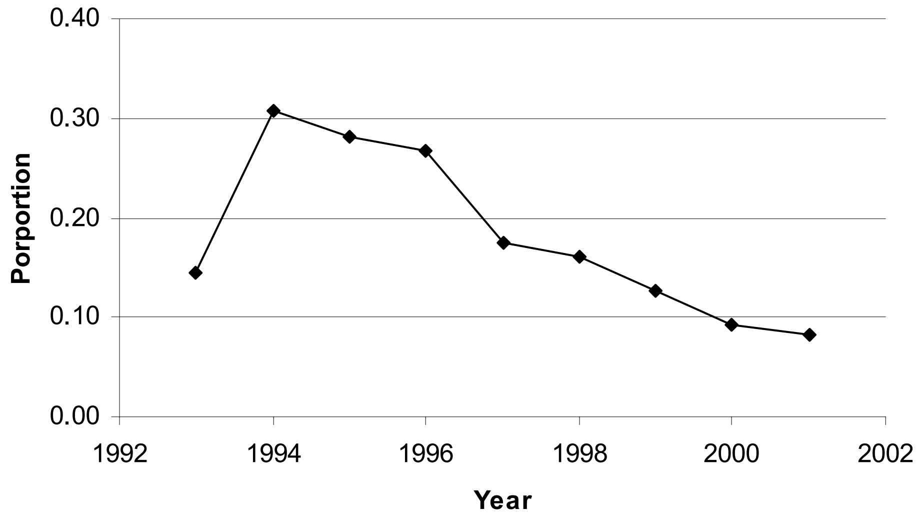



Figure 7: The estimated annual proportion of Dinas exported statistics that were sampled based on the total weight of tuna sampled that were graded as export quality in all processors that were sampled

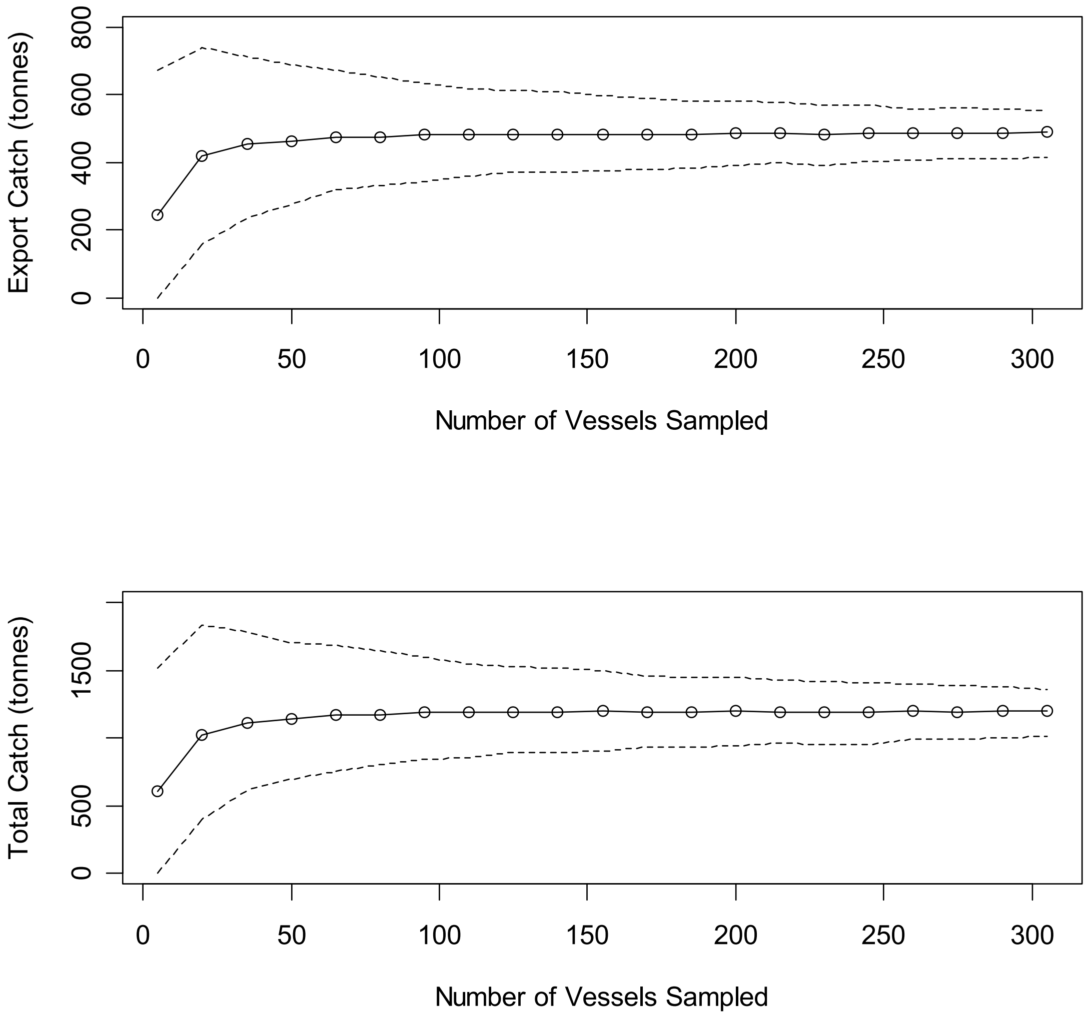



Figure 8. Estimated mean export SBT (top-panel) and mean total SBT (lower panel) catch as a function of the number of vessels sampled. Dashed lines are 95% confidence intervals.

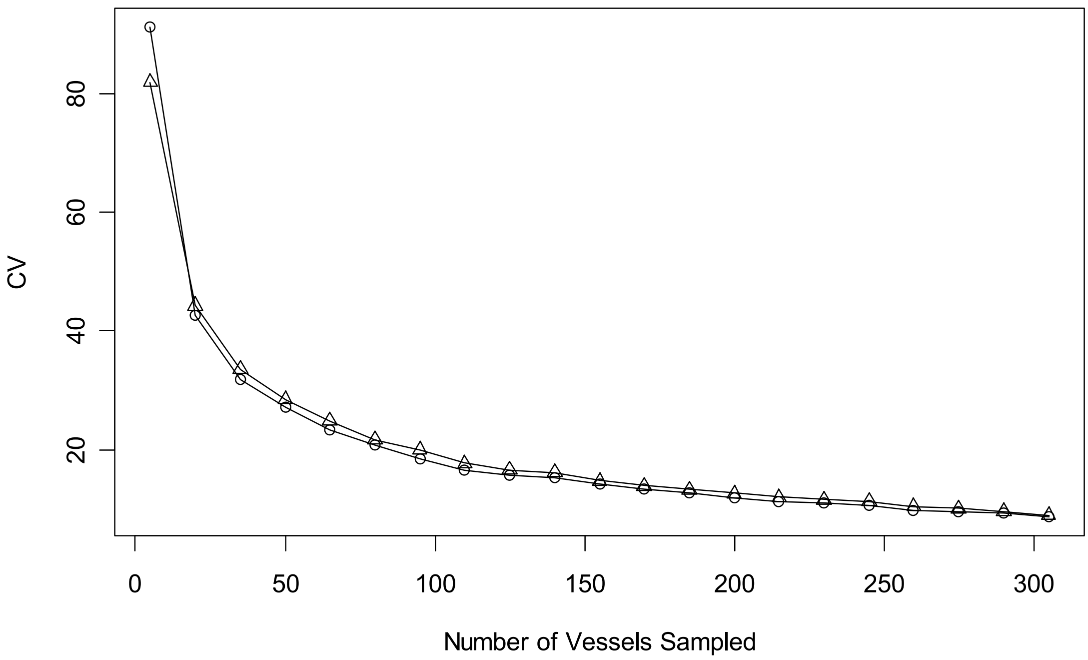
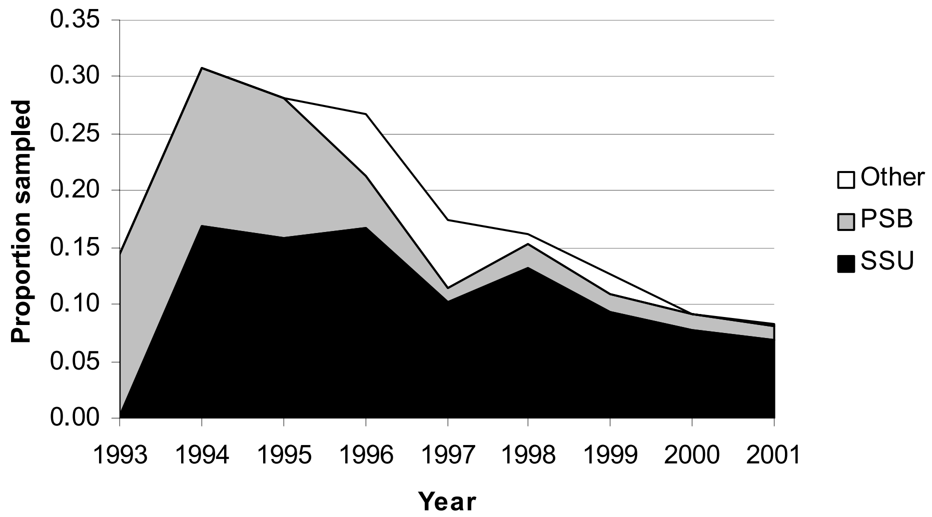



Figure 9: Estimates of the coefficient of variation for the estimates export and total SBT landings in 1996 as a function of the number of vessels sampled..



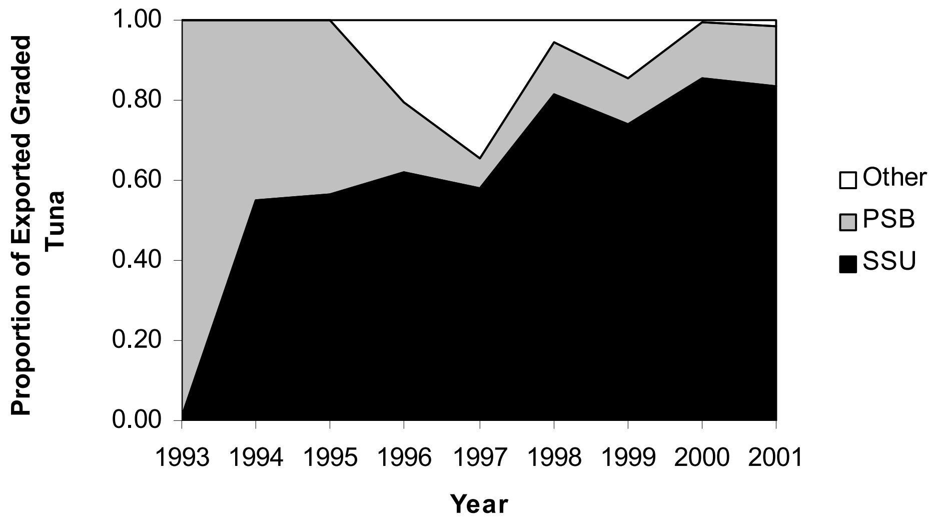




Figure 10: The estimated proportion of the Dinas export statistics of total tunas sampled by processor and the proportion of the total export statistics during a year which came from an individual processor.

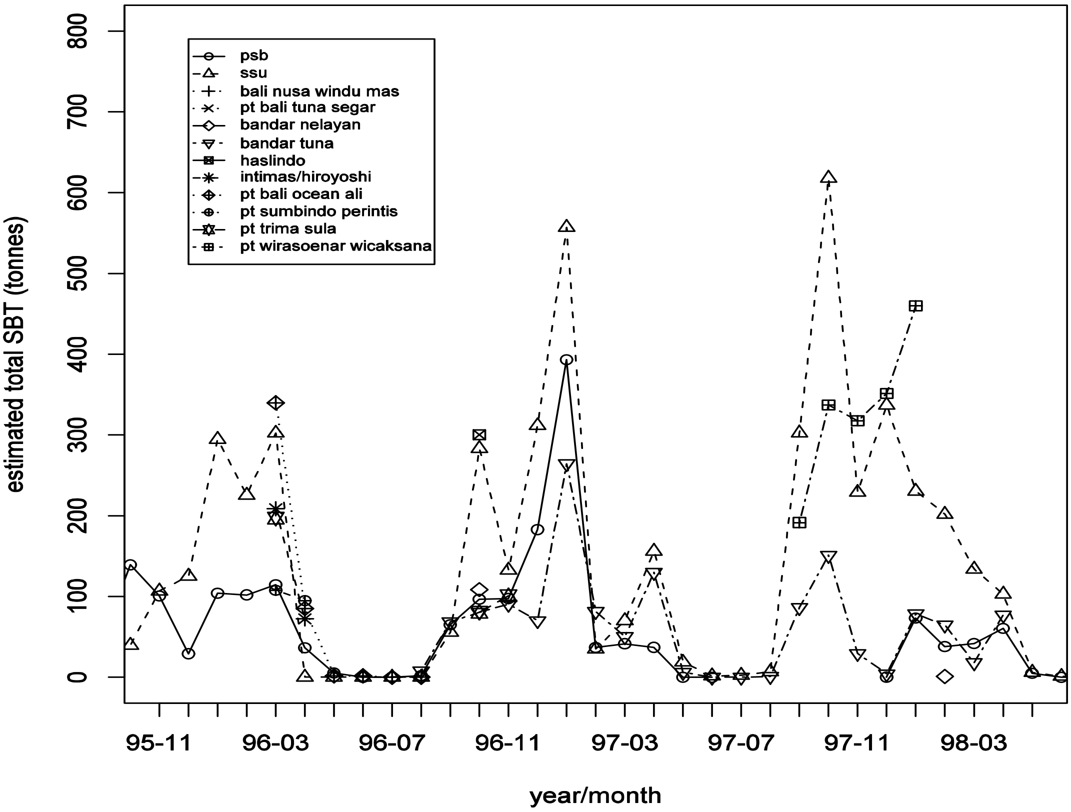



Figure 11. Estimates of the total monthly SBT landed in Bali when only the data from only a single processor are used in the estimation. Shown is the period in which sampling occurred at the largest number of processors (Nov-1995 to Jun-1998).

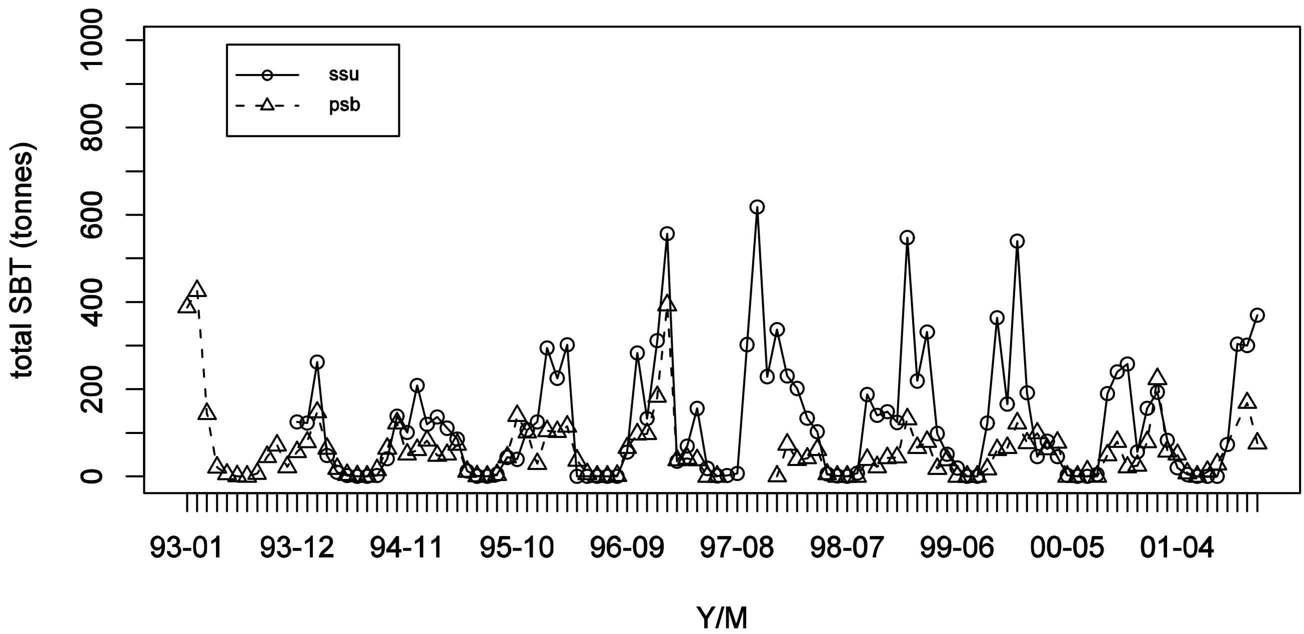
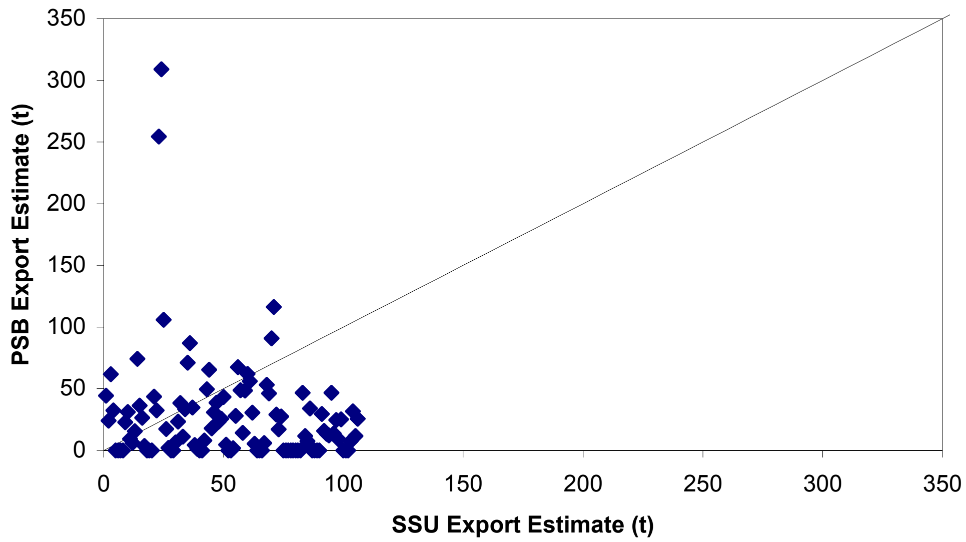



Figure 12. Estimates of the total monthly SBT landed in Bali when only the date from either the PSB and SSU processor are used in the estimation.



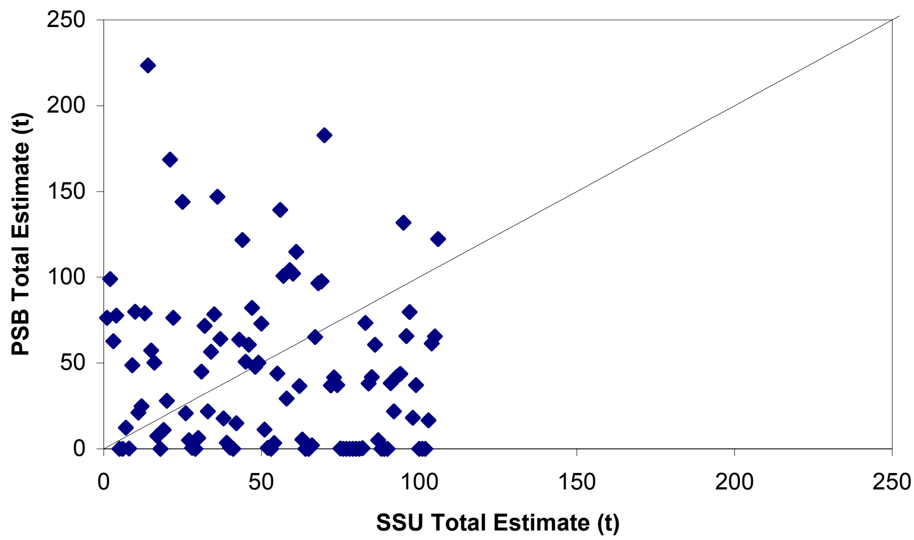




Fig 13. The relationship between the estimated exported quantity of SBT and the total SBT landings in a month when only data from either the PSB or SSU processor are used export and total catch estimates. The line is the 1:1 line.

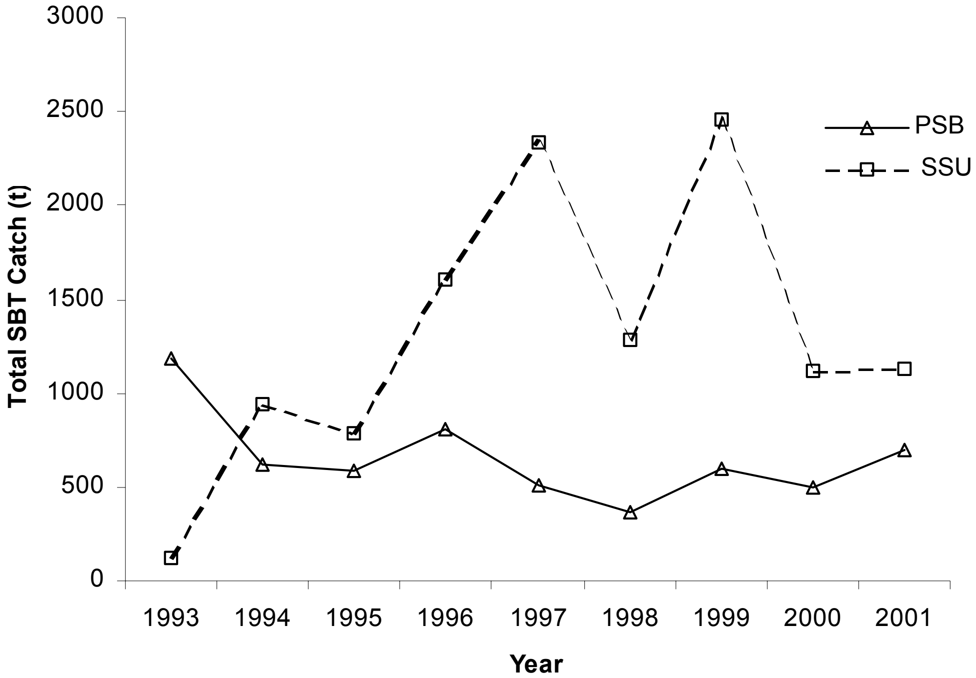
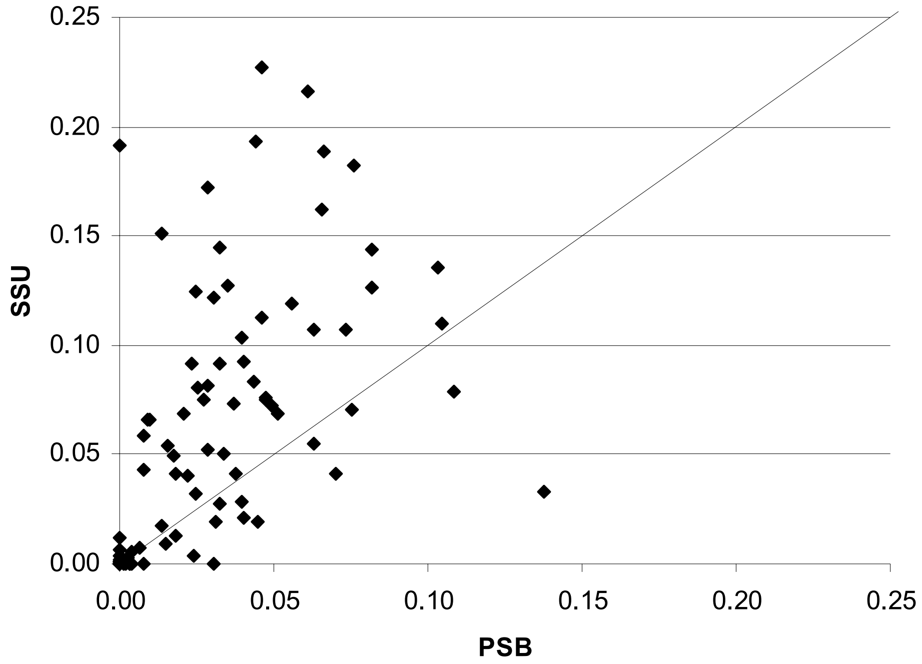



Figure 14: Estimates of the total annual SBT landed in Bali when only data from either the PSU or SSU processing facility are used.




]
Figure 15: Relationship between the proportion of the landed catch at PSB and SSU in a given month that was SBT. Note that the PSB figures exclude PSB owned vessels.

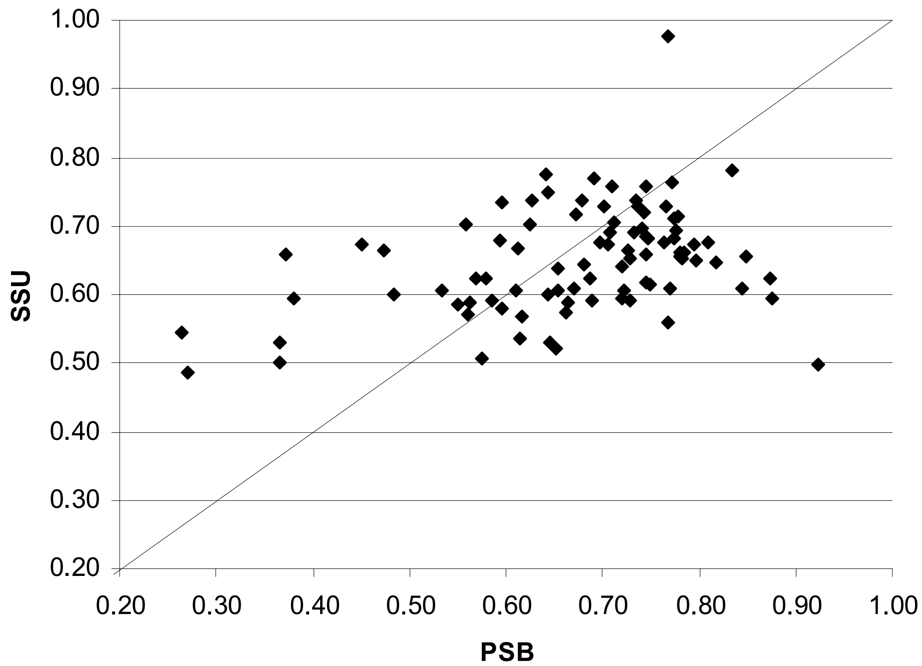
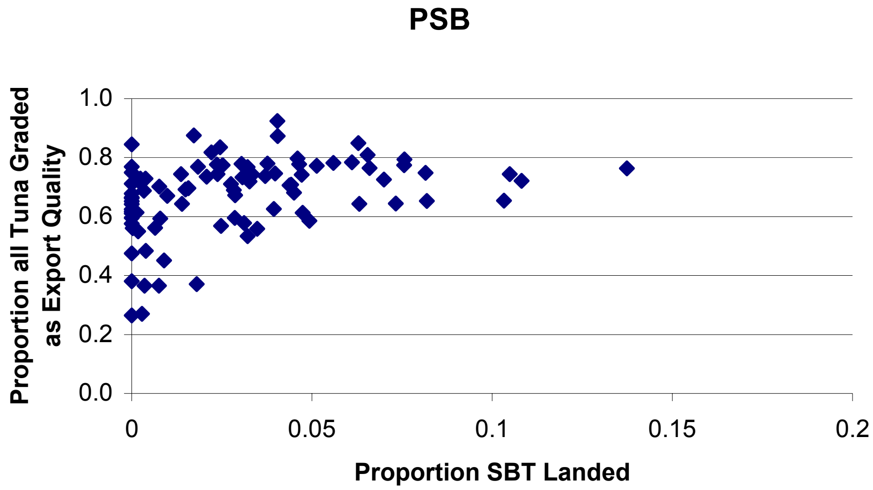



Figure 16: The relationship between the proportion of all tunas landed that were graded as exported quality at SSU and PSB in a given month.



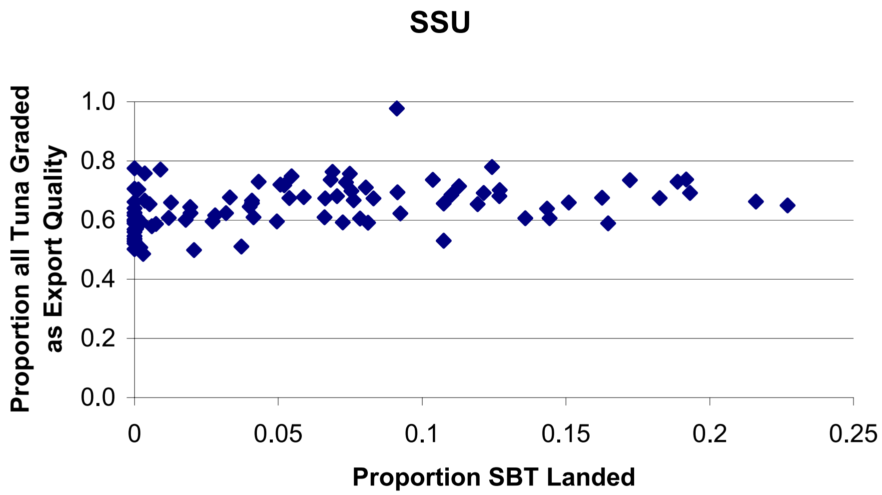




Figure 17: Relationship between the proportion of SBT landed at a processor in a month and the proportion of all tunas graded as export quality.

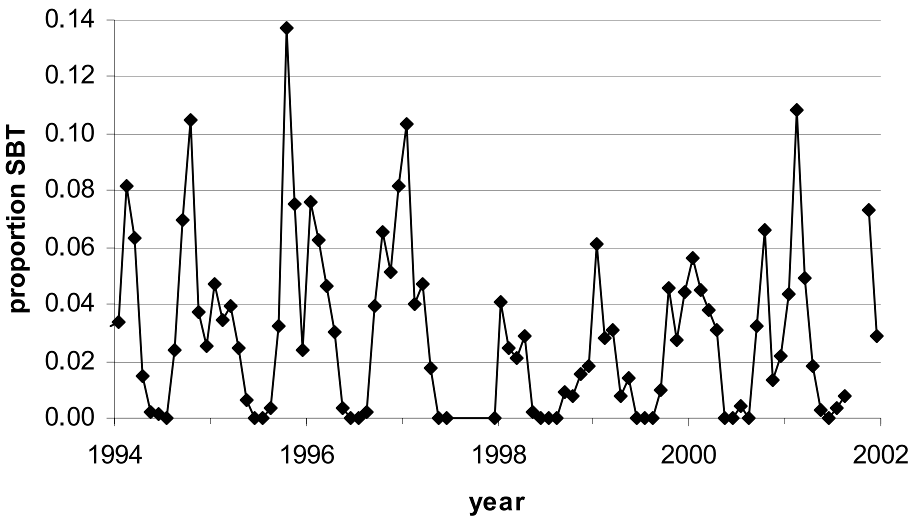



Figure 18: Proportion of all tunas landed which were SBT in the sample taken at PSB in a given month.

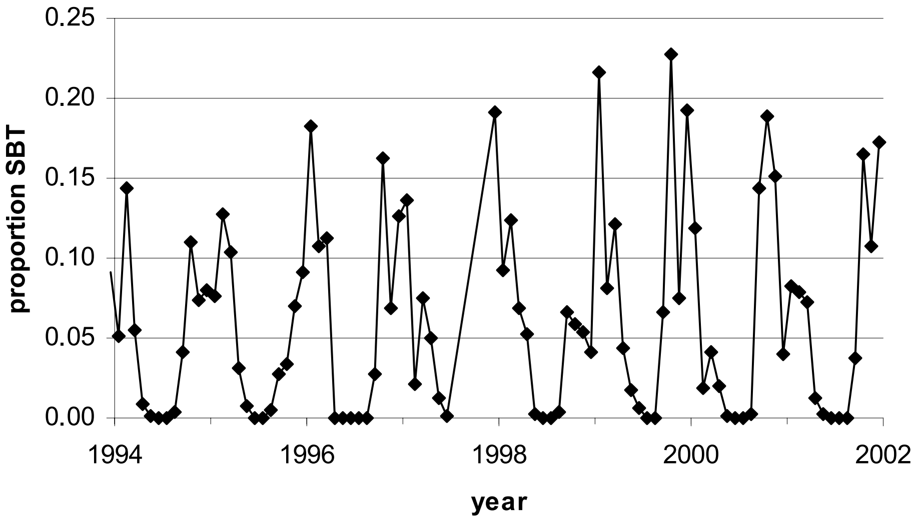



Figure 19: Proportion of all tunas landed which were SBT in the sample taken at SSU in a given month.

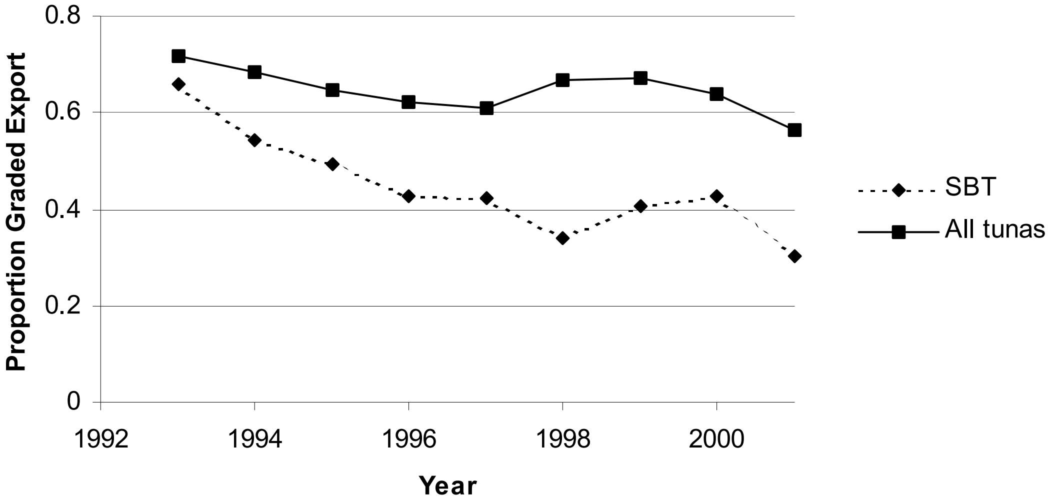



Figure 20: The proportion of all tunas sampled in a given year that were graded as export quality and the proportion of SBT sampled in a given year that were graded as export quality excluding catches by PSB vessels.