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INTRODUCTION

Port and at-sea observer sampling for length frequency are used to monitor sizes of fish caught by U.S. purse seiners fishing under the South Pacific Regional Tuna Treaty (SPTT). The majority of the port sampling is carried out in Pago Pago, American Samoa by National Marine Fisheries Service (NMFS) biological technicians. At-sea observers are trained and supervised by the Forum Fisheries Agency (FFA). NMFS technicians collect four types of fishery data from all U.S. vessels, catch report forms, unloading logsheets, catch length frequency and species composition. The FFA maintains approximately 23% coverage of U.S. fleet trips and collects logbook, catch length frequency and enforcement data.

This report contains the results of a study that compares length-frequency samples collected by port samplers and at-sea observers. The study uses yellowfin (*Thunnus albacares*) and skipjack tuna (*Katsuwonus pelamis*) catch length frequencies collected by port samplers and at-sea observers during the period 1988-1996.

METHODS

At-sea observer catch length-frequency data were provided by the FFA and the South Pacific Commission, for the period 1988-1996. NMFS provided similar data for port samplers. Length-frequency data were compared by levels of aggregation: single set, month-sampling area (Figure 1), year-sampling area and for the entire year.

The observer data were edited. Some duplicate samples were found and deleted. Samples were also deleted when no matching catch data were found in the catch report forms that could be used to weight the length frequencies before aggregation. Other differences between the observer samples and the catch report forms, especially for dates, times, set numbers and well numbers, caused samples to be deleted from this study.

Length-frequency samples were selected for comparison when certain criteria were met at each level of aggregation. In the first level, single-set samples were compared. If an observer sampled a single set and that set was placed in a well or set of wells and those wells were sampled by a port sampler, then these paired samples were selected for a level 1 comparison.

Because the port sampling program was not designed to sample single sets, three other levels of aggregation (levels 2-4) were used to see if port and observer sampling would produce the same results. In level 2, month-sampling area, samples were weighted by set catches or well catches and aggregated by month-sampling area strata. In level 3, year-sampling area, level 2 port and observer samples were further weighted by the catches in each month-sampling area strata and aggregated by year and sampling area. In level 4, samples compared at level 3 were further weighted by the catches in each sampling area and aggregated to yearly frequencies.

Length-frequency samples were weighted for the size of the catch sampled as follows: (1) Length frequencies were converted to weight frequencies with the length-weight relationship,

$$W_i = \alpha L_i^{\beta}$$

where W is weight in kilograms (kg), L is length in centimeters (cm), I is length interval in cm, α is .00003256 for yellowfin tuna and .00001062 for skipjack tuna and β is 3.05834 for yellowfin tuna and 3.36836 for skipjack tuna (Nakamura and Uchiyama, 1966). (2) Average weight was calculated from the weight frequencies, (3) The average weight was divided into the total catch for each single set (observer samples), or well (port sample), (4) The total number of fish estimated in step 3 was redistributed throughout the original sample using the ratio of the number of fish at each length interval divided by the total number of fish sampled. Once the original samples were weighted through steps 1-4, they were simply summed to month-sampling area strata and weighted again, this time to the catch in each sampling area and month for level 2 comparisons. The combined samples were then summed by sampling area for level 3 comparisons and by year for level 4 comparisons.

Comparison of length frequencies at the four levels was accomplished using the Kolmogorov-Smirnov test (KS). In order to use the test, all compared length frequencies were standardized to 100 fish and changed to cumulative length frequencies. The KS, "d" statistic was calculated for each set of comparisons and compared to the critical "d" statistic (0.134) at the 95% level of confidence. In each case, the null hypothesis was that the two compared length frequencies were the same and the alternative hypothesis was that they were different.

RESULTS

Level 1 (single set) comparisons showed that observer samples and port samples are very seldom statistically alike. Of the 313 skipjack tuna and 207 yellowfin tuna comparisons for samples taken between 1988 and 1996, only 34 skipjack tuna and 5 yellowfin tuna comparisons were statistically the same (Table 1). This low number was not surprising because port sampling was not designed to sample single wells or sets, but rather to obtain a representative length-frequency sample from each month-sampling area stratum. Figures 2 and 3 show the best and worst level 1 results.

For these comparisons, observers measured more large fish (>9 kg for yellowfin tuna and 3 kg for skipjack tuna) than port sampling, and the port sampling measured more small fish than the observer sampling (Figure 4). The average size of skipjack and yellowfin tuna measured by observers (1988-1996) was 57 cm and 86 cm respectively and for port samplers 53 cm and 69 cm. The differences in sizes sampled was probably caused by the relatively small tonnages of large fish, unloaded from wells, that pass by port samplers before they can be sampled. For example, many wells may contain only 1 or 2 tons of large yellowfin tuna. These fish would easily fit into two buckets when unloaded and would pass by port samplers, whereas, they would be more readily available when single sets are brailled aboard the vessels. The difference could also be caused by biased sampling by one or both samplers.

Observer sampling also tends to have more samples of fewer than 50 fish than does port sampling (Figure 5). Thirty-eight percent of the observer yellowfin tuna and 10% of the observer skipjack tuna samples that were compared had fewer than 50 fish measured. Whereas, only 2% of the port yellowfin tuna and 1% of the port skipjack tuna samples had fewer than 50 fish measured.

Level 2 (month-sample area) comparisons yielded a higher percentage of samples that were statistically alike than at level 1 (Table 2). Of the 197 month-sampling area strata with skipjack tuna samples and 183 month-sampling area strata with yellowfin tuna samples, 137 skipjack tuna and 130 yellowfin tuna paired length-frequencies could be analyzed. Of these comparisons only 46 skipjack tuna and 10 yellowfin tuna comparisons were statistically alike. The best and worst of these comparisons are shown in Figure 6 and 7.

Level 3 (year-sampling area) comparison, results are shown in Table 3. Of the 27 year-sampling area strata with skipjack tuna samples and 24 strata with yellowfin tuna samples, 21 skipjack tuna and 21 yellowfin tuna paired length-frequencies could be analyzed. Of these comparisons only 11 skipjack tuna and 3 yellowfin tuna comparisons were statistically alike. The best and worst of these comparisons are shown in Figures 8 and 9.

Level 4 (year) comparisons yielded 6 of the 9 skipjack tuna comparisons that were statistically alike and only 1 of 9 yellowfin tuna comparison that was statistically alike (Table 4). The best and worst of these comparisons are shown in Figures 10 and 11.

Differences between port and observer sampling for levels 2-4 were probably related to sample size, and missing month-sampling area strata. For data used in this study during the period 1988-1996, observers sampled 187,388 skipjack tuna and 82,305 yellowfin tuna, whereas, port samplers measured 261,435 skipjack tuna and 279,719 yellowfin tuna. Of the observer samples, approximately 52% of the yellowfin tuna samples and 25% of the skipjack tuna samples had fewer than 50 fish measured (Figure 12). Port samples had less than 1% of the skipjack tuna samples and less than 4% of the yellowfin tuna samples with fewer than 50 fish measured. Observers were unable to obtain samples from 56 month-sampling area strata for skipjack tuna and 51 month-sampling area strata for yellowfin tuna. Port samplers were unable to obtain samples from 3 skipjack tuna month-sampling area strata and 2 yellowfin tuna month-sampling area strata.

SUMMARY

Our findings show that observer sampling and port sampling yield statistically different length frequencies at the single set level and even for aggregated data (month-sampling area, year-sampling area, and year). Port sampling tends to measure fewer large fish and observer sampling fewer small fish. Causes of the significant differences may be inadequate sample sizes or missing month-sampling area strata from observer data. Sampling bias may also be a problem due to more availability of large fish to observers than to port samplers.

If observer samples will be used to estimate the lengths of fish in single sets, then studies are needed to establish sample sizes, especially for yellowfin tuna which have more modes to estimate. Sampling bias may also need to be assessed and may need to be corrected by augmenting port sampling with observer samples.

While our results may seem different from the most recent analysis presented by the SPC, they are not significantly different[1]. The SPC study shows that both port and observer samples produced modes that often correspond. We found that while the modes do often correspond, the distributions are statistically different; hence the two sources of sampling produce different results.

ACKNOWLEDGMENTS

We would like to thank the FFA and the SPC for supplying the observer size data.

LITERATURE CITED

Nakamura, N.L. and J.H. Uchiyama 1966. Length-weight relations of Pacific tunas. In Proceedings of the Governor's conference on central Pacific fishery resources, State of Hawaii, November 1966. p 197-201.

[1] Status of port sampling and observer size frequency data collected under the U.S. Multilateral Treaty, paper presented at the Ninth annual Treaty meeting, Port Villa, Vanuatu, March 10-14, 1997.

Table 1. Results of Kolmogorov-Smirnov level 1 (single set) comparisons of port and observer length-frequency samples.

YEAR	SKIPJACK TUNA			YELLOWFIN TUNA		
	NUMBER COMPARISONS	NUMBER REJECTED	NUMBER ACCEPTED	NUMBER COMPARISONS	NUMBER REJECTED	NUMBER ACCEPTED
1988	4	3	1	6	6	0
1989	23	21	2	23	23	0
1990	27	27	0	15	15	0
1991	81	74	7	44	43	1
1992	20	18	2	12	12	0
1993	32	30	2	28	27	1
1994	33	25	8	19	18	1
1995	48	41	7	31	30	1
1996	45	40	5	29	28	1
TOTAL	313	279	34	207	202	5

Table 2. Results of Kolmogorov-Smirnov level 2 (month-sampling area strata) comparisons of port and observer length-frequency samples.

YEAR	SKIPJACK TUNA				YELLOWFIN TUNA			
	NUMBER OF STRATA	NUMBER OF COMPARISONS	NUMBER REJECTS	NUMBER ACCEPTED	NUMBER OF STRATA	NUMBER OF COMPARISONS	NUMBER REJECTS	NUMBER ACCEPTED
1988	12	8	5	3	12	8	8	0
1989	20	13	5	8	17	13	11	2
1990	26	12	11	1	24	12	12	0
1991	22	20	18	2	19	19	18	1
1992	20	8	7	1	19	8	8	0
1993	19	15	8	7	18	13	12	1
1994	28	22	10	12	25	21	17	4
1995	25	18	9	9	24	16	15	1
1996	25	21	18	3	25	20	19	1
TOTAL	197	137	91	46	183	130	120	10

Table 3. Results of Kolmogorov-Smirnov level 3 (year-sampling area strata) comparisons of port and observer length-frequency samples.

YEAR	SKIPJACK TUNA				YELLOWFIN TUNA			
	NUMBER OF STRATA	NUMBER OF COMPARISONS	NUMBER REJECTS	NUMBER ACCEPTED	NUMBER OF STRATA	NUMBER OF COMPARISONS	NUMBER REJECTS	NUMBER ACCEPTED
1988	2	2	1	1	2	2	1	1
1989	3	2	1	1	3	2	1	1
1990	4	2	2	0	3	3	3	0
1991	3	2	2	0	2	2	2	0
1992	3	2	2	0	3	2	2	0
1993	3	3	1	2	3	2	2	0
1994	3	3	0	3	3	3	2	1
1995	3	2	0	2	2	2	2	0
1996	3	3	1	2	3	3	3	0
TOTAL	27	21	10	11	24	21	18	3

Table 4. Results of Kolmogorov-Smirnov level 4 (year strata) comparisons of port and observer length-frequency samples.

YEAR	SKIPJACK TUNA			YELLOWFIN TUNA		
	NUMBER OF FISH		REJECT/ ACCEPT	NUMBER OF FISH		REJECT/ ACCEPT
	OBSERVER SAMPLING	PORT SAMPLING		OBSERVER SAMPLING	PORT SAMPLING	
1988	6,241	12,113	ACCEPT	1,681	15,161	REJECT
1989	9,278	26,932	ACCEPT	7,189	40,093	ACCEPT
1990	7,649	30,099	REJECT	3,474	30,783	REJECT
1991	38,890	44,324	REJECT	8,046	32,873	REJECT
1992	13,759	31,434	REJECT	5,235	42,474	REJECT
1993	20,906	30,175	ACCEPT	13,259	37,674	REJECT
1994	28,878	28,726	ACCEPT	12,850	27,335	REJECT
1995	27,537	31,065	ACCEPT	15,436	30,681	REJECT
1996	34,250	26,567	ACCEPT	15,135	22,645	REJECT
TOTAL	187,388	261,435		82,305	279,719	

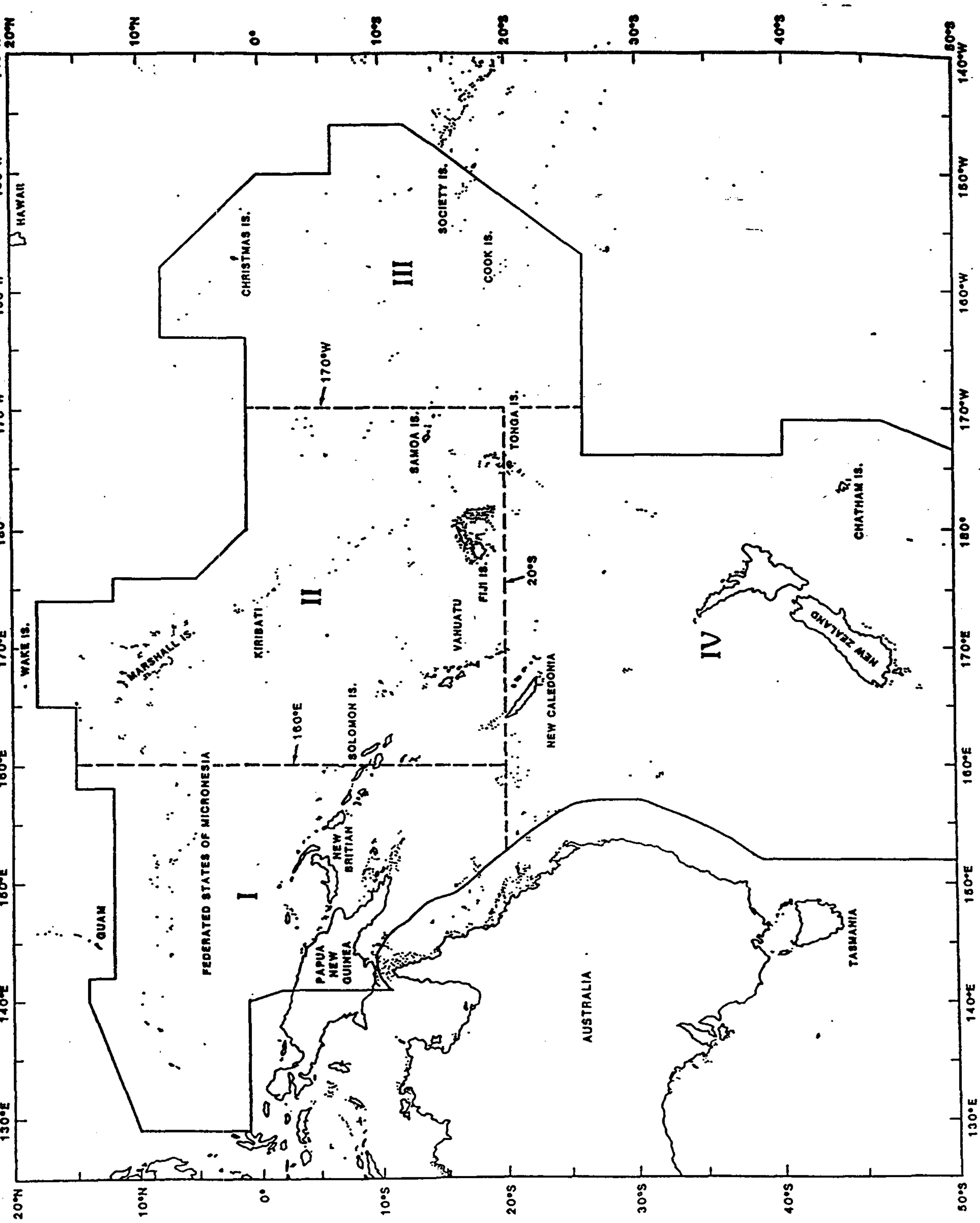
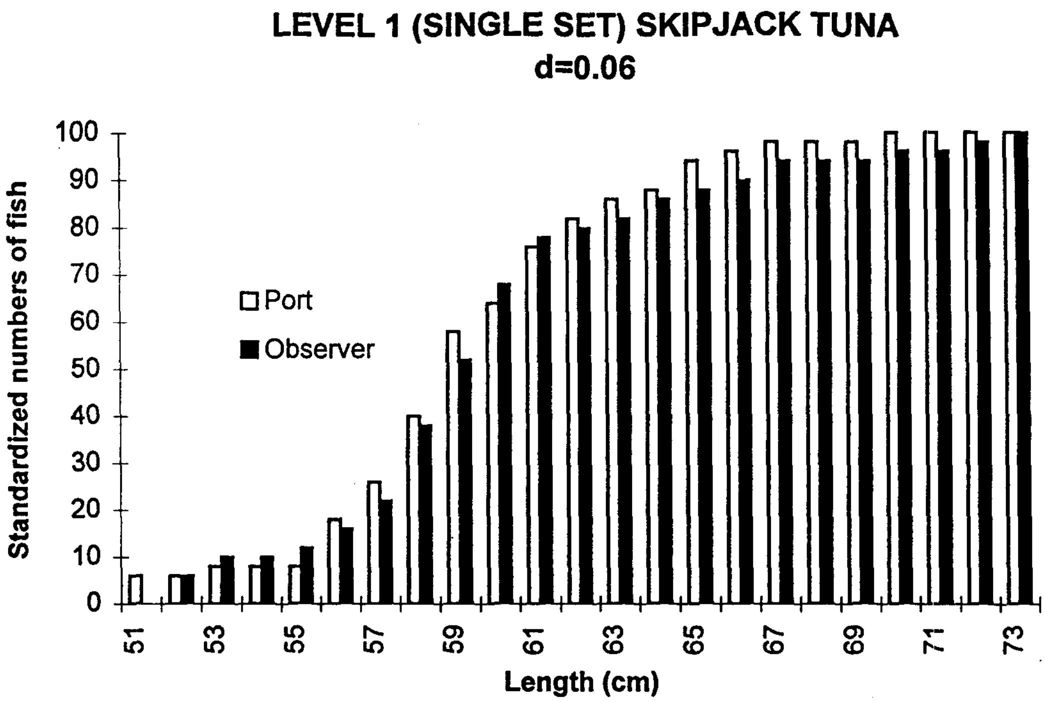


Figure 1. Sampling areas used to aggregate length-frequency samples for level 2 and 3 (month-sample area, year-sample area) comparisons.



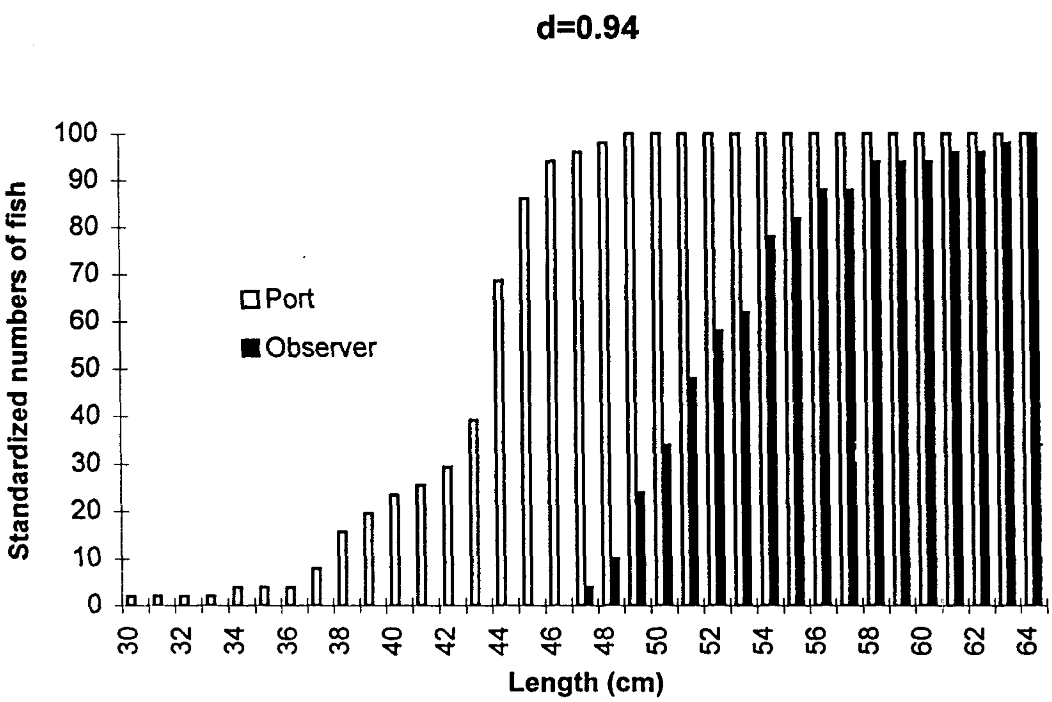


Figure 2. Best (top) and worst (bottom) level 1 (single set) skipjack tuna comparisons from port and observer sampling.

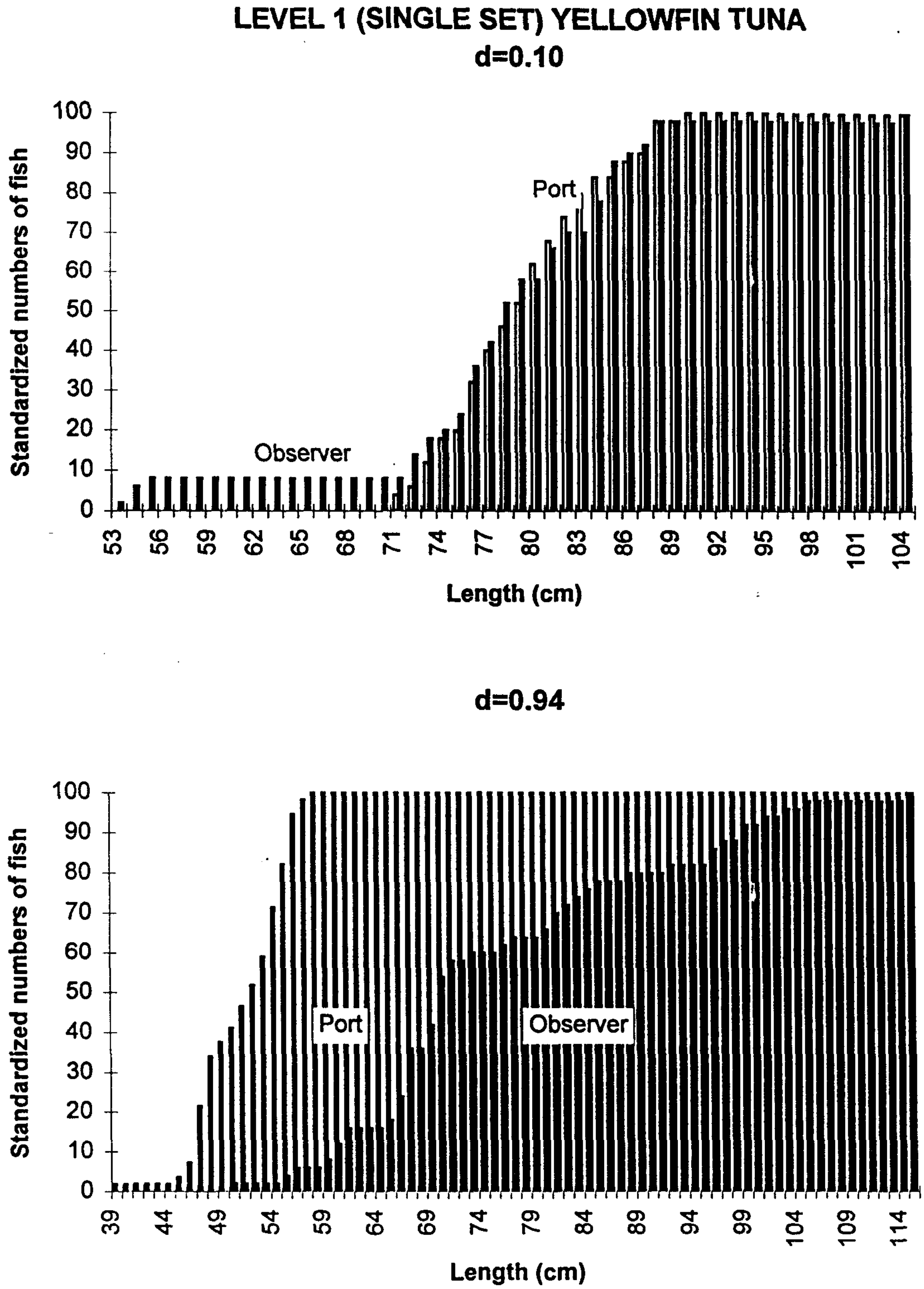
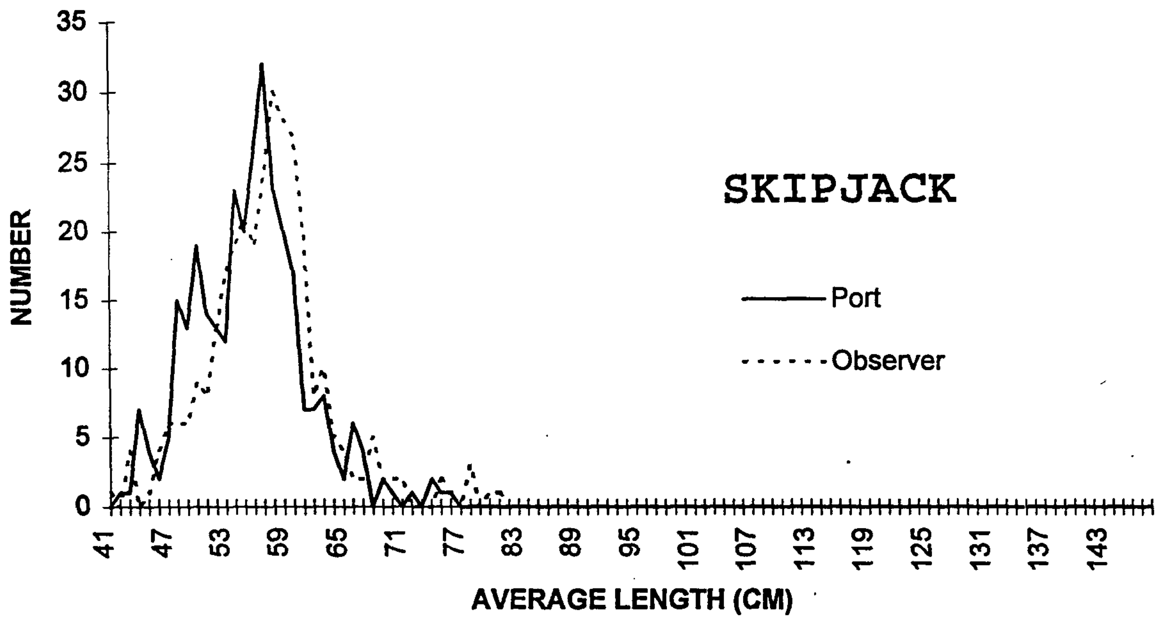


Figure 3. Best (top) and worst (bottom) level 1 (single set) yellowfin tuna comparisons from port and observer sampling.

AVERAGE LENGTHS OF PORT AND OBSERVER SAMPLES FOR LEVEL 1 COMPARISONS



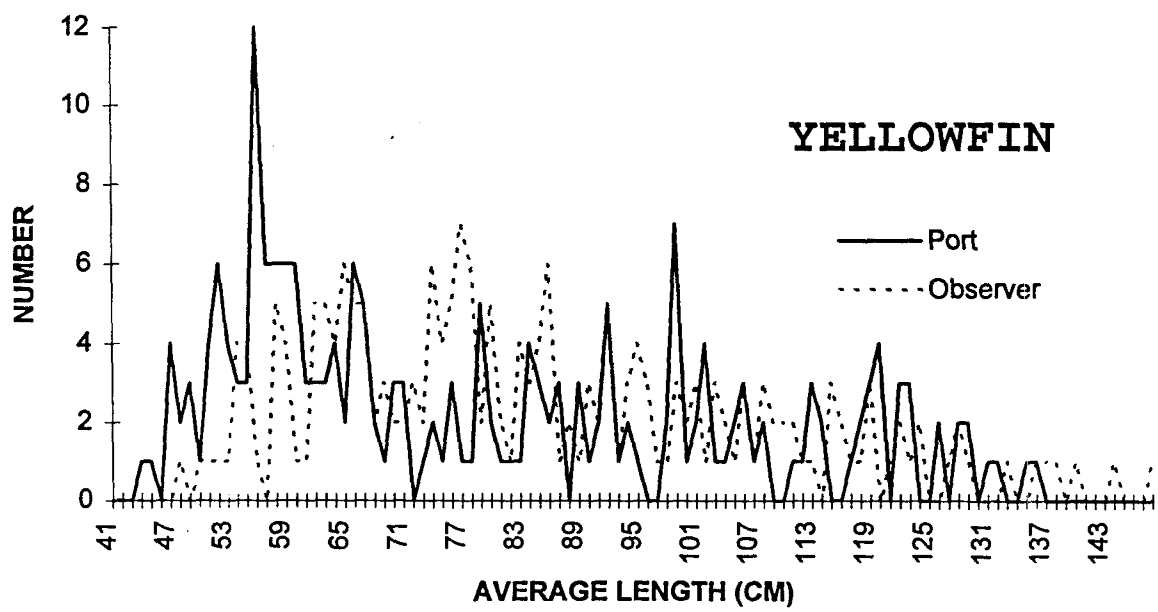
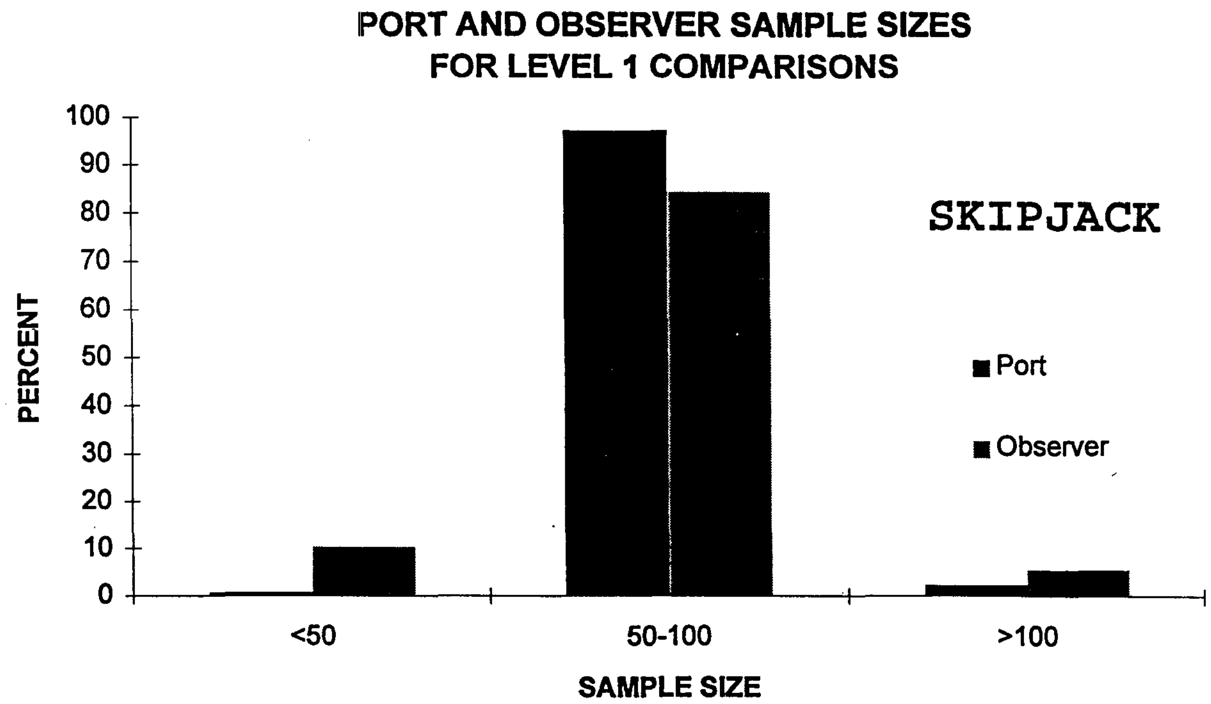


Figure 4. Average lengths of skipjack tuna (top) and yellowfin tuna (bottom) estimated from port and observer samples taken during the period 1988-1996.



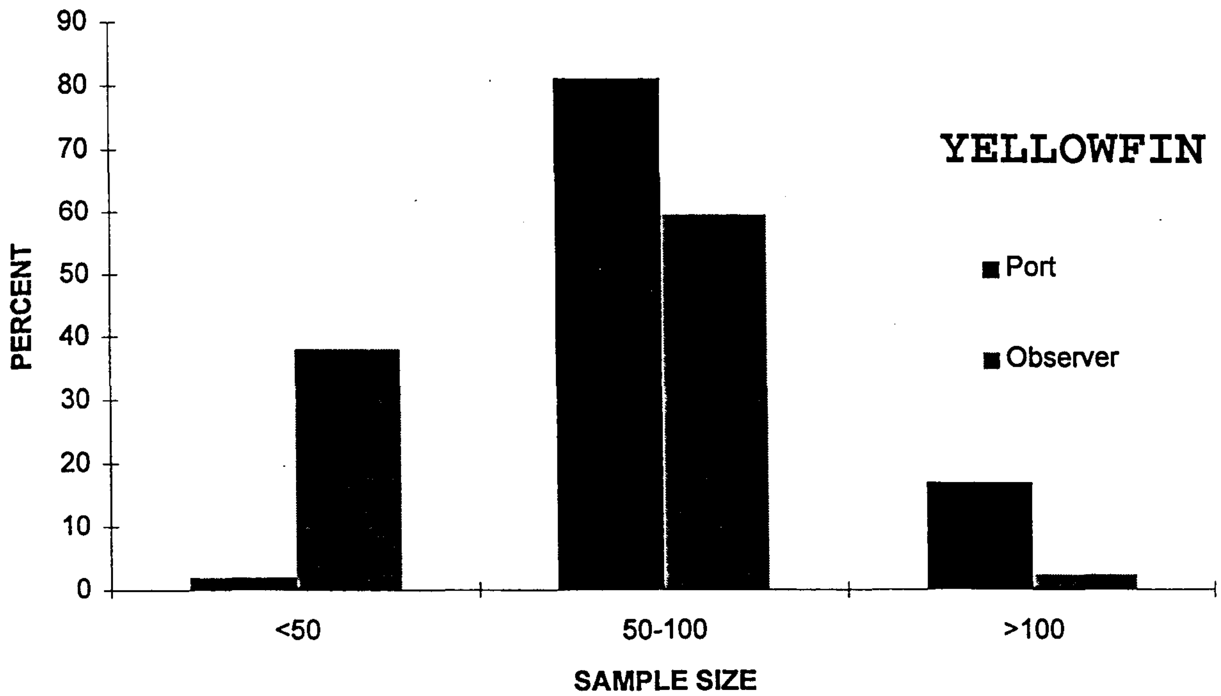
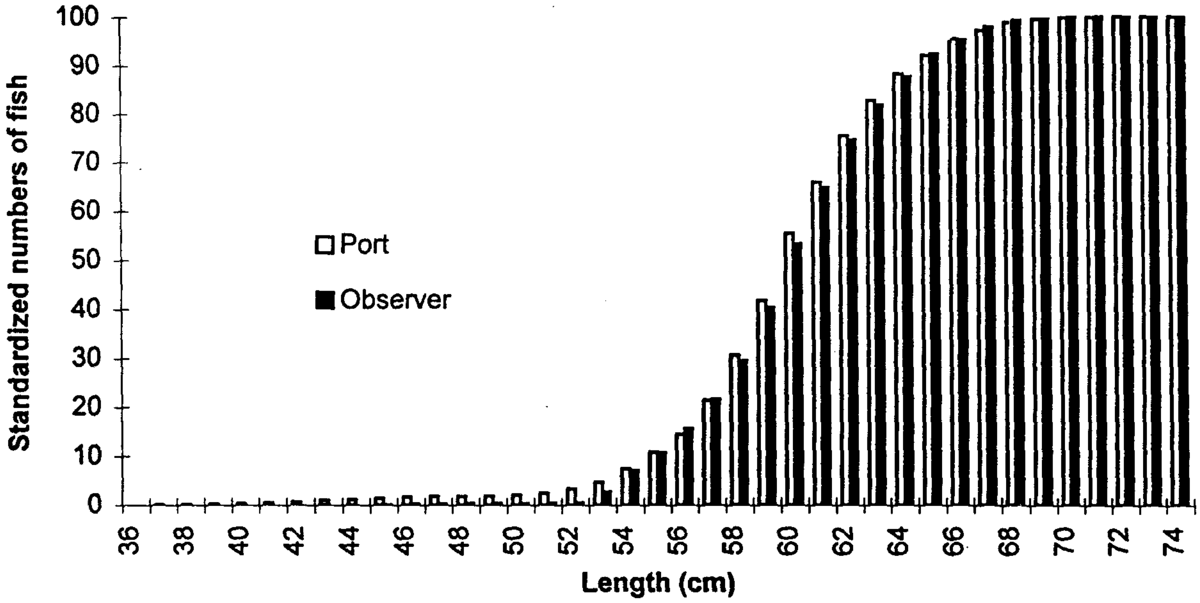


Figure 5. Percentages of skipjack tuna (top) and yellowfin tuna (bottom) samples taken at various sample sizes used in level 1 (single set) comparisons. Samples were taken by port and observer samplers during the period 1988-1996.

LEVEL 2 (MONTH-SAMPLING AREA) SKIPJACK TUNA

d=0.03



d=0.77

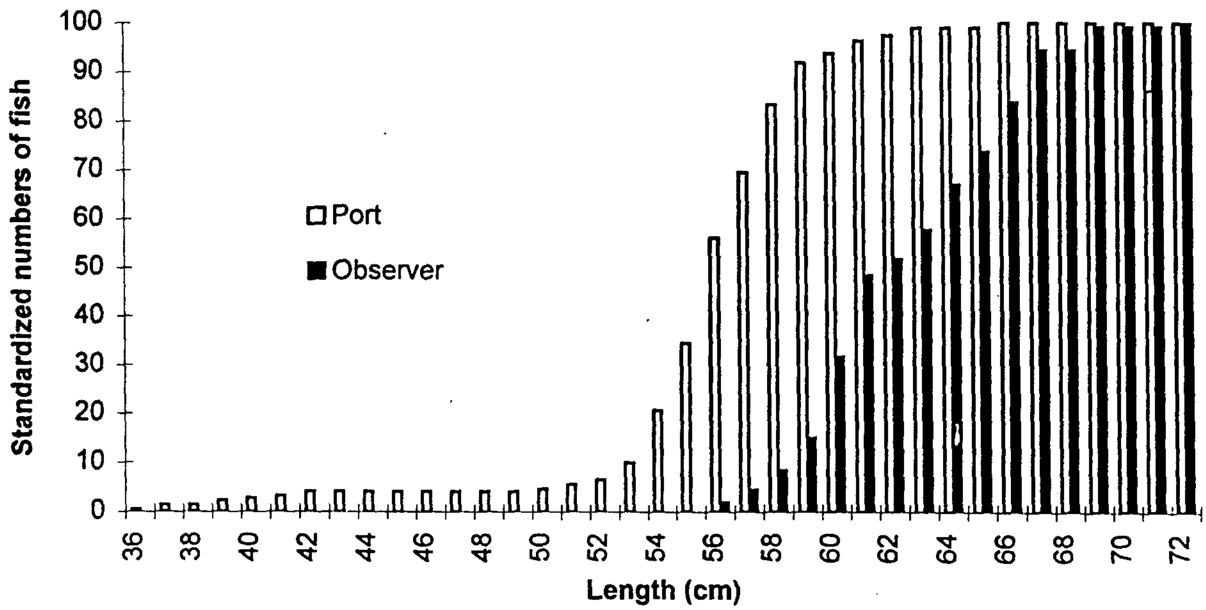
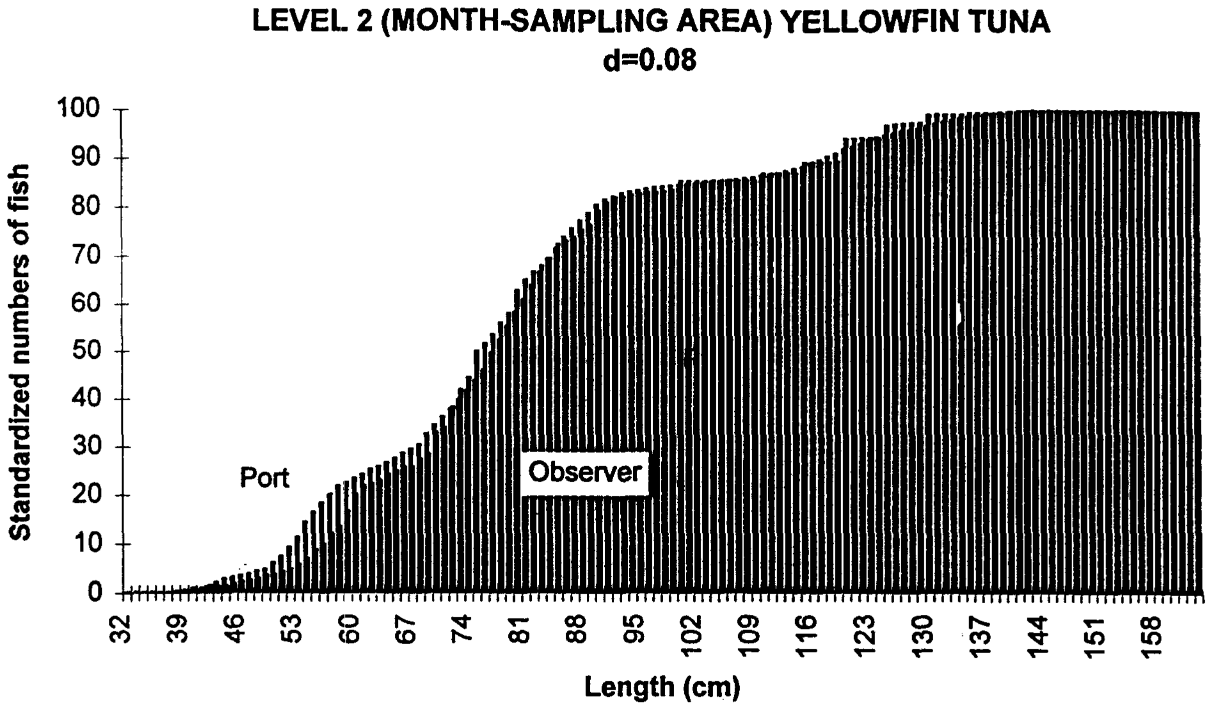


Figure 6. Best (top) and worst (bottom) level 2 (month-sampling area) skipjack tuna comparisons from port and observer sampling.



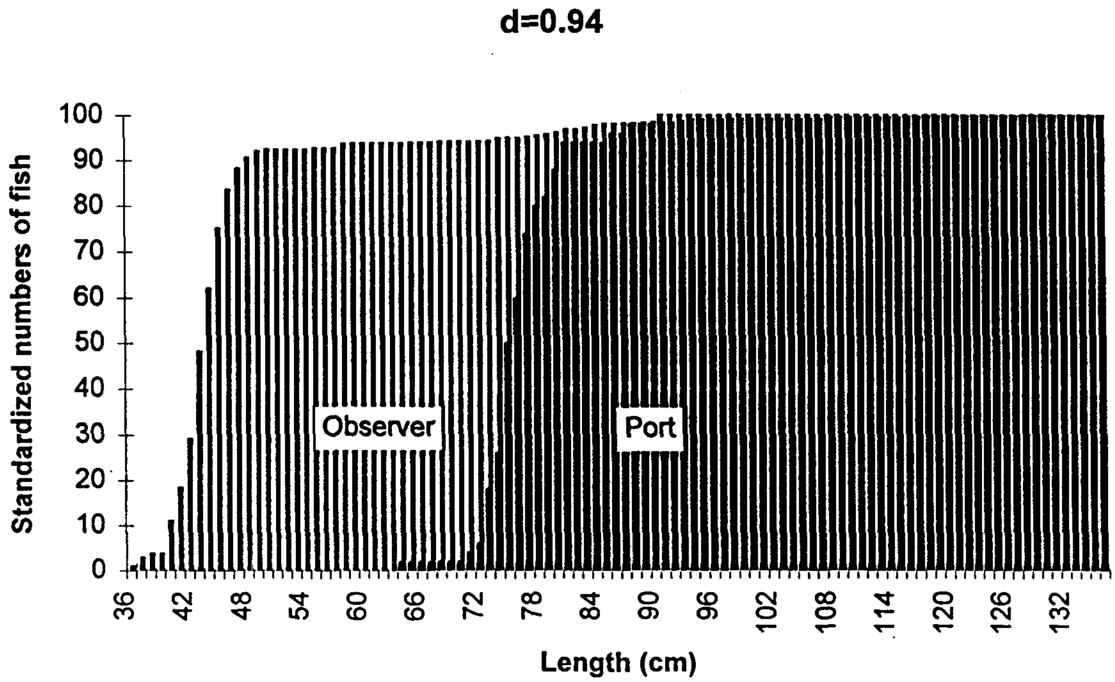


Figure 7. Best (top) and worst (bottom) level 2 (month-sampling area) yellowfin tuna comparisons from port and observer sampling.

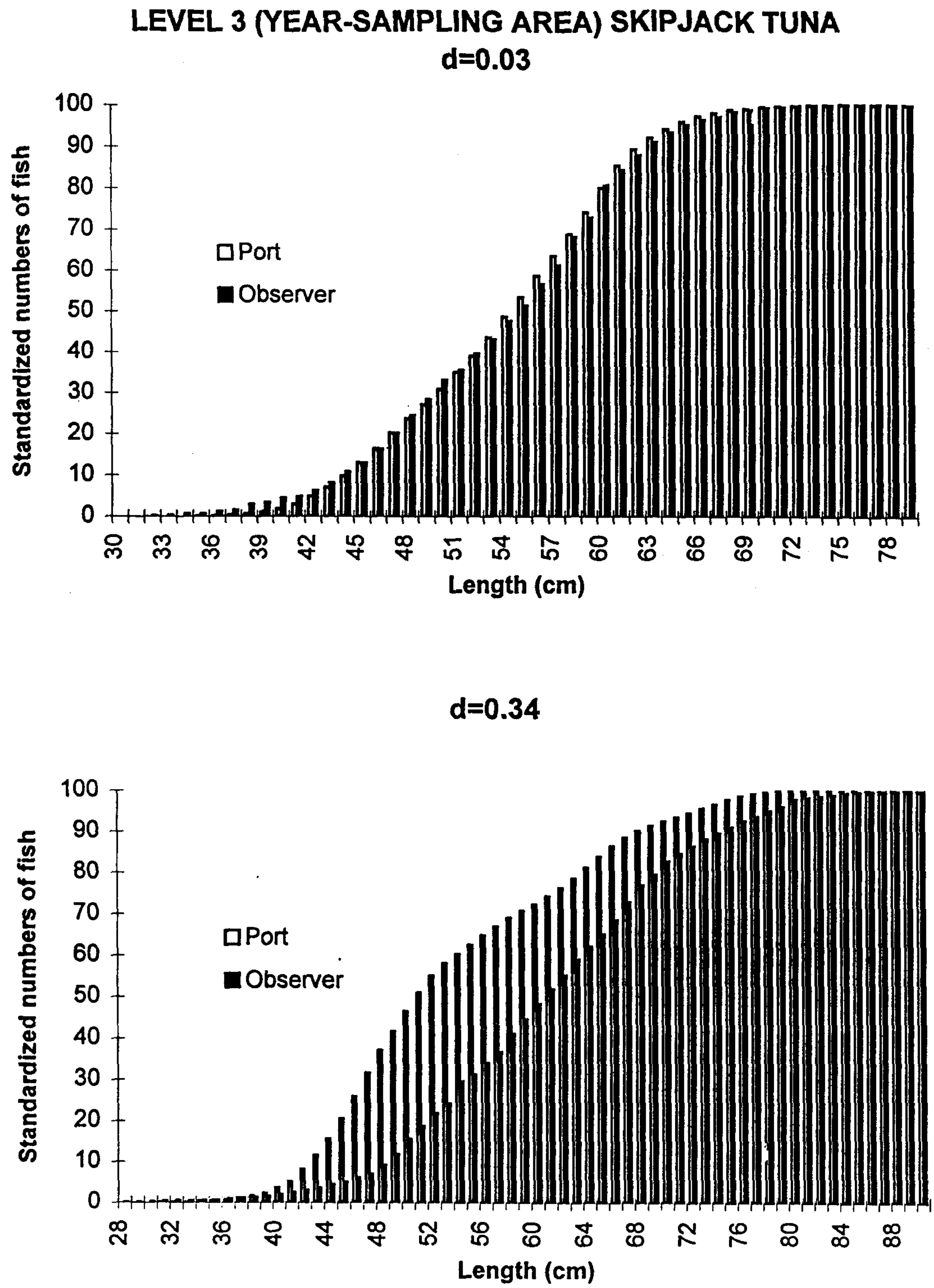
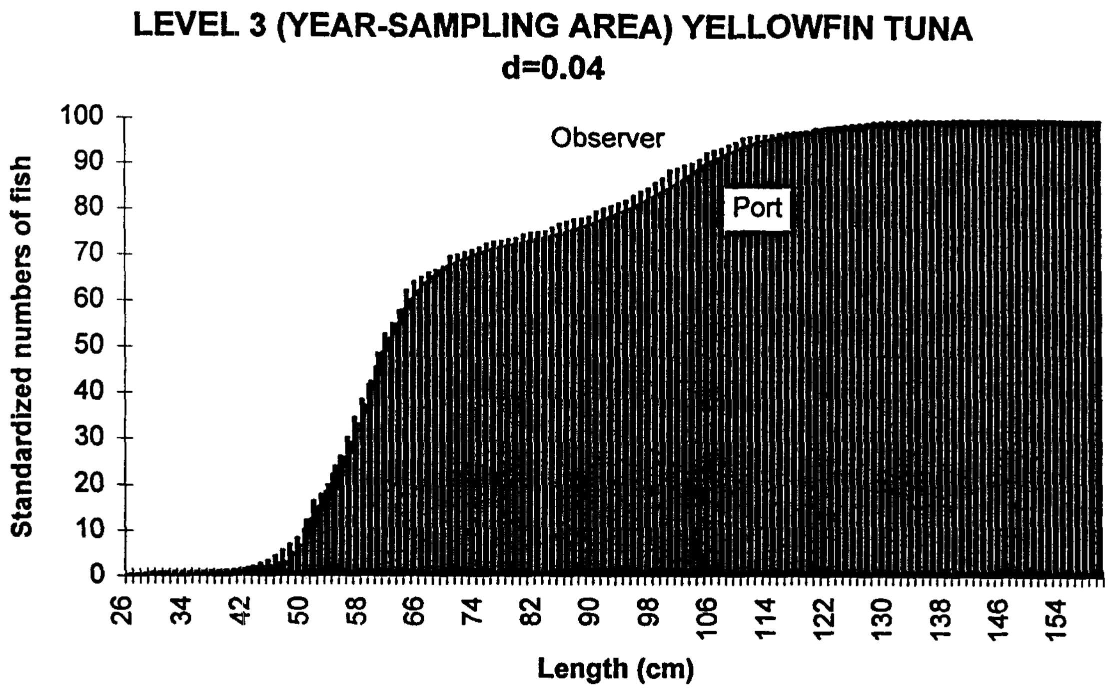


Figure 8. Best (top) and worst (bottom) level 3 (year-sampling area) skipjack tuna comparisons from port and observer sampling.



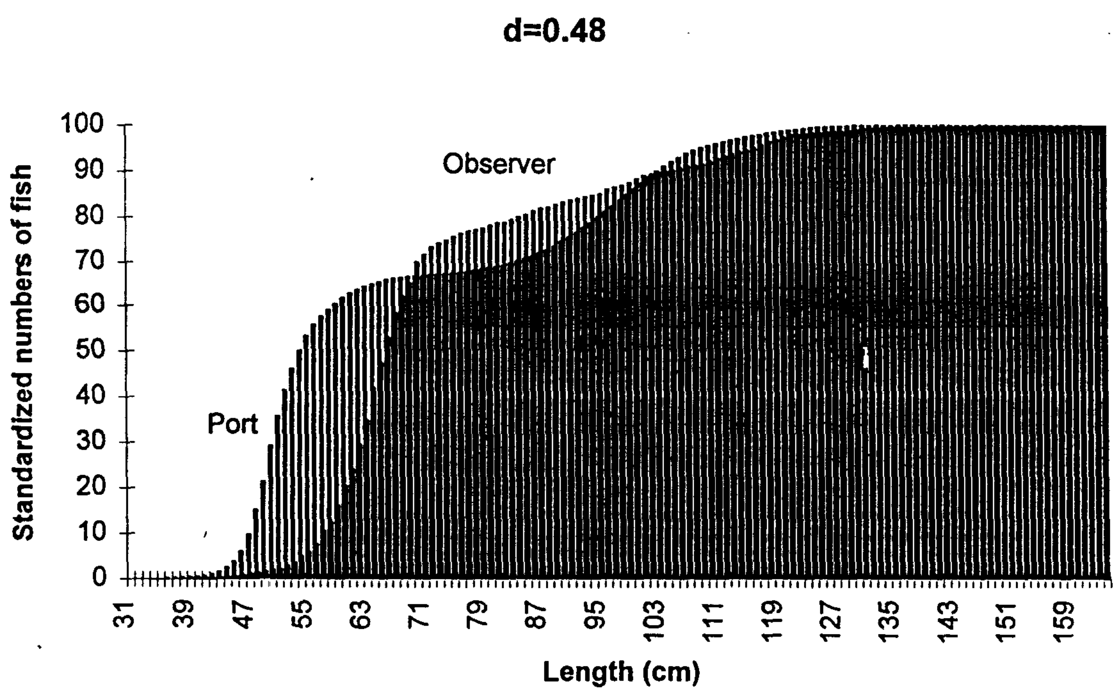
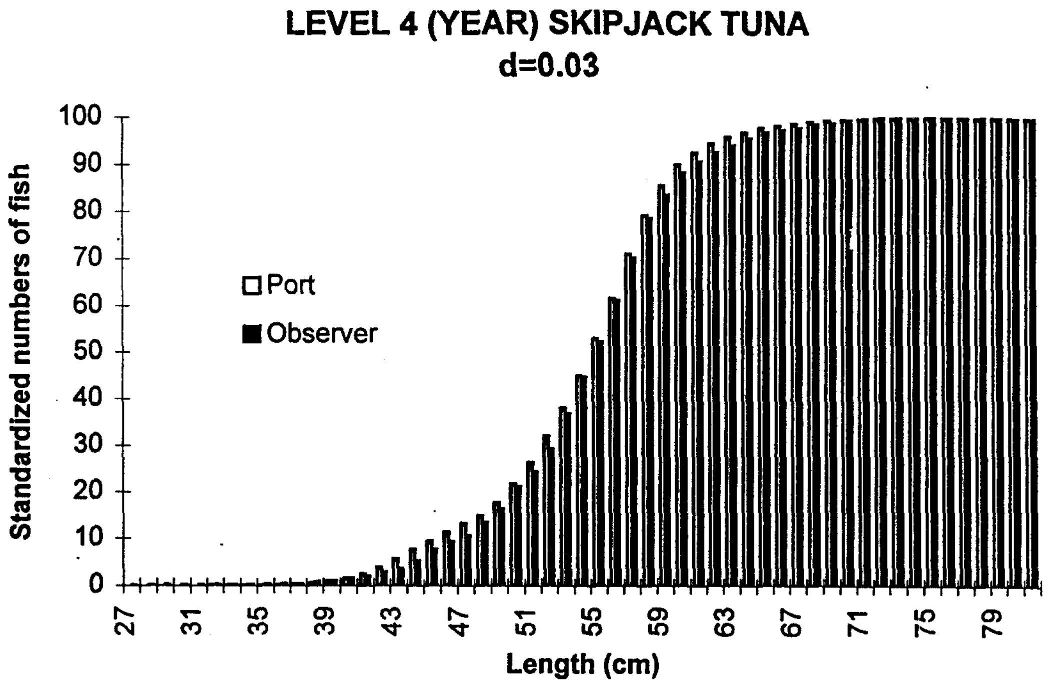


Figure 9. Best (top) and worst (bottom) level 3 (year-sampling area) yellowfin tuna comparisons from port and observer sampling.



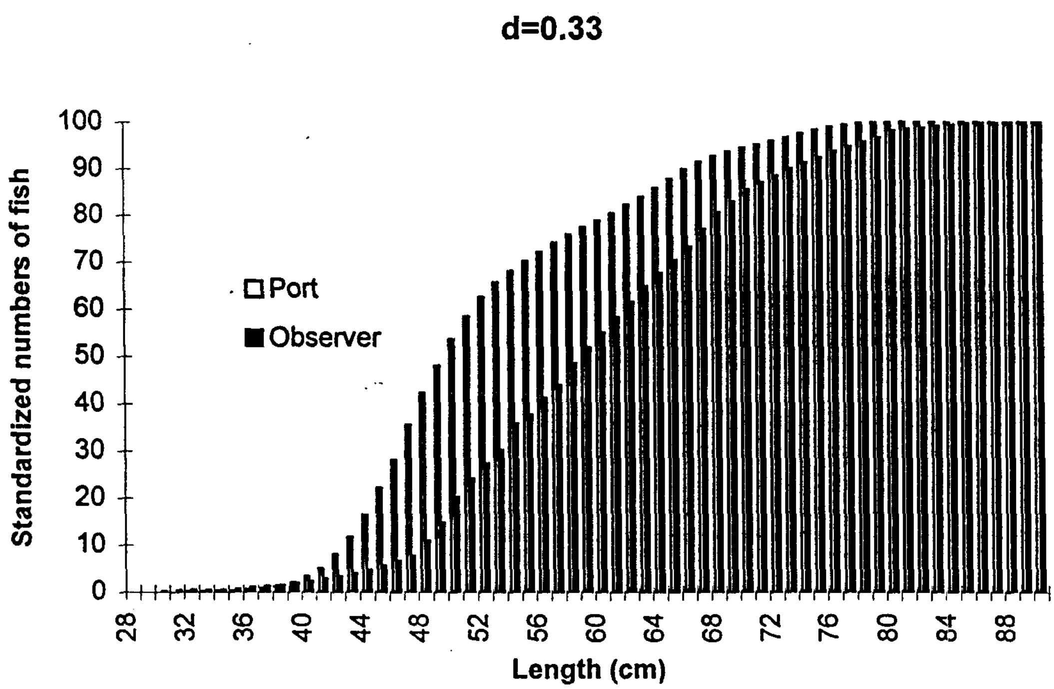
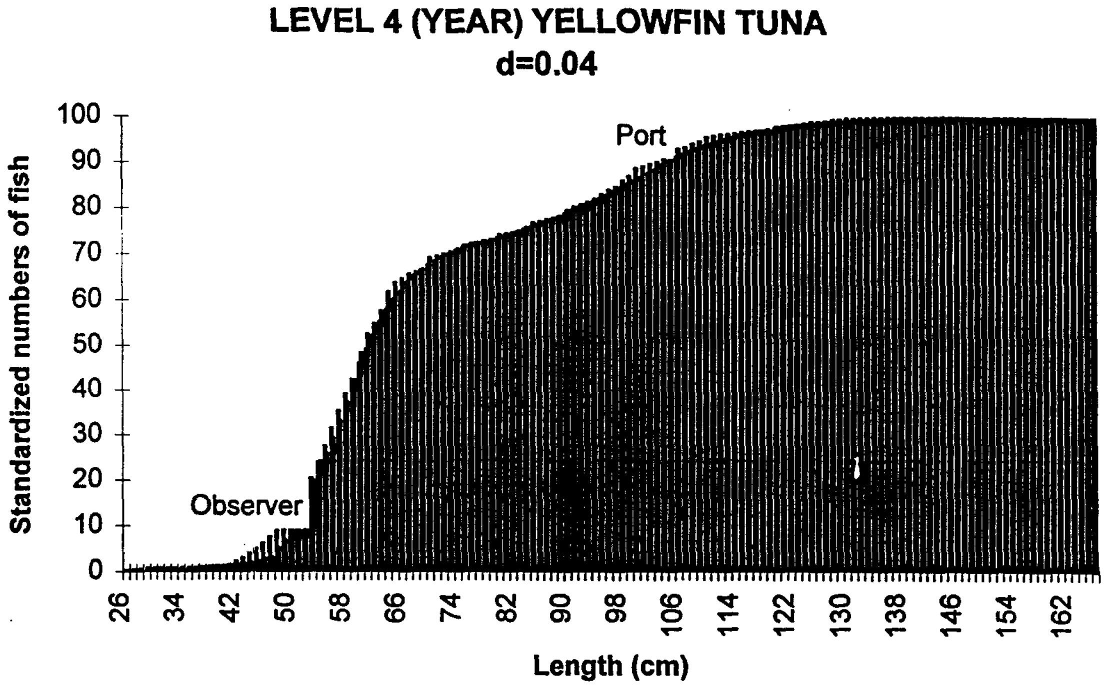


Figure 10. Best (top) and worst (bottom) level 4 (year) skipjack tuna comparisons from port and observer sampling.



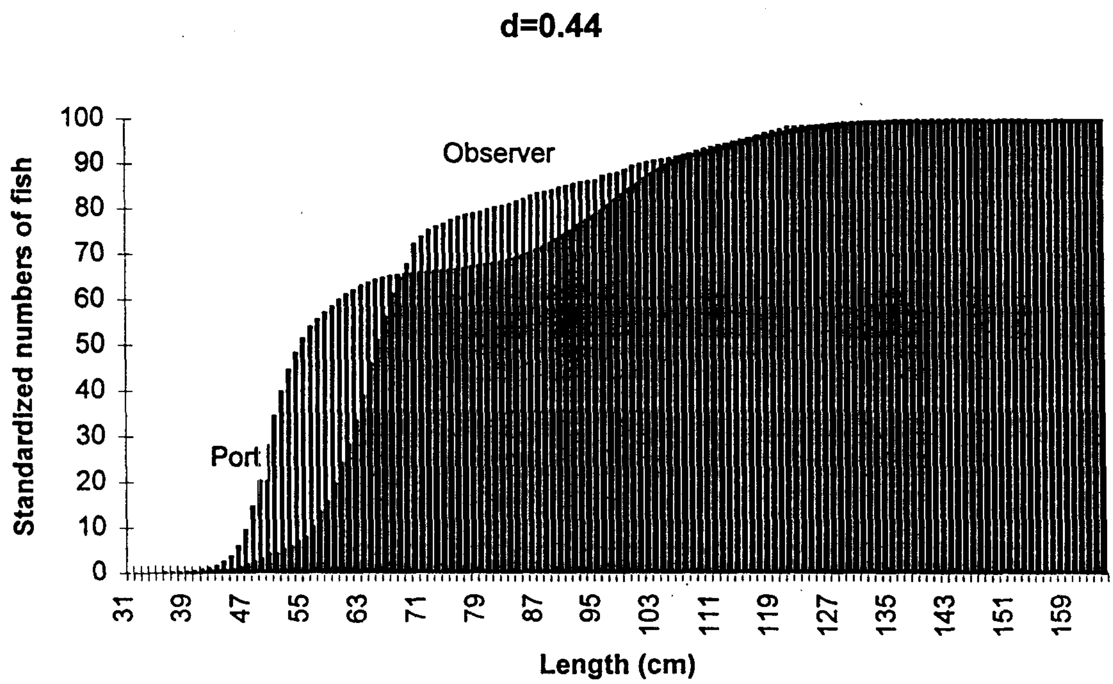


Figure 11. Best (top) and worst (bottom) level 4 (year) yellowfin tuna comparisons from port and observer sampling.

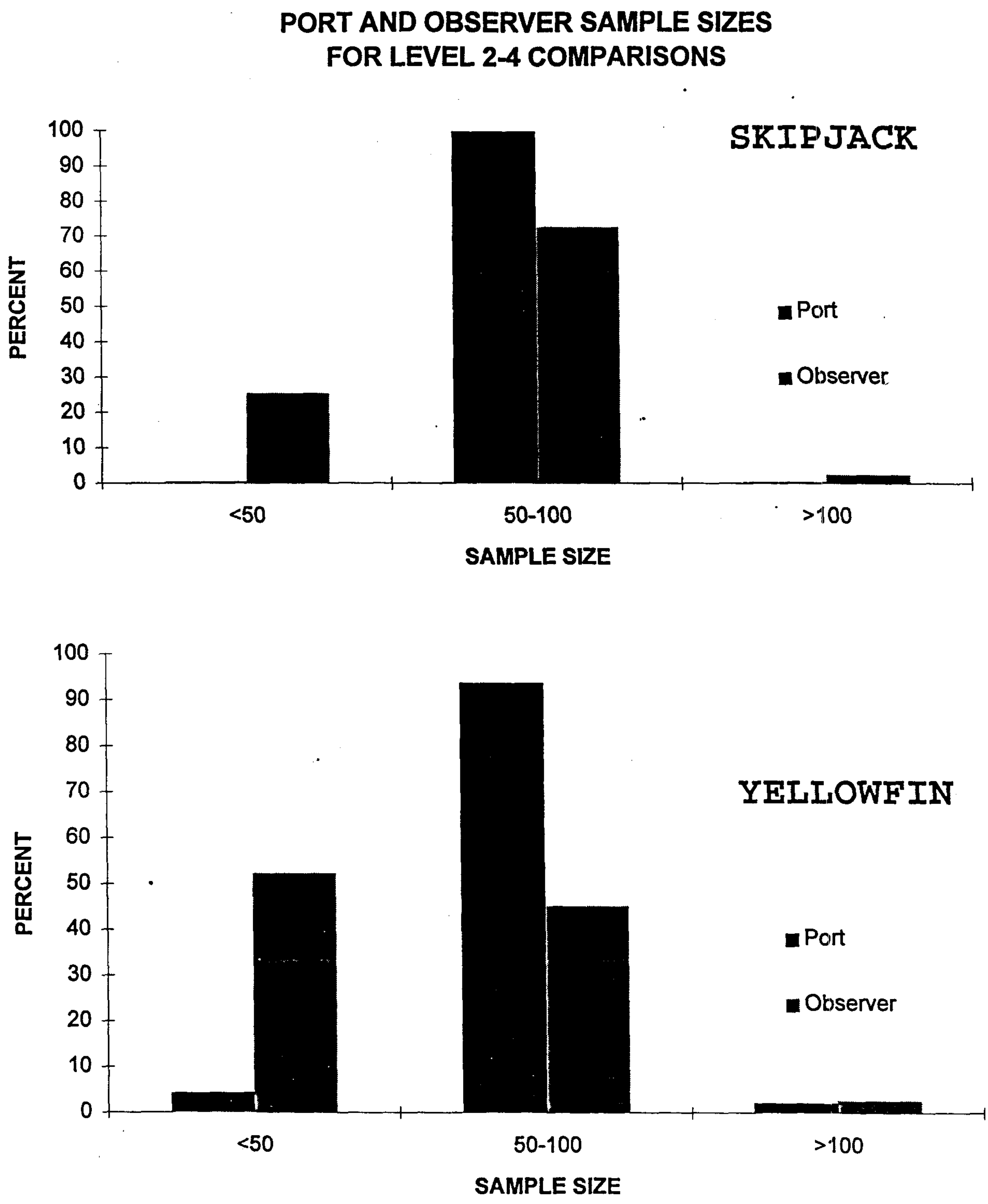


Figure 12. Percentages of skipjack tuna (top) and yellowfin tuna (bottom) samples taken at various sample sizes used in level 2-4 (month-sample area, year-sample area, year) comparisons. Samples were taken by port and observer samplers during the period 1988-1996.