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Length Composition of Yellowfin, Skipjack, and Bigeye Tunas Caught in the Eastern Tropical Atlantic by American Purse Seiners

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ABSTRACT

Sampling and analytical procedures that are used to estimate the size composition of Atlantic tunas caught by American purse seiners in the eastern tropical Atlantic are described. The procedures are based on a stratified, two-stage subsampling model. Estimates indicated that about 0.2 to 1.4 million yellowfin tuna, *Thunnus albacares*, 1.2 to 12.8 million skipjack tuna, *Katsuwonus pelamis*, and 0.5 to 41.2 thousand bigeye tuna, *T. obesus* were caught annually by the fleet in 1968-74. The dominant age group in most years was 1-yr olds for yellowfin and skipjack tuna and 2-yr olds for bigeye tuna.

INTRODUCTION

United States participation in the eastern tropical Atlantic tuna fishery off west Africa began in the 1950's. It was not until 1967, however, that significant numbers of U.S. purse seiners entered the fishery (Sakagawa and Lenarz 1972; Sakagawa 1974). Since then as many as 36 American[3] seiners have participated annually in the fishery.

The American tuna fleet that fishes in the eastern Atlantic consists primarily of purse seiners of 80 to 1,800 metric tons carrying capacity of fish. Home bases for U.S. vessels are in California and Puerto Rico; the eastern Atlantic is only one of several areas where the vessels fish in a year. Each seiner has upwards of 20 fish-holding wells that freeze and store an average of about 60 metric tons of tuna per well.

The fishing season in the eastern tropical Atlantic, while year round for most fleets, begins about July and usually ends in November-December for most American vessels. The American vessels generally fish in close proximity to each other, although they are operated by independent captains. Their catch consists of yellowfin, *Thunnus albacares*, and skipjack, *Katsuwonus pelamis*, tunas primarily and some bigeye tuna, *T. obesus*, and incidental catches of little tunny, *Euthynnus alletteratus*, frigate and bullet mackerels, *Auxis* spp., and rainbow runner, *Elagatis bipinnulata*. In 1967-69, more than half the catch was yellowfin tuna; since 1969, skipjack tuna has been the dominant species in the catch (Sakagawa and Lenarz 1972). Virtually all the U.S. catch is returned to the United States aboard the seiners or aboard transshipment vessels for processing, canning, and marketing. Transshipments were made in 1970-74.

Monitoring of the American catch to assess stock abundance was initiated by the National Marine Fisheries Service (NMFS), NOAA, in 1968 and continued annually since then. Catch, effort, and length-frequency samples are collected by NMFS representatives and under contract by the Inter-American Tropical Tuna Commission (IATTC) representatives. Summaries of catch and effort data were reported in Sakagawa and Lenarz (1972) and Sakagawa (1974). This report presents a description of procedures used to estimate the length composition of tunas in the American catch and the estimated length composition of tunas caught in 1968-74.

SAMPLING PROCEDURES

Tuna catches were sampled for length-frequencies aboard the seiners during unloadings at canneries in California and Puerto Rico in 1968-74, and during unloadings at freezer storage facilities and onto transshipment vessels in west Africa in 1971-73. Samples were also obtained from transshipment vessels that unloaded at canneries in California and Puerto Rico.

Sampling in west Africa was particularly critical in 1971 because in that year, and in 1970 to a lesser degree, large yellowfin and bigeye tunas with presumably high mercury content were selectively shipped to Europe, where a higher mercury content was acceptable, rather than to the United States. Samples taken only in California and Puerto Rico in those years were therefore biased.

Sampling in west Africa also presented the opportunity of sampling the transshipped catch before it was mixed in the holds of the transshipment vessels. Upwards of 700 metric tons of fish have been transported in

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[3]The fishing operations of Canadian, Dutch (based in Willemstad, Netherlands Antilles), Panamanian, and U.S. boats fishing in the eastern tropical Atlantic are monitored as a unit by the Inter-American Tropical Tuna Commission. "American" in this report refers to this fleet, which in 1968-73 consisted of at least 83% U.S. seiners.

a hold of a transshipment vessel. The transshipped catches of individual seiners are kept separate, but an entire seiner's catch, which is usually caught in several areas and over several months, is generally loaded into a single hold.

Length-Frequency Samples

The sampling procedures were virtually the same as those recommended by Hennemuth (1957) for the eastern tropical Pacific fishery, i.e., a stratified, by area and month, two-stage subsampling procedure (Cochran 1963) was used. The boundaries of the areas (Fig. 1) were drawn according to the distribution and concentration of fishing effort of the American fleet.

The first stage of the sampling was to choose the well (or hold if a transshipment vessel[4]) to sample. The second stage was to draw from the selected well a random sample of each species (yellowfin, skipjack, and bigeye tunas). Ancillary information, such as well number and catcher vessel name, was recorded for each sample. The date, location (NMFS area — Fig. 1), and tonnage of the catch sampled were obtained from logbooks after the samples were drawn.

Before 1972, samples were obtained on an opportunistic basis and the sample size varied (10 to 300 fish). Since 1971, a goal of 6 skipjack samples and 12 yellowfin samples of 50 fish each from each NMFS area and each fishing month was established in an attempt to ensure a more complete area-month coverage. The larger number of samples for yellowfin tuna was required because of the greater variability in sizes of this species (Hennemuth 1957). This goal, however, was not attained in any of the years.

Total Catch by NMFS Area-Month

Total catch, by species and month, of tunas caught in the Atlantic by American vessels is tabulated annually by the IATTC from landing receipts. Logbook information on estimated catch by species, 1° area, date, and well number in which the catch is stored for each net set is also collected by the IATTC from virtually the entire American fleet. This logbook information was used to identify those seine sets that contributed to the catch in wells that were sampled and also to prorate the total catch by species of the entire fleet into catch by NMFS area-month strata.

ANALYTICAL PROCEDURES

Different areas apparently contain different sizes of fish, at least for yellowfin tuna in the eastern tropical Atlantic (International Commission for the Conservation of Atlantic Tunas 1974a), and the stratified sampling procedure, by month and area, was designed to account partly for this difference. Sizes of fish in the total American catch were estimated from the stratified length-frequency samples and catch.

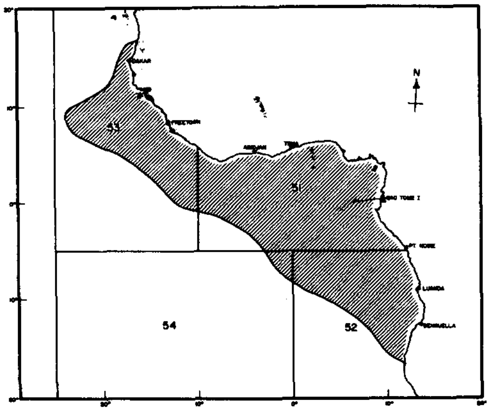

Figure 1.—Map of the eastern tropical Atlantic where American seiners fish for tropical tunas (shaded area). Numbered statistical areas used in this report are shown.

When a sample is drawn from a well, complete information on date, location, and tonnage of catch is not always available; complete information is obtained later from the ship's logbook. Fish that may have been caught in different strata were, consequently, sometimes drawn in a single sample. These samples were not used in our analysis unless 75% or more of the tonnage in the well was caught in a single NMFS area-month stratum. Because of this rule, virtually all samples from transshipment vessels were not used in this study. Analyses currently underway which contain a special stratum for transshipment samples may lead to new procedures for utilizing much of the rejected samples.

Weighting Factor

The sample size was fixed and not proportional to the numbers of fish in the well. Each sample was therefore weighted by a factor (number of fish) based on the species tonnage and average weight of fish in the well or, when this was unavailable, on the species tonnage and average weight of fish in seine sets that contributed to the catch in the sampled well.

Substituting Samples

Samples were unavailable for all area-month strata in which the fleet caught fish. For strata without samples, it was necessary to make assumptions about the catch and substitute samples from adjacent strata, within year to estimate the sizes of fish caught by the fleet. Substitution was on the basis of the following rules: 1) use same month and adjacent areas; 2) use same area and adjacent months; 3) use adjacent months and adjacent

[4]It is not uncommon to find several species stored in a well. The fish are partially thawed in the wells before unloading at the canneries or onto a transshipment vessel. Measurements were made on partially thawed fish.

areas. These rules are ordered according to priority and are based on the assumption that differences in sizes of fish from widely separated areas or months are greater than differences in sizes of fish from adjacent areas or months.

In Tables 1 and 2 the area-month strata with substituted samples are shown for yellowfin and skipjack tunas caught in 1968-74. About 20 to 60% of the strata in which yellowfin tuna were caught and about 10 to 60% of the strata in which skipjack tuna were caught had no samples and substitutes were necessary (Table 3). In terms of tonnage, substitutions were required for 2 to 29% of the total yellowfin tuna catch and 1 to 17% of the total skipjack tuna catch.

The poorest sampling coverage of yellowfin and skipjack tunas was in 1970. In that year, representative sampling was difficult because large yellowfin and bigeye tunas were transshipped in west Africa to foreign ports and not sampled. The best sampling coverage, in terms of tonnage, was in 1969 for yellowfin and 1971 for skipjack tuna.

Estimating Length Composition of Catch

Length-frequency of fish in the total catch by species was computed by summing estimates for each area-month stratum. The following procedures were used for the stratum estimates:

1. The weight (w in kilograms) of each fish was estimated from length (l in centimeters) based on the appropriate length-weight equation (Lenarz 1974) shown below. The average weight ($\bar{w}_i$) of fish in the sample, $i = 1, 2, \ldots, k$, was then estimated.

Table 1.—Catch (metric tons) and number of length-frequency samples of yellowfin tuna by NMFS area-month strata. Samples substituted in strata without samples are identified in parentheses.

Month - year		Area 53		Area 51		Area 52	
		Catch (tons)	Samples	Catch (tons)	Samples	Catch (tons)	Samples
January	1974			88	(July-51)	9	(July-51)
February	1974			11	(July-51)		
March	1974			33	(July-51)	2	(July-51)
May	1970			4	(June-51)		
	1972			363	1	11	(May-51)
June	1970			682	6	3	(June-51)
	1972	21	(June-51)	613	2		
	1974			95	(July-51)		
July	1969			605	1		
	1970			1578	5		
	1971			471	2		
	1972	34	(July-51)	1676	5	51	(July-51)
	1973			670	3		
	1974			1292	5		
August	1968			1995	7		
	1969			6786	8		
	1970			3207	3		
	1971	8	(Aug-51)	1730	10		
	1972	8	(Aug-51)	3955	14	993	3
	1973			369	(Aug-52)	867	3
	1974			1405	7	95	(Aug-51)
September	1968			1384	3	1352	3
	1969			5195	10	2	(Sept-51)
	1970	494	1	1769	(Sept-53)		
	1971			353	1	920	6
	1972	20	(Oct-53)	124	(Sept-52)	1059	5
	1973			9	(Sept-52)	261	3
	1974					51	(Oct-52)
October	1968			143	1	953	(Oct-51)
	1969			3643	4	351	(Oct-51)
	1970	962	3	12	(Oct-53)	597	(Oct-53)
	1971	8	1	93	2	179	1
	1972	1665	4	943	4	176	(Oct-51)
	1973			405	2	7	(Oct-51)
	1974			647	2	836	2
November	1969			3178	4	1	(Nov.-51)
	1970	36	(Oct.-53)	69	(Oct.-53)	398	(Oct.-53)
	1971	41	(Oct.-53)	31	(Oct.-51)		
	1972	344	4	28	1	18	(Nov.-51)
	1973			706	1		
	1974	28	(Nov.-51)	429	3	355	3
December	1974			191	1	53	(Dec.-51)

Table 2.—Catch (metric tons) and number of length-frequency samples of skipjack tuna by NMFS area-month strata. Samples substituted in strata without samples are identified in parentheses.

Month - year		Area 53		Area 51		Area 52	
		Catch (tons)	Samples	Catch (tons)	Samples	Catch (tons)	Samples
January	1974					133	(July-51)
February	1974			10	(July-51)		
March	1974			48	(July-51)	24	(July-51)
May	1970			29	(June-51)		
	1972			334	2		
June	1970			1007	5	11	(June-51)
	1972	130	(June-51)	703	3		
	1974	5	(July-51)	171	(July-51)		
July	1969			161	1		
	1970			1375	6		
	1971			423	2		
	1972	419	2	1504	4	121	(July-51)
	1973			214	(Aug-52)		
	1974			1245	5		
August	1968			1206	2		
	1969			2443	14		
	1970			4441	3		
	1971			1119	9		
	1972	75	2	1465	9	1811	6
	1973			94	(Aug-52)	6175	22
	1974			899	6	443	1
September	1968			1049	3	265	2
	1969			1011	9	1	(Sept-51)
	1970	428	(Sept-51)	1935	2		
	1971			402	1	6549	19
	1972	5	(Sept-51)	701	2	2124	7
	1973			19	(Sept-52)	11465	28
	1974					10796	10
October	1968			268	1	375	1
	1969			1071	5	155	(Oct-51)
	1970	1087	3	4	(Oct-53)	814	(Sept-51)
	1971	46	(Oct-51)	3155	6	3725	9
	1972	826	7	1180	7	379	2
	1973			56	(Oct-52)	4189	13
	1974			308	1	2453	6
November	1968					15	(Oct-52)
	1969			43	1	7	(Nov-51)
	1970			23	(Oct-53)	643	(Oct-53)
	1971	218	1	1191	1		
	1972	382	5	34	(Nov-53)	9	(Oct-52)
	1973			82	2		
	1974	45	(Nov-51)	275	1	810	1
December	1974			102	(Dec-52)	2207	8

yellowfin tuna

$$w = (2.18 \times 10^{-5})\ l^{2.970}$$

skipjack tuna

$$w = (5.61 \times 10^{-6})\ l^{3.315}$$

bigeye tuna

$$w = (1.25 \times 10^{-6})\ l^{3.121}$$

2. Average weight was used to convert the well tonnage (S_i) from which the ith sample was taken to numbers of fish ($M_i = S/\bar{w}_i$).
3. M is distributed proportionately by 2-cm intervals, according to the length-frequency distribution of the ith sample.
4. A weighted average weight ($\bar{\bar{w}}$) of fish in all the samples of a stratum was estimated with M_i as the weighting factor, $\bar{\bar{w}} = \Sigma(M_i \bar{w}_i)/\Sigma M_i$.
5. The number of fish (N) in the total catch (C) of a stratum was estimated with $N = C/w$.
6. The length-frequency distributions of all M_i's of a stratum were pooled and the pooled frequency distribution was used to estimate the length composition of N.

Table 3.—Sampling coverage of NMFS area-month strata in which yellowfin and skipjack tunas were caught by American tuna seiners in 1968-74.

Species-year	Area-month strata[1]			Catch			Samples	
	Total	Sampled		Total	Sampled		Total	Number/
	(number)	Number	Percent	(tons)	Tons	Percent	(number)	Catch of 1,000 tons
Yellowfin								
1968	5	4	80.0	5,830	4870	93.8	14	2.40
1969	8	5	62.5	19,760	19,410	98.2	27	1.37
1970	13	5	38.5	9,810	6,920	70.6	18	1.83
1971	10	7	70.0	3,830	3,750	97.9	51	13.31
1972	19	10	52.6	12,100	11,640	96.2	43	3.55
1973	8	5	62.5	3,300	2,910	88.3	12	3.64
1974	17	7	41.2	5,620	5,160	91.7	28	5.00
Skipjack								
1968	6	5	83.3	3,180	3,160	99.5	9	2.83
1969	8	5	62.5	4,890	4,730	96.7	31	6.34
1970	12	5	41.7	11,790	9,840	83.5	19	1.61
1971	9	8	88.9	16,830	16,780	99.7	59	3.51
1972	18	13	72.2	12,200	11,900	97.6	58	4.75
1973	8	4	50.0	22,290	21,910	98.3	67	3.01
1974	17	9	52.9	19,970	19,440	97.3	39	1.95

[1] Only strata in which a catch was made are included.

ESTIMATES OF LENGTH COMPOSITION OF CATCHES

Yellowfin Tuna

The estimated length compositions of yellowfin tuna in the 1968-74 catches by month strata, all areas combined, are shown in Appendix Tables 1 to 7. Area differences are presumed to be not as significant as monthly differences within a year.

As many as four modal groups are found in the length-frequency distributions, but only two or three are prominent (Fig. 2). The prominent modes correspond to the apparent entering year class (approximately 33 to 47 cm long), 1-yr-old (48 to 85 cm long), and 2-yr-old (86 to 123 cm long) fish. The modal size of the apparent entering year class is peculiar in that it differs from the modal size of the 1-yr-old fish by about 18 cm. According to the growth curve for Atlantic yellowfin tuna of Le Guen and Sakagawa (1973), the difference should be about 57 cm if the two groups are 1 yr apart. Some possible causes for this difference are: 1) there is extreme sampling bias of the entering year class, and perhaps even of 1-yr-old fish in the catch, owing to differential availability or vulnerability; 2) the entering year class in fact represents slower growing or later hatching fish of the same year class as the 1-yr-old fish, i.e., from multiple spawnings (Richards 1969); or 3) that the growth curve of Le Guen and Sakagawa (1973) is incorrect. Both 1) and 2) are probably the major causes for the difference. Hennemuth (1961) similarly identified length modes that were less than a year apart in age and presumably from identical year classes or subpopulations of yellowfin tuna from the eastern tropical Pacific.

In 1968-74, about 0.2 to 1.1 million yellowfin tuna were caught annually by the American fleet in the eastern tropical Atlantic. The age-frequency distributions of the catches (Table 4), based on analysis of modal progression and the growth curve of Le Guen and Sakagawa (1973), indicate that the dominant age group was 1-yr-old fish in 1968 and 1970-74, and 2-yr-old fish in 1969.

The catch of 1969 is unusual compared to that of the other years. Besides the dominance of 2-yr olds in the catch of that year, the 1969 catch (in weight) of yellowfin tuna was the highest recorded for the American fleet and virtually all (98%) was taken in NMFS area 51. About 90% of the catch, furthermore, was from pure yellowfin schools, the remainder from mixed yellowfin-skipjack schools. In the other years, a smaller percentage (61 to 75%) of yellowfin tuna was caught in area 51 and only about 60% of the catch was from pure yellowfin schools. Yellowfin tuna in mixed yellowfin-skipjack schools are generally smaller than in pure yellowfin schools

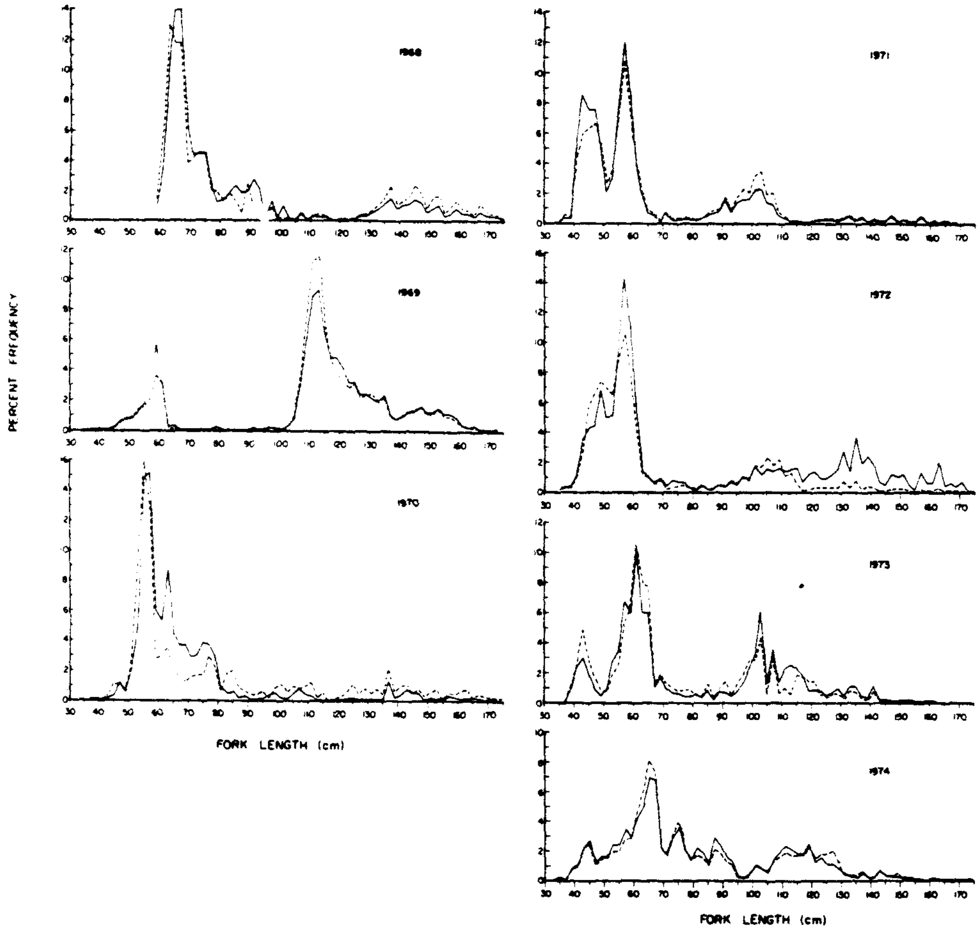

Figure 2.—Estimated length composition of yellowfin tuna caught by American seiners in the eastern tropical Atlantic, 1968-74. (Solid line — stratified procedure; dashed line — unstratified procedure.)

(Calkins 1965). The predominance of large yellowfin tuna (>100 cm) in the 1969 catch could have been caused therefore by the high percentage of pure schools fished in that year.

Skipjack Tuna

The catch of skipjack tuna by the American fleet markedly increased from 3,180 metric tons in 1968 to 22,290 metric tons in 1973, then decreased to 19,970 metric tons in 1974 (Table 3). This represents for skipjack tuna an estimated 1.2 million in 1968, 12.8 million in 1973, and 10.6 million in 1974. The estimated length composition of the 1968-74 catches by month strata, all areas combined, are shown in Appendix Tables 8 to 16.

Two apparent age groups, probably 1-yr-old (31 to 55 cm long) and 2-yr-old (56 to 67 cm long) fish, contributed to the catch (Fig. 3). The dominant group was 1-yr-old fish in all years except 1969 (Table 5).

The dominant modal length in the skipjack catch decreased from about 50 to 55 cm in 1968-70 to about 45 cm in 1971-74 (Fig. 3). This decrease, while relatively small, occurred with the discovery by the American fleet in 1971 that skipjack fishing is good off Angola (NMFS area 52) during the fall months. Before 1971 most of the

Table 4.—Estimated age composition of yellowfin tuna caught by the American purse seine fleet in the eastern tropical Atlantic.

Age group	Approximate length (cm)	Estimated catch (numbers) by year						
		1968	1969	1970	1971	1972	1973	1974
0	35-51			29,900	169,100	368,300	25,200	46,700
I	52-91	230,300	116,900	907,500	186,600	763,600	122,000	157,800
II	92-125	54,200	339,600	63,000	81,100	218,500	82,700	99,500
III	126-149	16,400	142,900	77,700	16,300	46,600	15,300	99,800
IV	150-169	38,600	41,100	25,700	7,000	15,300	700	13,400
V+	170+	19,400	3,200	7,000		2,300		
Total		358,900	643,700	1,110,800	460,100	1,414,600	245,900	417,200

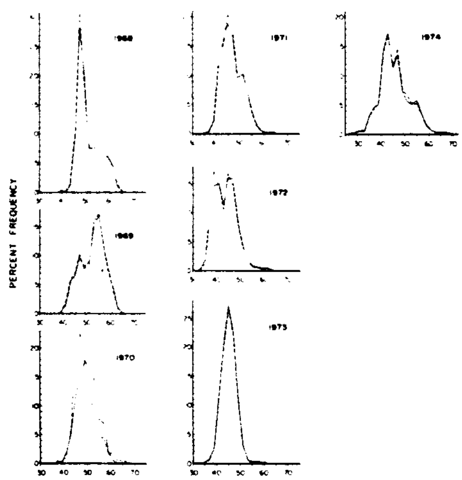

Figure 3.—Estimated length composition of skipjack tuna caught by American seiners in the eastern tropical Atlantic, 1968-74. (Solid line — stratified procedure; dashed line — unstratified procedure.)

American catch was made in the Gulf of Guinea and only about 3 to 21% of the skipjack tuna was caught in area 52. Since the discovery in 1971, as much as 98% of the annual American catch of skipjack has been taken from area 52.

Bigeye Tuna

Bigeye tuna are not often available to the surface fisheries (purse seine and pole-and-line) of the eastern tropical Atlantic. This species is sometimes confused with yellowfin tuna and catches may have been included with yellowfin tuna catches, but the amount is probably small. The American fleet reported bigeye tuna catches only in 1968 and 1971-74. A few length-frequency samples were collected in those years (Table 6). Because the samples were few, estimates of the length composition of the catch were based on all samples combined without stratification, i.e., all catches and samples pooled and one estimate calculated for each year (Appendix Table 17).

About four major modal groups (39 to 51 cm, 52 to 73 cm, 74 to 105 cm, and 106 to 131 cm) can be identified in the length-frequency distributions (Fig. 4). These groups apparently represent age groups of 1 to 4 yr, based on

Table 5.—Estimated age composition of skipjack tuna caught by the American purse seine fleet in the eastern tropical Atlantic.

Age group	Approximate length (cm)	Estimated catch (numbers) by year						
		1968	1969	1970	1971	1972	1973	1974
I	31-55	802,800	531,000	4,268,700	6,413,700	7,290,200	12,754,800	9,327,500
II	56-67	409,700	1,137,300	486,000	2,069,200	121,600	43,300	1,222,800
Total		1,212,500	1,668,300	4,754,700	8,482,900	7,411,800	12,798,100	10,550,300

Table 6.—Catch and number of length-frequency samples of bigeye tuna caught by the American purse seine fleet in the eastern tropical Atlantic.

Year	Number of samples	Catch	
		Tons	Estimated Numbers
1968	2	15	500
1971	7	540	19,700
1972	3	210	29,400
1973	3	110	10,600
1974	8	860	41,200

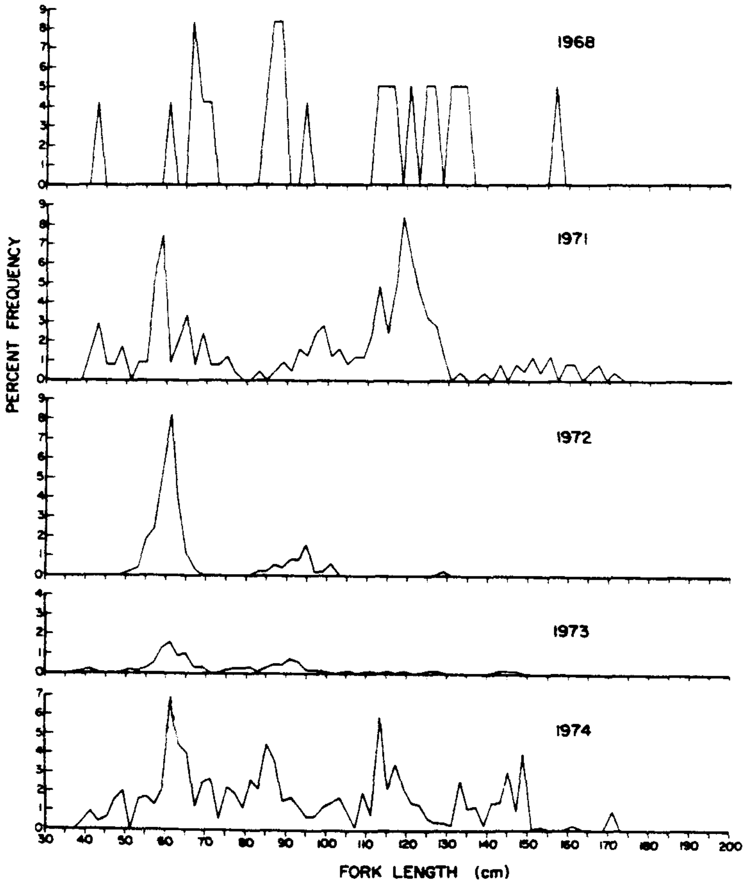

Figure 4.—Estimated length composition of bigeye tuna caught by American seiners in the eastern tropical Atlantic, 1968 and 1971-74.

Champagnat and Pianet's[4] growth curve for Atlantic bigeye tuna.

The estimated total number of bigeye tuna caught by the American fleet in 1968 and 1970-74 ranges from about 500 to 41,200 fish. The largest catch was in 1974, the smallest in 1968.

SOURCES OF BIAS IN THE ESTIMATES

Several possible sources of bias in the sampling, weighting, and substitution procedures could have significantly influenced the estimated length-frequency distributions of the catches. Some of the sources are discussed below.

Sampling Bias

Hennemuth (1957) found a slight size-depth stratification of skipjack tuna but none for yellowfin tuna in wells he examined. He mentioned that stratification could result from settling of large fish to the bottom of the well or from different schools of fish of different sizes packed in a layer fashion.

Early in our sampling program, size-depth stratification was recognized as a possible source of error and steps were taken to reduce the influence of this error by limiting sampling to wells that did not appear to contain fish that were stratified by size and depth. How effective this measure was is not known.

A more serious sampling bias was introduced in 1970 with the discovery that tunas, particularly large specimens, contain high levels of mercury which the Food and Drug Administration of the United States deemed unacceptable for U.S. markets. Canneries in the United States, therefore, limited their purchases of large fish, and American fishermen were forced either to not land large tunas or to sell the large tunas to foreign markets where the acceptable level of mercury contamination was higher. Because large yellowfin and bigeye tunas caught off Africa in 1970 and 1971 were selectively sold and transshipped from west African ports directly to foreign buyers, fish landed in the United States were biased towards the smaller fish. This bias probably affected our estimates for 1970. Estimates for 1971 were not affected because catches transshipped to foreign ports were sampled in west African ports prior to transshipment.

Weighting Bias

Some of our length-frequency samples were weighted by a factor (number of fish) based on the total tonnage and average weight of fish in sets that contributed to the catch in the sampled well. As indicated earlier, this technique was used because the sample size was not proportional to the numbers of fish present and the amount of tonnage in the well was not known. The use of the total tonnage, instead of the tonnage in the sampled well only, to base a weighting factor introduced a bias of overweighting the samples. For example, a sample from a well containing 20 tons of fish from a 80-ton set A and 40 tons from a 40-ton set B would have a weighting factor based on 120 tons, causing the sample to be disproportionately weighted by the catch of set A.

We examined this bias with the August 1973 yellowfin tuna catch of area 52 (Table 1) in which the actual tonnages of fish in the three sampled wells were available. A biased estimate length composition of the catch was derived with weighting factors based on tonnages of 127, 41, and 17 for the three samples. An unbiased estimated length composition of the catch was derived with weighting factors based on the actual tonnages in the sampled wells of 60, 20, and 15, respectively. The unbiased and biased estimated length compositions of the catch are not very different (Fig. 5). However, the total estimated number of yellowfin tuna is 7% higher in the unbiased than in the biased estimate, owing to the greater numbers of small fish (<61 cm) in the unbiased estimate.

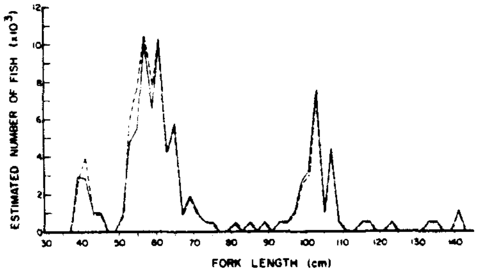

Figure 5.—Estimated length composition of yellowfin tuna caught in August 1973 in NMFS area 52. (Solid line — biased weighting factors; dashed line — unbiased weighting factors.)

Substitution Bias

Of all the possible sources of bias in our estimates, substitution bias perhaps is the most serious. As indicated earlier, 11 to 61% of the strata were not sampled and required substitution of samples from adjacent strata. Furthermore, not all of the sampled strata were sampled adequately. Between 20 to 43% of the strata sampled for yellowfin tuna and 0 to 33% of the strata sampled for skipjack tuna were sampled only once. These samples were also used in the substitution procedure, at times applied to a large catch (Table 7).

The effects of our substitution procedure and single samples on the estimated length composition of the catch were examined with the 1970 data. In that year, sampling coverage was poorest. In Figures 6 and 7, we show the estimated length composition by month using substitutions and also the portion of the composition derived from strata with two or more samples only. In general, the results indicate that substitutions affected

[4]Champagnat, C., and R. Pianet. Croissance du patudo (*Thunnus obesus*) dans les regions de Dakar et de Pointe. Unpubl. manuscr., 7 p. Centre de Recherches Oceanographiques, B. P. 2241, Dakar, Senegal.

Table 7.—Number of NMFS area-month strata in which single samples were obtained or substituted.

Species - Year	Number of Strata[1]	Strata sampled once		Strata with one sample (including substitutions)	
		Number	Catch (tons)	Number	Catch (tons)
Yellowfin					
1968	5	1	140	2	1,100
1969	8	1	600	1	600
1970	13	1	490	2	2,260
1971	10	3	540	4	580
1972	19	2	390	4	420
1973	8	1	710	1	710
1974	17	1	190	2	260
Skipjack					
1968	6	2	640	3	660
1969	8	2	200	3	210
1970	12	0	0	0	0
1971	9	3	1,810	3	1,810
1972	18	0	0	0	0
1973	8	0	0	0	0
1974	17	4	1,840	5	1,880

[1] Only strata in which a catch was made are included.

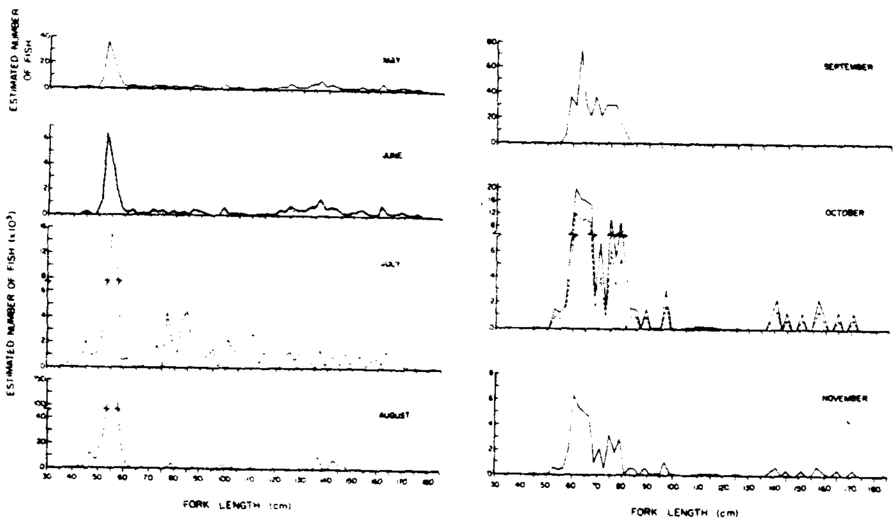

Figure 6.—Estimated length composition of yellowfin tuna by month caught by American seiners in 1970. (Solid line — stratified procedure with substituted samples; dashed line—stratified procedure without substituted samples and strata with one sample.)

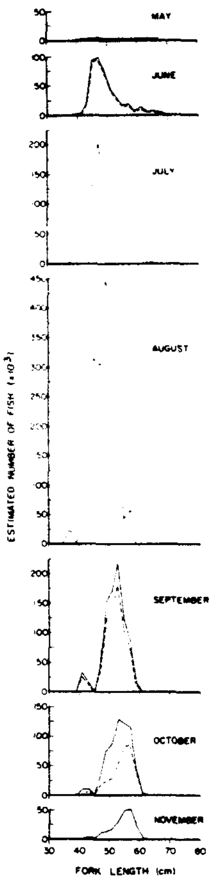

Figure 7.—Estimated length composition of skipjack tuna by month caught by American seiners in 1970. (Solid line — stratified procedure with substituted samples; dashed line — stratified procedure without substituted samples and strata with one sample.)

principally the estimates of fish caught at the beginning (May) and end (September-November) of the 1970 fishing season. The effects are greater for yellowfin tuna (Fig. 6) than for skipjack tuna (Fig. 7).

DISCUSSION

Estimates of length composition of the American catches of yellowfin and skipjack tunas from the eastern tropical Atlantic have been published in the data records of the International Commission for the Conservation of Atlantic Tunas (1973; 1974b, c). The published estimates were based on preliminary data on total catches and on a stratified procedure with unweighted samples; consequently, they underestimated the numbers of fish caught and are not comparable to our estimates. Our estimates were based on total catches and on weighted samples. We consider them to be more accurate than those published in the data records.

The stratified procedure was used in our study to gain greater precision in our estimates. However, in years when sampling coverage was poor, the stratified procedure probably was inappropriate and may have distorted the results. In such circumstances, the unstratified procedure may have been more appropriate. Estimates based on the unstratified procedure are shown by dashed lines in Figures 2 and 3.

The stratified procedure is the most desirable for estimating the size composition of the catch of tunas because it can result in precise estimates (Hennemuth 1957). The choice between the unstratified and stratified procedures should be based on sampling cost as well as precision. For the American tuna catches from the eastern tropical Atlantic, the sampling cost is currently not much greater with the stratified than the unstratified procedure. The choice then is to use the stratified procedure which can account for area-time differences in the sizes of fish caught. If the sampling coverage is poor, however, particularly for yellowfin tuna with a wide range of sizes, the full advantage of the stratified procedure is lost and the estimates would not be very different from those based on the unstratified procedure. In this case, the procedures are equally precise in estimating the size composition of the catch and either procedure can be used without fear of losing more precision from one than the other.

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ppendix Table 1.– Estimated length composition of yellowfin tuna caught by American purse seiners in the eastern tropical Atlantic in 1968.

Midpoint length (cm)	Number of fish by month		
	Aug.	Sept.	Oct.
59.0	1143	1948	0
61.0	2644	9460	0
63.0	8583	20216	7688
65.0	7313	16765	25628
67.0	5043	21756	23065
69.0	3861	3868	15377
71.0	2050	8371	5126
73.0	3570	7177	5126
75.0	1286	9878	5126
77.0	26	5672	2563
79.0	1561	2726	0
81.0	1479	777	2563
83.0	2061	1891	2563
85.0	877	2178	5126
87.0	83	1113	5126
89.0	480	6412	0
91.0	500	1737	7688
93.0	21	1886	5126
95.0	21	187	0
97.0	1041	717	2563
99.0	26	0	2563
101.0	0	0	5126
103.0	0	336	0
105.0	0	0	0
107.0	582	706	0
109.0	0	0	0
111.0	230	706	0
113.0	661	0	0
115.0	440	243	0
117.0	10	94	0
119.0	0	0	0
121.0	5	275	0
123.0	5	66	0
125.0	0	243	0
127.0	453	628	0
129.0	443	611	0
131.0	318	1782	0
133.0	518	2449	0
135.0	853	3534	0
137.0	2478	2883	0
139.0	351	2583	0
141.0	961	2469	0
143.0	1456	2517	0
145.0	3015	2021	0
147.0	2128	2077	0
149.0	766	1102	0
151.0	1882	1163	0
153.0	1772	1780	0
155.0	507	582	0
157.0	942	663	0
159.0	1539	872	0
161.0	902	517	0
163.0	762	681	0
165.0	399	196	0
167.0	1539	229	0
169.0	705	421	0
171.0	606	98	0
173.0	440	131	0
175.0	0	66	0
177.0	0	33	0
Total	71337	159492	128143

Appendix Table 2.– Estimated length composition of yellowfin tuna caught by American purse seiners in the eastern tropical Atlantic in 1969.

Midpoint length (cm)	Number of fish by month				
	Jul.	Aug.	Sept.	Oct.	Nov.
39.0	0	0	0	243	0
41.0	0	0	0	0	0
43.0	0	0	0	0	0
45.0	1100	0	146	0	0
47.0	1100	857	1583	0	0
49.0	1100	1501	1715	83	0
51.0	0	3672	146	1131	0
53.0	0	6002	0	2180	0
55.0	5502	4502	1467	83	0
57.0	9903	4502	1147	3311	0
59.0	16505	6002	858	12663	0
61.0	2201	7503	73	13712	0
63.0	1100	0	0	0	0
65.0	1100	0	0	1048	0
67.0	0	0	0	0	0
69.0	0	0	0	83	0
71.0	0	0	0	0	0
73.0	0	0	0	0	0
75.0	0	0	0	0	0
77.0	0	0	0	0	0
79.0	1100	0	0	0	0
81.0	0	0	0	0	0
83.0	0	0	0	0	0
85.0	0	0	0	0	0
87.0	0	0	0	0	0
89.0	0	0	0	0	0
91.0	0	0	721	0	0
93.0	0	0	0	0	0
95.0	0	0	721	0	0
97.0	0	993	0	0	0
99.0	0	0	721	0	0
101.0	0	0	0	0	0
103.0	1100	0	721	0	0
105.0	0	3429	1442	0	0
107.0	2201	15538	2163	0	0
109.0	1100	29220	8074	1362	0
111.0	2201	49690	5190	0	0
113.0	1100	48992	6716	3772	0
115.0	0	27385	5707	9150	317
117.0	0	12022	6200	12679	0
119.0	1100	7272	3655	19093	0
121.0	0	3346	7439	16464	0
123.0	0	6337	3444	10518	317
125.0	1100	7228	5542	6580	0
127.0	1100	4388	4776	5230	0
129.0	1100	3532	7087	2807	713
131.0	0	2099	10621	0	1030
133.0	1100	835	8333	83	1830
135.0	1100	1341	7489	1937	2695
137.0	0	186	3345	166	2695
139.0	0	0	2058	243	2061
141.0	0	1642	1149	326	2638
143.0	0	1188	3686	326	2507
145.0	0	929	2692	409	4575
147.0	0	1341	3417	1463	4222
149.0	0	671	2379	415	4444
151.0	0	0	2245	1297	4092
153.0	0	671	3087	569	5433
155.0	0	0	1349	811	4898
157.0	0	259	1924	984	3730
159.0	0	0	1273	1540	2832
161.0	0	0	563	1297	735
163.0	0	0	497	811	173
165.0	0	0	248	971	483
167.0	0	0	392	0	173
169.0	0	0	0	243	0
171.0	0	0	0	0	0
173.0	0	0	0	728	0
Total	55013	265075	134201	136811	52593

Appendix Table 3.- Estimated length composition of yellowfin tuna caught by American purse seiners in the eastern tropical Atlantic in 1970.

Midpoint length (cm)	Number of fish by month						
	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.
37.0	[illegible]	0	343	0	0	0	0
39.0	0	0	343	0	0	0	0
41.0	0	0	0	0	0	0	0
43.0	0	0	538	862	0	0	0
45.0	1	225	2135	862	0	49	16
47.0	0	0	881	12636	0	0	0
49.0	0	0	1076	5787	0	0	0
51.0	7	1222	2135	19562	0	0	0
53.0	37	6446	6565	38463	0	1456	466
55.0	24	[illegible]	14769	143727	0	1208	387
57.0	10	1821	9606	147666	7427	1698	544
59.0	2	352	538	19331	37135	6729	2154
61.0	1	147	715	2586	29708	19557	6259
63.0	2	373	186	0	74269	16894	5407
65.0	0	0	0	0	29708	15986	5116
67.0	1	106	0	0	22281	14531	4651
69.0	0	0	343	0	37135	2664	852
71.0	2	386	715	0	22281	6686	2140
73.0	1	171	1774	0	29708	1456	466
75.0	2	260	0	0	29708	9941	3182
77.0	0	0	4292	0	29708	5526	1769
79.0	2	345	1774	3925	14854	9005	2882
81.0	1	106	1059	0	7427	0	0
83.0	1	246	3763	0	0	1456	466
85.0	0	0	4478	0	0	1504	481
87.0	2	400	1253	0	0	0	0
89.0	2	281	715	0	0	1456	466
91.0	1	171	687	0	0	49	16
93.0	0	0	881	0	0	0	0
95.0	0	0	1431	0	0	49	16
97.0	0	0	0	0	0	3008	963
99.0	3	559	687	3925	0	49	16
101.0	1	134	2312	0	0	0	0
103.0	1	150	1059	0	0	0	0
105.0	1	134	1597	3925	0	49	16
107.0	0	37	1059	7850	0	0	0
109.0	0	0	1940	3925	0	146	47
111.0	0	0	2833	0	0	146	47
113.0	1	134	343	0	0	97	31
115.0	1	106	1245	0	0	97	31
117.0	0	0	0	0	0	49	16
119.0	1	106	0	0	0	0	0
121.0	2	392	0	0	0	0	0
123.0	2	345	902	0	0	0	0
125.0	4	708	1253	0	0	49	16
127.0	2	350	538	0	0	0	0
129.0	2	407	1076	0	0	0	0
131.0	2	366	538	0	0	0	0
133.0	4	729	538	0	0	0	0
135.0	4	680	50	0	0	0	0
137.0	7	1294	1464	11774	0	0	0
139.0	3	492	237	0	0	1208	387
141.0	4	617	816	0	0	2319	742
143.0	3	583	795	7850	0	0	0
145.0	1	196	237	3925	0	1160	371
147.0	1	147	1147	3925	0	0	0
149.0	1	220	287	0	0	0	0
151.0	1	253	739	0	0	1160	371
153.0	3	504	910	0	0	0	0
155.0	1	155	50	0	0	0	0
157.0	1	147	473	0	0	2319	742
159.0	0	0	659	0	0	1160	371
161.0	5	820	252	0	0	0	0
163.0	1	248	1334	0	0	0	0
165.0	1	113	151	0	0	1160	371
167.0	1	239	403	0	0	0	0
169.0	2	260	151	0	0	0	0
171.0	1	98	50	0	0	1160	371
173.0	0	0	538	0	0	0	0
175.0	1	203	0	0	0	0	0
Total	168	29247	91658	442506	371349	133236	42645

Appendix Table 4.- Estimated length composition of yellowfin tuna caught by American purse seiners in the eastern tropical Atlantic in 1971.

Midpoint length (cm)	Number of fish by month				
	Jul.	Aug.	Sept.	Oct.	Nov.
37.0	0	1428	0	0	0
39.0	0	714	763	0	0
41.0	0	2496	11530	8309	2802
43.0	0	636	17676	15805	4987
45.0	1421	2183	11668	15071	4397
47.0	2131	5895	13291	10639	2903
49.0	710	7621	8928	4472	1166
51.0	0	3293	5066	809	273
53.0	4972	4046	4541	443	149
55.0	12786	6158	9779	6901	273
57.0	9234	12972	14705	18291	347
59.0	2131	5729	14545	17261	0
61.0	710	1692	11865	3268	75
63.0	0	591	6899	1015	0
65.0	0	409	2853	0	0
67.0	0	758	1710	0	0
69.0	0	419	0	0	0
71.0	1421	1265	493	0	0
73.0	0	718	245	0	0
75.0	0	678	490	0	0
77.0	0	510	914	0	0
79.0	0	556	843	0	0
81.0	0	219	735	0	0
83.0	0	563	1162	0	0
85.0	0	1069	1299	0	0
87.0	0	1732	1391	0	0
89.0	0	1403	2384	0	0
91.0	0	2618	4553	0	0
93.0	0	1339	2028	0	0
95.0	0	3418	2718	7	35
97.0	0	5424	1604	14	71
99.0	0	4072	3106	28	142
101.0	0	7294	2911	28	142
103.0	0	8177	1773	69	354
105.0	0	4192	1813	35	177
107.0	0	4847	713	42	212
109.0	0	1952	133	42	212
111.0	0	568	870	14	71
113.0	0	129	307	21	106
115.0	0	224	381	7	35
117.0	0	0	0	35	177
119.0	0	100	0	7	35
121.0	0	371	381	0	0
123.0	0	469	381	0	0
125.0	0	1026	0	0	0
127.0	0	759	381	0	0
129.0	0	503	232	0	0
131.0	0	414	1144	0	0
133.0	0	1033	1244	0	0
135.0	109	721	0	0	0
137.0	0	865	763	0	0
139.0	0	282	100	0	0
141.0	219	306	813	0	0
143.0	656	59	0	0	0
145.0	437	273	50	0	0
147.0	1421	451	431	0	0
149.0	437	290	0	0	0
151.0	219	183	945	0	0
153.0	219	339	0	0	0
155.0	219	431	0	0	0
157.0	547	1064	381	0	0
159.0	109	195	0	0	0
161.0	328	473	0	0	0
163.0	109	156	0	0	0
165.0	328	480	0	0	0
167.0	0	90	0	0	0
169.0	109	37	0	0	0
Total	40982	121377	175931	102633	19141

Appendix Table 5.– Estimated length composition of yellowfin tuna caught by American purse seiners in the eastern tropical Atlantic in 1972.

Midpoint length (cm)	Number of fish by month						
	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.
35.0	0	0	2287	0	0	0	0
37.0	0	0	3045	960	0	0	149
39.0	0	2580	[illegible]	0	0	0	149
41.0	0	0	[illegible]	6715	0	8004	526
43.0	0	3893	3045	15300	8	25709	972
45.0	0	2580	5332	43939	8	7203	2379
47.0	0	0	2287	51155	1694	3910	2785
49.0	0	6473	[illegible]	50626	20265	5619	1574
51.0	0	9053	8551	47229	2199	3109	79
53.0	0	19419	4910	35526	513	10590	680
55.0	0	63651	34264	24288	6295	12941	747
57.0	0	55959	25452	62227	31511	26213	1398
59.0	0	28471	19040	49289	33396	25956	1338
61.0	0	2580	3977	36288	26814	11899	905
63.0	0	0	1516	10628	36	5041	1959
65.0	0	0	3045	5551	27	3477	1930
67.0	0	0	0	3239	27	2230	2656
69.0	0	0	5332	55	62	5087	3643
71.0	0	0	0	28	54	4460	680
73.0	0	0	175	0	108	8920	1358
75.0	0	0	0	28	102	8431	1673
77.0	0	0	2934	0	903	3345	2125
79.0	0	0	2287	0	407	0	1337
81.0	0	0	472	0	0	0	1474
83.0	0	0	2759	2943	127	0	1416
85.0	0	0	1230	148	815	0	788
87.0	0	0	1888	28	1538	1115	0
89.0	0	0	1524	1602	1410	2362	0
91.0	0	0	2575	380	1284	1208	394
93.0	0	0	1413	7070	468	1115	0
95.0	0	0	1993	2608	1003	1115	0
97.0	0	0	4183	6096	1804	1468	867
99.0	0	0	5680	2261	1466	3227	0
101.0	0	0	6474	8864	4435	3852	316
103.0	0	0	6811	6475	2554	742	237
105.0	0	0	2979	12280	3666	3203	395
107.0	0	0	1171	9518	5015	3715	316
109.0	0	0	175	11637	5462	4875	552
111.0	0	0	469	4511	1745	5332	79
113.0	0	0	175	7699	1070	5512	0
115.0	0	0	758	3068	268	2485	0
117.0	274	0	0	543	14	2138	0
119.0	91	0	588	55	8	3631	0
121.0	639	0	1710	28	498	2270	0
123.0	365	0	1826	712	0	116	0
125.0	1461	0	766	120	498	116	0
127.0	1369	0	647	515	14	1115	0
129.0	1735	0	766	55	142	2231	0
131.0	1096	0	2651	2200	21	1691	0
133.0	639	0	882	1022	12	1188	38
135.0	183	0	472	6931	23	2044	0
137.0	639	0	175	802	32	2620	113
139.0	183	0	766	2159	24	2677	0
141.0	0	0	0	1698	29	2411	0
143.0	183	0	0	609	6	569	192
145.0	0	0	0	570	3	280	189
147.0	91	0	0	1452	9	747	76
149.0	0	0	0	1255	4	475	113
151.0	91	0	294	1448	3	266	113
153.0	0	0	294	625	0	0	38
155.0	0	0	0	326	0	0	76
157.0	0	0	0	1649	3	266	189
159.0	0	0	0	850	0	0	151
161.0	0	0	0	375	3	266	227
163.0	91	0	294	2450	0	0	151
165.0	0	0	0	464	0	0	113
167.0	0	0	0	686	0	0	76
169.0	0	0	0	457	0	0	76
171.0	0	0	0	878	0	0	38
173.0	0	0	0	83	0	0	0
175.0	0	0	0	28	0	0	0
Total	9130	194659	199281	561304	159905	250587	39845

Appendix Table 6.- Estimated length composition of yellowfin tuna caught by American purse seiners in the eastern tropical Atlantic in 1973.

Midpoint Length (cm)	Number of fish by month				
	Jul.	Aug.	Sept.	Oct.	Nov.
39.0	93	4117	0	0	0
41.0	93	3937	1702	0	0
43.0	93	1372	6020	0	0
45.0	93	1372	2461	570	0
47.0	93	0	1838	285	0
49.0	0	0	1086	0	0
51.0	93	1372	443	0	0
53.0	374	6682	0	0	0
55.0	187	7874	344	0	0
57.0	374	14736	1439	0	0
59.0	654	9426	4687	0	0
61.0	374	16467	7773	285	0
63.0	374	6264	8116	0	0
65.0	93	8233	5791	856	0
67.0	0	1372	1131	0	0
69.0	0	2744	1131	285	0
71.0	0	1372	480	570	0
73.0	0	775	0	856	0
75.0	187	775	272	285	0
77.0	187	0	0	856	0
79.0	187	0	0	856	0
81.0	187	775	0	285	0
83.0	467	0	0	285	0
85.0	93	775	0	1141	0
87.0	93	0	0	285	0
89.0	187	775	0	781	0
91.0	0	0	959	736	0
93.0	93	775	0	285	0
95.0	0	775	0	1186	0
97.0	0	1549	480	1306	0
99.0	0	3873	959	1021	0
101.0	0	4648	959	736	1624
103.0	0	10845	480	901	2706
105.0	0	1549	0	0	1624
107.0	0	6438	0	1186	1082
109.0	286	775	0	165	2165
111.0	0	0	0	736	4871
113.0	0	0	0	165	5953
115.0	143	775	0	1488	3247
117.0	0	775	0	1323	2165
119.0	0	0	0	1488	541
121.0	429	0	959	662	0
123.0	428	775	0	165	541
125.0	1143	0	0	0	0
127.0	1428	0	0	165	0
129.0	1571	0	0	165	541
131.0	1001	0	0	0	0
133.0	1571	775	0	165	0
135.0	1858	775	0	0	0
137.0	1001	0	0	0	0
139.0	572	0	0	0	0
141.0	1144	1549	0	0	0
143.0	428	0	0	0	0
145.0	429	0	0	0	0
147.0	143	0	0	0	0
149.0	143	0	0	0	0
151.0	143	0	0	0	0
153.0	285	0	0	0	0
155.0	0	0	0	0	0
157.0	0	0	0	0	0
159.0	0	0	0	0	0
161.0	0	0	0	0	0
163.0	143	0	0	0	0
Total	18958	127866	49510	22525	27060

Appendix Table 7.—Estimated length composition of yellowfin tuna caught by American purse seiners in the eastern tropical Atlantic in 1974.

Midpoint Length (cm)	Number of fish by month									
	Jan.	Feb.	Mar.	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
35.0	0	0	0	0	0	87	33	540	0	0
37.0	0	0	0	0	0	87	0	0	0	0
39.0	0	0	0	0	0	745	132	2609	0	0
41.0	142	16	52	139	1893	174	33	540	1420	0
43.0	189	21	69	186	2524	793	0	0	5181	0
45.0	241	27	89	237	3218	928	66	1080	5430	0
47.0	73	8	27	72	978	1089	66	1080	1420	0
49.0	147	16	54	144	1956	875	99	1844	1420	0
51.0	121	13	44	118	1609	875	66	1753	1828	0
53.0	525	58	193	516	7003	349	66	1304	0	0
55.0	503	56	185	495	6719	1525	0	224	355	0
57.0	603	67	221	592	8044	2854	33	540	1118	0
59.0	366	41	135	360	4890	3734	66	2426	0	0
61.0	262	29	96	258	3502	2298	199	6606	4105	0
63.0	168	19	62	165	2240	770	298	9348	8024	0
65.0	73	8	27	72	978	652	199	7055	19749	0
67.0	73	8	27	72	978	910	33	1438	24512	0
69.0	0	0	0	0	0	257	33	540	8541	0
71.0	143	16	52	140	1906	201	33	764	3684	0
73.0	191	21	70	187	2544	772	0	0	8431	0
75.0	143	16	52	140	1906	1311	0	0	11579	0
77.0	96	11	35	94	1276	1218	0	0	6009	0
79.0	111	12	41	110	1488	2088	0	224	1766	0
81.0	118	13	43	116	1572	1141	296	4818	1105	0
83.0	276	31	102	272	3689	688	127	2065	760	0
85.0	138	15	51	136	1845	0	42	688	1901	0
87.0	290	32	107	285	3872	457	380	6194	380	0
89.0	274	30	101	269	3659	1028	253	4578	0	0
91.0	65	7	24	64	874	1336	211	3666	344	0
93.0	18	2	7	18	243	457	253	4578	0	0
95.0	16	2	6	16	213	201	42	688	0	0
97.0	32	4	12	31	425	288	0	0	0	0
99.0	34	4	13	34	455	370	42	688	355	235
101.0	138	15	51	136	1847	1208	42	913	344	0
103.0	65	7	24	64	874	1226	0	449	355	118
105.0	0	0	0	0	0	1378	0	449	355	118
107.0	236	26	87	232	3155	989	42	913	355	118
109.0	280	31	103	276	3744	2122	42	688	710	118
111.0	358	40	132	352	4785	3833	0	0	0	118
113.0	298	33	110	293	3979	2811	42	688	344	118
115.0	147	16	54	144	1956	4671	0	224	0	470
117.0	95	11	35	93	1262	4299	42	1137	0	353
119.0	139	15	51	136	1852	4800	108	2441	0	705
121.0	63	7	23	62	844	3131	0	1085	0	235
123.0	63	7	23	62	844	3232	33	1699	355	235
125.0	26	3	10	26	347	990	0	2468	355	353
127.0	50	6	18	49	661	87	33	3568	0	235
129.0	16	2	6	16	213	594	66	2239	0	235
131.0	18	2	7	18	243	663	42	688	355	0
133.0	0	0	0	0	0	707	0	374	0	118
135.0	2	0	1	2	30	292	0	187	355	0
137.0	5	1	2	4	61	436	42	1473	0	0
139.0	23	3	8	22	303	349	0	187	0	0
141.0	2	0	1	2	30	262	42	875	0	118
143.0	25	3	9	25	334	518	84	1750	0	0
145.0	20	2	8	20	273	493	0	187	0	353
147.0	18	2	7	18	243	349	0	0	0	470
149.0	5	1	2	4	61	117	0	411	0	705
151.0	14	2	5	13	182	466	0	0	0	0
153.0	11	1	4	11	152	292	0	0	0	235
155.0	5	1	2	4	61	0	0	224	0	0
157.0	11	1	4	11	152	174	0	0	0	0
159.0	0	0	0	0	0	0	0	0	0	0
161.0	9	1	3	9	121	0	0	0	0	118
163.0	5	1	2	4	61	87	0	0	0	0
165.0	2	0	1	2	30	0	0	0	0	0
167.0	5	1	2	4	61	0	0	0	0	0
169.0	5	1	2	4	61	0	0	0	0	0
171.0	0	0	0	0	0	0	0	0	0	0
173.0	2	0	1	2	30	0	0	0	0	0
Total	7592	845	2795	7458	101351	71134	3761	93195	123300	5881

ppendix Table 8.– Estimated length composition of skipjack tuna caught by American purse seiners in the eastern tropical Atlantic in 1968.

Midpoint Length (cm)	Number of fish by month			
	Aug.	Sept.	Oct.	Nov.
39.0	0	0	2409	0
41.0	0	0	0	0
43.0	0	9257	2409	0
45.0	32798	70624	12046	0
47.0	131436	139866	68875	452
49.0	123675	91380	25709	362
51.0	28540	39476	22903	543
53.0	58833	21281	11452	271
55.0	45815	19055	27127	814
57.0	26035	28488	24718	814
59.0	25036	36659	11254	362
61.0	1752	34206	19900	814
63.0	0	9901	2211	90
65.0	1752	1076	0	0
Total	475672	501269	231013	4522

Appendix Table 9.– Estimated length composition of skipjack tuna caught by American purse seiners in the eastern tropical Atlantic in 1969.

Midpoint length (cm)	Number of fish by month				
	Jul.	Aug.	Sept.	Oct.	Nov.
39.0	0	4739	1048	0	0
41.0	0	18759	7150	0	0
43.0	22468	51955	14148	2013	872
45.0	17653	57873	26569	5965	2617
47.0	17653	96038	25620	15956	7414
49.0	8024	65096	24959	32961	3489
51.0	4815	73737	24851	45359	2617
53.0	1605	147494	49613	48242	2181
55.0	4815	157306	54574	63066	2181
57.0	1605	91651	57854	59256	436
59.0	1605	54032	34425	46465	0
61.0	0	33216	15788	34248	0
63.0	0	7631	1925	10974	0
65.0	0	1431	0	2259	0
Total	80243	860958	338524	366764	21807

Appendix Table 10.– Estimated length composition of skipjack tuna caught by American purse seiners in the eastern tropical Atlantic in 1970.

Midpoint length (cm)	Number of fish by month						
	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.
37.0	0	0	0	24835	0	0	0
39.0	0	0	4943	0	0	0	0
41.0	70	2446	12334	24835	32939	11349	0
43.0	548	19219	39089	149012	16469	11242	3355
45.0	2610	91520	135299	311362	0	2476	1492
47.0	2761	96812	206739	301012	41173	32304	10918
49.0	2128	74613	91742	442347	151716	75504	13999
51.0	1259	44155	67015	381942	170979	87829	17427
53.0	737	25827	35296	250967	218438	128026	31797
55.0	426	14935	14286	41588	121571	123720	49316
57.0	525	18418	7986	56027	87236	115101	51251
59.0	162	5666	8398	0	17866	46369	24234
61.0	391	13692	13004	0	0	2141	1290
63.0	114	3983	1844	0	0	0	0
65.0	177	6212	0	0	0	0	0
67.0	108	3789	0	0	0	0	0
Total	12016	421287	637975	1983927	858387	636061	205079

Appendix Table 11.– Estimated length composition of skipjack tuna caught by American purse seiners in the eastern tropical Atlantic in 1971.

Midpoint length (cm)	Number of fish by month				
	Jul.	Aug.	Sept.	Oct.	Nov.
35.0	0	778	0	3879	0
37.0	0	1054	13973	10622	0
39.0	1715	1969	79921	87724	22140
41.0	5358	2552	423894	572735	27721
43.0	37829	11730	601535	591718	99537
45.0	80052	62618	921515	389419	135261
47.0	47581	94475	612368	533072	126521
49.0	18539	91279	361004	220877	120755
51.0	14683	97721	384174	313773	57679
53.0	4394	68150	155941	355220	54889
55.0	6109	25970	70307	236933	32933
57.0	0	10751	21632	90572	10978
59.0	0	2250	19227	20129	0
61.0	1715	1969	4787	0	0
63.0	0	0	3722	0	0
65.0	1715	864	0	0	0
Total	219690	474130	3674000	3426673	688414

Appendix Table 12.– Estimated length composition of skipjack tuna caught by American purse seiners in the eastern tropical Atlantic in 1972.

Midpoint length (cm)	Number of fish by month						
	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.
33.0	0	0	2275	0	0	0	1290
35.0	2659	4106	42896	11985	0	8569	9871
37.0	5548	4646	44684	305230	100456	64367	70298
39.0	13525	13833	56322	497974	244828	206845	54401
41.0	22888	27127	64237	335621	391793	233145	33312
43.0	46122	50895	89352	231361	277366	109356	15386
45.0	63232	38305	278838	367061	300561	128683	14973
47.0	29478	86480	268123	279298	301074	179767	26969
49.0	2659	57565	126408	173796	111142	165454	26809
51.0	10636	61671	19085	59862	42428	113891	16855
53.0	2774	23297	22120	8954	30863	83770	11305
55.0	1387	4106	13263	2383	7122	27694	5450
57.0	0	14373	2275	9277	4748	15051	27
59.0	1387	8484	19586	0	0	3372	0
61.0	0	2323	26671	1711	0	2984	0
63.0	0	0	9360	0	0	0	0
Total	202295	397211	1085495	2284513	1812381	1342948	286946

Appendix Table 13.– Estimated length composition of skipjack tuna caught by American purse seiners in the eastern tropical Atlantic in 1973.

Midpoint length (cm)	Number of fish by month				
	Jul.	Aug.	Sept.	Oct.	Nov.
33.0	126	3696	0	0	0
35.0	114	3340	0	5663	0
37.0	2151	62958	26879	3935	0
39.0	5594	163760	147907	21511	0
41.0	16286	476786	688219	185781	0
43.0	28982	848494	1392101	317625	0
45.0	31955	935517	2028754	478645	0
47.0	24474	716497	1518342	630823	1108
49.0	13104	383647	706955	388533	1582
51.0	3372	98730	133770	177279	4021
53.0	423	12382	11543	45677	5748
55.0	206	6024	0	2819	7422
57.0	299	8747	9252	0	4800
59.0	0	0	0	0	1399
61.0	68	1998	0	0	291
Total	127154	3722576	6663722	2258291	26371

Appendix Table 14.– Estimated length composition of skipjack tuna caught by American purse seiners in the eastern tropical Atlantic in 1974.

Midpoint Length (cm)	Number of fish by month									
	Jan.	Feb.	Mar.	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
29.0	0	0	0	0	0	0	22682	0	0	0
31.0	0	0	0	0	0	0	56705	0	0	0
33.0	0	0	0	0	0	443	56705	0	0	0
35.0	0	0	0	0	0	0	317157	0	0	0
37.0	214	15	116	282	2002	0	458035	9524	0	8228
39.0	2399	174	1304	3164	22462	19659	425648	11547	6739	38798
41.0	6191	448	3365	8164	57965	38702	767286	415456	25499	207593
43.0	6602	478	3588	8705	61805	121033	680598	631623	75404	236729
45.0	5710	414	3103	7529	53455	102638	455170	208315	69577	260544
47.0	17511	1268	9517	23091	163939	102108	507089	300723	65934	243426
49.0	6597	478	3585	8699	61760	74915	262163	128828	115659	123428
51.0	11755	851	6389	15501	110056	105090	172428	27220	72673	55381
53.0	1254	91	682	1654	11743	30830	437149	0	26957	31378
55.0	264	19	144	348	2472	18203	502969	0	47175	27108
57.0	950	69	516	1252	8892	12519	318003	0	6739	22506
59.0	963	70	524	1270	9018	10518	118255	0	6739	12866
61.0	0	0	0	0	0	5786	44346	0	0	0
63.0	97	7	53	128	908	2384	14782	0	0	0
65.0	963	70	524	1270	9018	795	0	0	0	0
67.0	915	66	497	1206	8564	0	0	0	0	0
Total	62385	4518	33907	82263	584059	645623	5617170	1733236	519095	1267985

Appendix Table 15.– Estimated length composition of bigeye tuna caught by American purse seiners in the eastern tropical Atlantic.

Midpoint Length (cm)	Number of fish by year				
	1968	1971	1972	1973	1974
39.0	0	0	0	70	126
41.0	0	315	0	140	478
43.0	22	567	0	0	353
45.0	0	158	0	0	364
47.0	0	166	0	0	655
49.0	0	329	0	0	496
51.0	0	0	204	140	227
53.0	0	175	392	71	642
55.0		175	1794	211	914
57.0	0	1032	2390	493	787
59.0	0	1449	5163	1262	581
61.0	22	175	8116	1546	2372
63.0	0	420	3972	848	2517
65.0	0	646	1191	992	2187
67.0	44	158	400	284	792
69.0	22	472	0	284	1342
71.0	22	154	0	0	943
73.0	0	158	0	0	624
75.0	0	235	0	140	844
77.0	0	88	0	213	738
79.0	0	0	0	210	304
81.0	0	0	0	281	738
83.0	0	79	196	70	1477
85.0	22	0	204	282	1463
87.0	44	77	604	421	2070
89.0	44	158	400	417	643
91.0	0	79	799	701	867
93.0	0	312	791	566	1240
95.0	22	235	1574	142	661
97.0	0	471	196	142	204
99.0	0	548	196	71	325
101.0	0	236	587	0	394
103.0	0	315	0	0	482
105.0	0	166	0	71	238
107.0	0	245	0	0	41
109.0	0	235	0	0	755
111.0	0	465	0	71	430
113.0	26	954	0	0	1624
115.0	26	469	0	71	1028
117.0	26	940	0	0	1186
119.0	0	1656	0	71	803
121.0	26	1179	0	0	388
123.0	0	866	0	0	364
125.0	26	630	0	71	172
127.0	26	550	0	71	107
129.0	0	235	196	0	107
131.0	26	0	0	0	41
133.0	26	77	0	0	705
135.0	26	0	0	0	315
137.0	0	0	0	0	344
139.0	0	77	0	0	41
141.0	0	0	0	0	587
143.0	0	158	0	71	376
145.0	0	0	0	71	842
147.0	0	156	0	71	270
149.0	0	79	0	0	1079
151.0	0	232	0	0	0
153.0	0	77	0	0	235
155.0	0	232	0	0	0
157.0	26	0	0	0	0
159.0	0	154	0	0	0
161.0	0	154	0	0	41
163.0	0	0	0	0	0
165.0	0	77	0	0	0
167.0	0	154	0	0	0
169.0	0	0	0	0	0
171.0	0	88	0	0	270
Total	524	19687	29365	10636	41239

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