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A Preliminary Population Study of the Yellowfin Tuna and the Albacore

By
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CONTENTS

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The publication of this report was unavoidably delayed by the outbreak of the recent war, and over this long interval a number of people have contributed their time or experience to the original work, the analysis or to the subsequent preparation of the manuscript. Hence to various members of the staff I am indebted for help, generously given in one form or another. In particular, I acknowledge gratefully the invaluable help of Mr. R. D. Byers, who as a member of the staff at that time, performed an appreciable part of the laborious calculations in the preliminary phases of this study.

Finally to Captain L. J. Weseth and the crew of the *N. B. Scofield*, I am profoundly indebted for indispensable aid in collecting the material on the distant fishing grounds. To all I extend my sincere thanks.

H. C. GODSIL
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1. GENERAL DISCUSSION

In "A Systematic Study of the Pacific Tunas" [1] it was shown that specimens of yellowfin tuna, (Neothunnus macropterus), and albacore (Thunnus germo), obtained from Japan and the Hawaiian Islands are individually indistinguishable from those taken in the eastern Pacific. In the present study the relationship of the foreign to the local specimens is more closely investigated. In the two sections of this report an effort is made to determine, firstly, whether fish (of the two species discussed) from Japan and from the Hawaiian Islands are of the same or different populations from those taken by the California fishing fleet off this coast; and secondly, whether the yellowfin tuna in the eastern Pacific constitute a single, homogeneous and intermingling population or an aggregate of separate and recognizable groups, each confined to a specific geographic area.

The term "population" as used herein, may be defined as a group of intermingling fish inhabiting a restricted area and constituting a separate and distinct unit, the fish of which may collectively be distinguished and identified by minor morphological characteristics. Underlying this definition is the assumption that distinct populations do not normally intermingle, with the corollary that differences existing between populations are constant. Motivating this study is the necessity of determining whether the local industry shares a common reservoir of albacore and yellowfin tuna with the Hawaiian and Japanese fisheries or is exploiting populations of these species confined to the eastern Pacific. In the latter event it will be necessary for intelligent management to determine further whether the local stock is composed of a single reservoir or a number of distinct and nonintermingling units.

The two species treated in this report are discussed separately. But because the problems are so similar and the methods identical the introductory remarks and necessary explanations suffice for both.

In both species body proportions were used throughout. Meristic counts were tried but were abandoned as unsatisfactory. All measurements are straight line distances recorded in millimeters and made by the author with the same instruments, namely two pairs of slide calipers made expressly for this work. The precise manner in which the measurements were made is described in Appendix A.

The methods of analysis, in themselves simple, are collectively confusing because three distinct approaches lead to the final conclusions. Hence a preliminary explanation of the procedure is given in the belief that it will materially aid the reader in following the discussion.

In the following paragraphs a brief description of the scope of each of the two investigations is given. This is followed by a detailed description of the methods used and the reasons governing their selection. Possible criticisms are next anticipated, but are reserved for a fuller discussion until the results of the yellowfin tuna study have been presented. With this background the actual results of the two individual

[1] Calif. Div. of Fish and Game, Fish Bull. No. 60.

studies are next presented, that of the yellowfin tuna coming first because it is more extensive and more complex. Finally a miscellaneous collection of data which might be of interest or use to other workers but which is irrelevant to the immediate presentation is assembled in the appendix.

The scope of the two investigations differs, and this fact will explain the differing procedures. In the case of the yellowfin tuna an investigation was started about 1934, and the need of a population study foreseen. Some preliminary work was done on suitable population characters and a program outlined to meet the special requirements of the fishery. Because it was necessary to collect numerous samples from distant and distinct fishing grounds in order to determine whether the extensive stock exploited was of one or more populations, it was decided to collect in the field a few proportional measurements from large numbers of fish. The six measurements selected were: body length, head length, the insertion of the first dorsal, second dorsal, anal and ventral fins.

Beginning in 1936, the author made a number of trips aboard tuna boats, and in the course of these trips collected data on the fishing grounds for this study, segregating the data according to the geographic origin of the catch. Later the work was resumed and completed upon the catch of tuna of the research vessel *N. B. Scofield*. Thirteen samples aggregating 1,911 yellowfin were handled between 1936 and 1940, and these samples constitute the basis of the present analysis of "local" material. Ultimately a small shipment of five yellowfin was obtained from Japan, and through the courtesy of the Hawaiian Tuna Packers 12 specimens were secured from the Hawaiian Islands. Six Peruvian specimens were obtained from a small commercial shipment. All local fish were handled fresh, aboard ship, and the foreign shipments were frozen and measured immediately after thawing.

The analysis of this material leads to the following general conclusions.

- 1. The stock of yellowfin tuna now exploited in the eastern Pacific by the California fleet, ranging from Southern California to the equator, consists of a single, intermingling population.
- 2. The sample of yellowfin from Japan is, with a high degree of probability, drawn from a population which is separate and distinct from that of the eastern Pacific.
- 3. The sample of Hawaiian yellowfin indicates that this population is likewise distinct from our local fish, but is intermediate between the Japanese and American populations.
- 4. The relationship of the Hawaiian to the Japanese populations cannot be determined from the present data, but the distribution of individual values suggests that these two populations are more closely related to one another than to the American stock.
- 5. The Peruvian yellowfin are similar to the local population in four of the five proportions, but a suggestive difference exists in the fifth proportion. Until this apparent difference can be further explored in a larger sample, the two populations should be regarded as distinct.

The albacore investigation was of secondary importance and work was done as opportunity offered. The systematic study of the species was the first major objective accomplished and this laid the foundation for the present population study. With this species it was deemed necessary to determine only whether or not the Japanese and Hawaiian fish constitute populations distinct from our own. The homogeneity of the local stock was temporarily assumed. ("Local" in these pages refers to the fish off the North and Central American mainland and adjacent islands.) With only a few Hawaiian and Japanese fish available it was decided to collect extensive measurements from two relatively small local samples, in the belief that numerous characters would offset the dearth in numbers of fish. Accordingly, a preliminary analysis was made of the available and extensive systematic data, and 14 characters were selected for duplication upon sufficient local specimens to yield the necessary basis of comparison.

Results of this study indicate with a high degree of probability that the Japanese specimens represent a population of albacore quite distinct from our local fish. In view of the large size of the three Hawaiian specimens no valid conclusions can be drawn. However, indications are that the Hawaiian specimens resemble those of the Japanese population more than local specimens.

1.1. METHODS

Because the size of individual fish varied greatly, the actual measurements were not directly comparable and it was accordingly necessary to employ methods of regression analysis. Plotting to a large scale the actual measurements of a given character against the body length in each case, revealed that the sample regressions were nearly but not quite linear. of the various functions tried [2] the expression:

$$Y = a + bx + c\frac{1}{x}$$

FORMULA

(where x = body length in each case and Y = the dependent variable) resulted in the best fit. The reduction in the sum of the squared deviations obtained from the above expression, when compared with that from a linear regression was, in most cases, highly significant: therefore curvilinear regression was used throughout using conventional methods of analysis of variance.

Because the interest in this study focuses upon the similarity and differences of the various sample regression lines rather than upon means or regression coefficients, the sum of the squared deviations from the individual sample regression lines was compared directly with the sum of the squared deviations of all variates in all samples from the "total" regression line, with the loss of three degress of freedom for each regression computed. The method, used consistently, is illustrated by the following analysis of the regression of the second dorsal insertion upon body length, wherein the 13 local samples include 1,910 fish. With three degrees of freedom lost in each of the 13 individual regressions, the 1,910 variates are reduced by 39 to 1,871 degrees of freedom. For the "total" sample regression line only three degrees of freedom are lost, so that N becomes 1,910 - 3 = 1,907, and the resulting "between regression lines" degrees of freedom becomes 1,907 - 1,871 = 36.

[2] $Y = a + bx$.
$Y = a + bx + cx^2$.
$Y = a + bx + cx^2 + dx^3$.
$Y = ax^b$.
$Y = ae^{bx}$.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Dev. from total regressions	1907	39,231.4	
Dev. from (13) indiv. regressions	1871	36,508.98	19.513
Between regressions	36	2,722.42	75.6228

$$F = \frac{75.6228}{19.513} = \underline{\underline{3.876}}$$

EQUATION

This F value indicates significant differences between the samples.

Results of the application of the foregoing method to the data at hand indicate that in all regressions the 13 local samples of yellowfin cannot be considered as of the same population. Furthermore individual comparisons of two or more of the 13 samples yield the same conclusion. Finally, samples taken from the same area, comprising fish of the same size, prove to be significantly different. Accepting these results at their face value leads inevitably to the conclusion that the stock of tuna is composed of innumerable, distinct populations in no discernable way associated with geographical habitat. If such were the case then one could not predict the characteristic regression of a sample taken from any specified region and there would be no basis upon which to found assumptions for the better understanding of the fishery. Furthermore, if all (or most) of the local samples differ significantly from one another, how would one evaluate such differences as occurred between local and foreign samples? While such a situation is possible it seems highly improbable, and one is compelled to look deeper for an explanation of this anomalous condition. To the writer it suggests a fundamental difference in the concepts of statistical and biological homogeneity.

Consider a population of tuna distributed from California to the equator. Each year this population is augmented by an annual spawning which may occur over an extensive area and a relatively prolonged season. Varying environmental conditions during the developmental period undoubtedly result in slight variations in the characteristics of the individuals. Let it be assumed that over the extensive but circumscribed distributional area progressive diffusion from spawning and rearing grounds, seasonal migrations, etc. cause an eventual complete mixing of the mature stock. This will nevertheless take time, and inasmuch as annual increments of varying magnitudes are being constantly added to the reservoir, strict statistical homogeneity can hardly be attained, despite the fact that upon the foregoing assumptions the stock is composed of a single, freely intermingling and biologically homogeneous population. Random sampling would necessitate sampling the several age components in proportion to their composition of the total stock. This is impractical, and it is therefore not surprising to find that successive samples, even from the same locality, differ significantly—in a statistical sense—from each other.

For these reasons a second approach to the problem was sought in the plotted distribution of all variates. Whereas this does not evaluate the significance of existing differences or give a numerical measure of such differences, it nevertheless gives a visual, objective meaning to the data and enables one to draw rational and practical conclusions. Accordingly this was adopted as a second method of approach to supplement the analysis of variance, and graphs are shown depicting for each regression the distribution of all variates. Throughout this paper all values are plotted except those that coincide or whose contiguity is so close as to preclude clear reproduction.

In an effort to overcome the limitations of the graphical method an attempt was made to devise a measure of the difference existing between regression lines. In this, an empirical population regression line for each regression was assumed, based upon all variates in all local samples. This was regarded as a population parameter and the divergence of each sample regression line was measured from this base. The idea behind this was essentially to measure the variation of all local samples from the population regression in order to afford a means of evaluating, in terms of this anticipated local variation, the differences (again measured from this base) occurring in the foreign samples.

The comparison suggested above was effected as follows: Given a single sample of variates, the average squared distance of each variate in the sample from its own regression line is equal to the mean square,

$$A = \frac{\text{Sum of squared deviations from sample regression line}}{\text{Number of variates in sample}}$$

EQUATION

For the same sample the average squared distance of each variate measured now from a second, empirical regression line is equal to,

$$B = \frac{\text{Sum of squared deviations from empirical regression line}}{\text{Number of variates in sample}}$$

EQUATION

Because the variates are identical, the difference in the two quantities, B-A, measures approximately the average squared distance existing between the sample and the empirical regression lines throughout the range of the sample. This quantity, B-A, therefore gives a relative, numerical measure of the divergence of the two regression lines. Complete coincidence of the lines would yield a value of zero, while there would be a proportionate increase in this value as the two regression lines progressively diverged.

The quantity A in the present case, where the values of x and Y are in actual units of measurement and not in deviations from the means, and where:

$$Y = a + bx + c\frac{1}{x},$$

EQUATION

is obtained from the equation:

$$\Sigma(Y_o - Y_c)^2 = \Sigma Y^2 - a\Sigma Y - b\Sigma xY - c\Sigma\frac{1}{x}Y \text{ ---------- } (1)$$

EQUATION

which gives the sum of squared deviations from the line of best fit, e.g., the sample regression line. This, however, is a particular case of the general expression:

$$\Sigma(Y_o - Y_c)^2 = \Sigma Y^2 - 2a\Sigma Y - 2b\Sigma xY - 2c\Sigma\frac{1}{x}Y + Na^2 +$$
$$2ab\Sigma x + 2ac\Sigma\frac{1}{x} + b^2\Sigma x^2 + 2Nbc + c^2\Sigma\frac{1}{x^2} \text{ -------------- } (2)$$

EQUATION

which results from the expansion of the regression formula:

$$\Sigma(Y_o - Y_c)^2 = \Sigma[Y_o - (a + bx + c\frac{1}{x})]^2$$

EQUATION

Equation (1) is conditioned by the fact that [E]$(Y_o - Y_e)^2$ is a minimum, and is derived by substituting in equation (2) the three equations of condition. Now, while equation (1) applies only to the line of best fit, equation (2) is not so limited, and gives the sum of squared deviations of a sample of variates from any comparable regression line of which a is the constant and b and c the coefficients. To determine, therefore, for a given sample the sum of squared deviations from an empirical regression line, one substitutes in equation (2) the constant and coefficients of the empirical regression line and the several values of the variates from the particular sample under consideration. Although the expression seems cumbersome, the amount of work involved is not excessive because the majority of the required values must necessarily be calculated for the solution of the normal equations.

For a linear regression the comparable formulae are:

$$\Sigma(Y_o - Y_c)^2 = \Sigma Y^2 - a\Sigma Y - b\Sigma xY \quad (1)$$

and:

$$\Sigma(Y_o - Y_c)^2 = \Sigma Y^2 - 2a\Sigma Y - 2b\Sigma xY + Na^2 + 2ab\Sigma x + b^2\Sigma x^2 \quad (2)$$

EQUATION

Without in any way affecting the statistical conclusions resulting from the analysis of variance, the above method is introduced to clarify the relationship of the foreign to the local population. As will be seen in the discussion of the yellowfin tuna, all local samples, although differing significantly in a statistical sense, possess regression lines remarkably similar and close to the empirical regression line assumed to be characteristic of this population; whereas the foreign fish are distant from this empirical regression line to an extent many times that of the local variates. The method thus enables one to compare any subsequent sample of variates with this population regression line. The results in general amplify the analysis of variance. Hence this method is introduced as a third approach to the problem. In the specific discussions to follow, an attempt is made to distinguish the methods employed by consistently referring to the analysis of variance as the "statistical" method. In both studies the results of the analysis of variance are presented first, and then the data are evaluated by the graphical method supplemented by the suggested measure of divergence.

Several criticisms have occurred, or have been suggested to the writer. Among these are: (1) as the range in size of fish within the various samples differs appreciably, the resulting regression lines are not comparable and this fact may explain the resulting heterogeneity; (2) regression lines based on samples including very few variates, e.g., all the foreign samples, may diverge disproportionately from the empirical population regression line by virtue of the small numbers included, so that a measure of divergence based thereon is not comparable with one based on a relatively large sample; (3) inasmuch as the foreign specimens were all frozen, stored and subsequently thawed before handling, the treatment may have affected the measurements to an extent which makes them noncomparable with the local measurements made upon fresh specimens. These criticisms have been considered and tested to a limited extent, but a discussion of them is deferred until the results of the study have been presented in order to avoid unnecessary confusion at this point.

2. YELLOWFIN TUNA

Neothunnus macropterus

Thirteen local samples from nine distinct fishing areas were collected for this study between 1936 and 1940 both inclusive. For each sample five regressions were calculated, based on the six measurements enumerated on page 6. The general origin of each sample and the number of fish in each is shown in Table 1. In Figure 1, the geographical origin of

TABLE 1

Origin, Date Taken, and Number of Fish Included in Each of the 13 Local Samples

Sample number	Origin	Date taken	Number of fish
1	White Friars, Mexico (17° 20′ N. 101° 30′ W.)	March, 1939	94
2	Gorda Bank, Mexico (22° 50′ N. 109° 50′ W.)	March, 1939	98
3	Cocos Island (5° 20′ N. 87° 00′ W.)	April, 1940	168
4	Costa Rica (9° 00′ N. 85° 00′ W.)	Nov. Dec.,1936	387
5	Costa Rica (9° 00′ N. 85° 00′ W.)	Jan. Feb.,1937	350
6	Guatemala (13° 30′ N. 91° 00′ W.)	March, 1939	120
7	Cocos Island (5° 20′ N. 87° 00′ W.)	January, 1937	143
8	Galapagos Islands (0° 00′ 91° 00′ W.)	April, 1940	194
9	Punta Galera, Mexico (15° 55′ N. 97° 40′ W.)	May, 1940	69
10	Panama (7° 00′ N. 81° 30′ W.)	Jan. Feb.,1937	123
11	Clipperton Island (10° 30′ N. 109° 00′ W.)	March, 1940	38
12	Costa Rica (9° 00′ N. 85° 00′ W.)	April, 1940	27
13	White Friars, Mexico (17° 20′ N. 101° 30′ W.)	March, 1939	100

TABLE 1

Origin, Date Taken, and Number of Fish Included in Each of the 13 Local Samples

the samples is indicated approximately. The total number of fish is 1,911, but in the various regressions this number varies from 1,907 to 1,911, due to the fact that measurements were occasionally omitted because of damage to an individual fin.

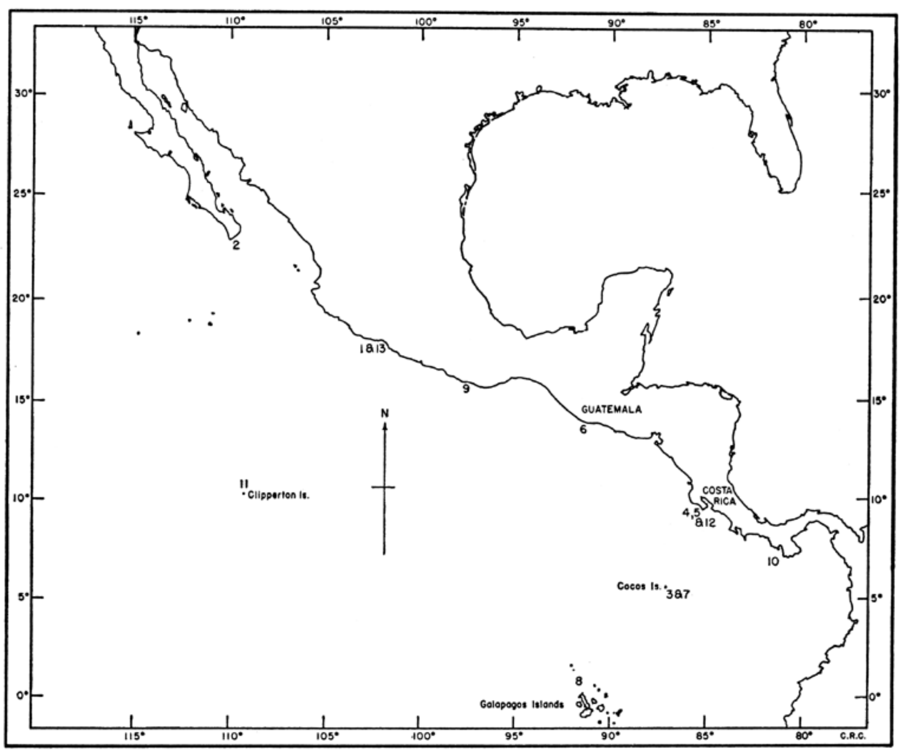

FIGURE 1. The extent of the fishing grounds for yellowfin tuna, showing the origin of the 13 local samples numbered as in Table 1, of the text.

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2.1. STATISTICAL ANALYSIS

Local Samples

Applying the method of analysis of variance to the several regressions, in order to test the statistical homogeneity of the 13 local samples, yields the following F values:

Head length	*1st dorsal*	*2d dorsal*	*Anal insertion*	*Ventral insertion*
6.405	4.215	3.876	10.036	4.327

The above F values are to be interpreted with degrees of freedom 36 and 1,872. The corresponding 5 percent and 1 percent F values are about 1.43 and 1.64 respectively. Therefore it is obvious that from a statistical standpoint the 13 samples cannot be considered a homogeneous population.

It remains to be shown whether or not this heterogeneity can be reconciled with geographical origin. If such is the case, then duplicate samples taken from the same region should be homogeneous, and it should be possible to obtain homogeneity by a proper and natural grouping of the samples according to origin.

There are three series of duplicate samples (see Table 1). Two samples are from Cocos Island, two from White Friars and three from Costa Rica. A comparison of the regression lines of these duplicate samples is summarized in Table 2, comparing in each case the sum of squared deviations from the combined-sample, regional regression line with that from the individual regression lines as discussed above.

TABLE 2

F Values, With Corresponding Degrees of Freedom, Resulting From an Analysis of Homogeneity of Duplicate Samples. "Significant" Implies Below the 1 Percent Level

Regression	Costa Rica		White Friars		Cocos Island	
	D. of Free.	"F"	D. of Free.	"F"	D. of Free.	"F"
Head length	6 & 755	3.98 (Significant)	3 & 188	3.33 (Between 1% & 5%)	3 & 305	1.06 (Not significant)
First dorsal	6 & 755	1.70 (Not significant)	3 & 188	0.74 (Not significant)	3 & 305	13.31 (Significant)
Second dorsal	6 & 754	1.17 (Not significant)	3 & 188	3.13 (Between 1% & 5%)	3 & 305	1.04 (Not significant)
Anal	6 & 753	4.68 (Significant)	3 & 188	9.38 (Significant)	3 & 305	10.56 (Significant)
Ventral	6 & 755	3.66 (Significant)	3 & 188	3.76 (Between 1% & 5%)	3 & 305	2.13 (Not significant)

TABLE 2

F Values, With Corresponding Degrees of Freedom, Resulting From an Analysis of Homogeneity of Duplicate Samples. "Significant" Implies Below the 1 Percent Level

In every series of duplicate samples there are significant differences (below the 1 percent level) in one or more of the characters investigated. Thus in the case of the White Friars region, the two samples were taken less than one month apart and consisted approximately of the same number of fish of the same approximate size; and yet of the five regressions investigated one differed by a highly significant value, three differed by a probability between the 1 percent and 5 percent values, and only one was not significantly different. Duplicate samples, therefore, differ as much as do samples from some widely separated regions, and it is obviously futile to attempt to explain the heterogeneity of the 13 samples on the assumption of characteristic regional regression lines. On the basis of this statistical analysis one must therefore conclude that the heterogeneity of the data is due to causes other than geographic segregation, and there is no present justification for assuming that the stock of tuna on this coast is composed of distinct and geographically localized populations. Results show, on the contrary, that the differences manifest in the 13 samples are found also within samples from the same region, indicating a free and perhaps extensive movement within and probably through a given area. Under these circumstances it seems advisable (until these divergent sample regression lines can be correlated with and explained by the causative factors) to regard the stock of yellowfin tuna as composed of a single (though statistically heterongeneous) population, the parameters of which are best estimated from the total sample. Assuming a regression line of the type discussed,

$$Y = a + bx + c\frac{1}{x}$$

EQUATION

these statistics are:

Regression: (*on body length*)	*Constant* 'a'	*Regression* 'b'	*Coefficients* 'c'	*Mean Square*
Head length	83.27424	.212240	-20,467.8084	9.650
First dorsal	95.19221	.226156	-23,086.8236	15.964
Second dorsal	111.91554	.441629	-27,416.5652	20.572
Anal	88.79915	.515977	-18,202.4687	25.327
Ventral	58.22874	.257736	-9,616.8242	19.358

2.1.2. Foreign Samples

Upon this assumption it is now in order to compare statistically the Japanese, Hawaiian and Peruvian samples with the foregoing local sample from the eastern Pacific. The results tabulated below (Table 3) are based on analyses identical in method with that previously described, namely, a comparison of deviations from the total, combined-sample regression with the deviations from the individual (two in this case) sample regression lines.

For 3 and 1,900 degrees of freedom the corresponding 5 percent and 1 percent values are 2.60 and 3.79. Inasmuch as the numbers of fish in the foreign samples are small, (5 Japanese, 6 Peruvian and 12 Hawaiian specimens) the results are indicative rather than conclusive, and for that reason the 1 percent value is a safer level of significance to use. On this

TABLE 3

F Values, With Corresponding Degrees of Freedom, Resulting From an Analysis of Homogeneity of the Local and Individual Foreign Samples

Regression	Local and Japanese		Local and Hawaiian		Local and Peruvian	
	D. of freedom	"F"	D. of freedom	"F"	D. of freedom	"F"
Head length	3 & 1910	48.361	3 & 1917	8.184	3 & 1911	1.268
First dorsal	3 & 1910	9.505	3 & 1917	0.331	3 & 1911	2.819
Second dorsal	3 & 1909	1.723	3 & 1916	0.051	3 & 1910	3.696
Anal insert	3 & 1906	1.126	3 & 1913	4.275	3 & 1907	12.540
Ventral	3 & 1908	18.158	3 & 1915	7.602	3 & 1909	0.517

TABLE 3

F Values, With Corresponding Degrees of Freedom, Resulting From an Analysis of Homogeneity of the Local and Individual Foreign Samples

basis the following tabulation shows graphically the foregoing results, "Yes" indicating significance beyond this level.

Comparison	*Head*	*1st dorsal*	*2d dorsal*	*Anal*	*Ventral*
Local and Japanese	Yes	Yes	No	No	Yes
Local and Hawaiian	Yes	No	No	Yes	Yes
Local and Peruvian	No	No	No	Yes	No

It appears from the foregoing that both the Japanese and the Hawaiian fish differ significantly from the local fish in three of the five regressions investigated, whereas the Peruvian fish differ from the local in only one regression. From a purely statistical standpoint the indicative results are that Japanese, Hawaiian and Peruvian yellowfin are derived from populations distinct from the local population. Before drawing conclusions, however, the data will be analysed by means of the second and third methods suggested earlier.

2.2. GRAPHS AND A MEASURE OF DIVERGENCE

A survey of the data from the local population reveals a close agreement in the distribution of measurements from all samples and gives no clue as to the reason for the statistical differences observed. This point is illustrated in Figure 2, which shows for the regression of anal insertion upon body length the distribution of individual values in relation to the population regression line. The latter is reproduced successively (parallel and identical in each case) in order to show the distribution of all values in each separate sample. (Throughout this report all variates are plotted in the graphs except those that coincide or are so close together as to preclude reproduction. Extreme values are always plotted.)

If the individual sample regression lines were superimposed upon the corresponding arrays in Figure 2, they would, in the majority of cases, approximate the population regression line so closely that the two lines could not be distinguished in the reproduction, and for this reason they have been omitted.

In each case, the individual sample regression line coincides, or is parallel with the population regression line for a greater or less extent of its length, while for the remainder of its extent it diverges from the latter by measureable amounts. The magnitude of this divergence was measured by means of the method suggested on page 9 of the introductory remarks. The results so obtained clarify the picture and approximate the limits within which subsequent sample regression lines of this population can be expected to fall.

In Table 4 the figures, in millimeters, are proportionate to the average squared distance separating, throughout their range, the individual sample regression lines from the total-sample regression line assumed as the most probable statistic for this local population. The quantities listed are equal to B-A of the foregoing discussion.

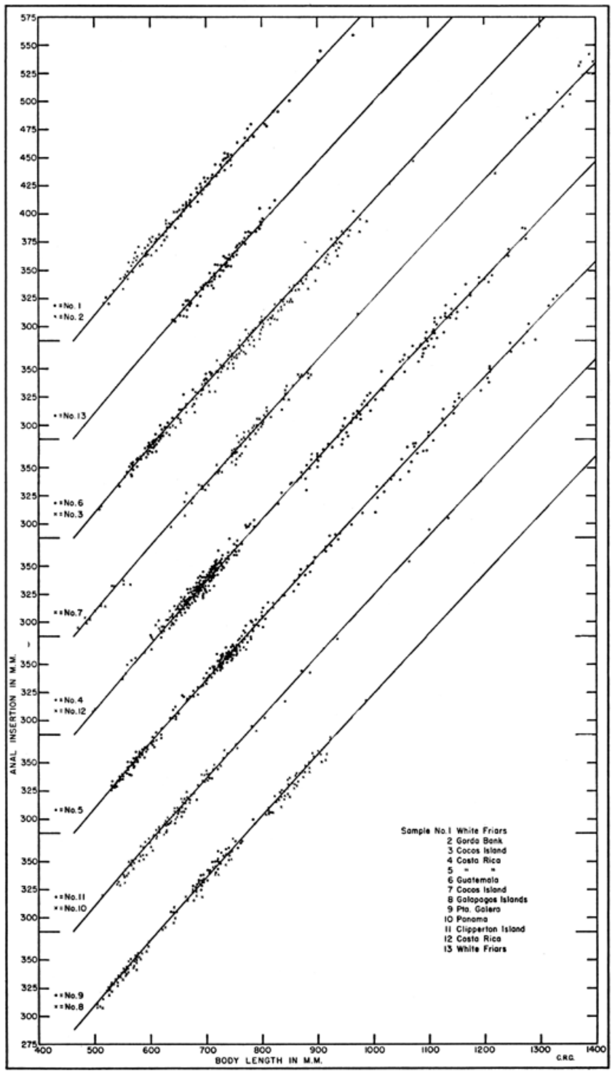

FIGURE 2. Yellowfin Tuna. The regression of anal insertion upon body length. The distribution about the local-population regression line of all the individual values in the 13 local samples. The regression line is reproduced identical in each array. The arrangement of the figure is such as to bring samples from the same region together for comparison. The figure has been condensed by combining two samples into one array where possible without obscuring the identity of the individual values.

FIGURE 2. Yellowfin Tuna. The regression of anal insertion upon body length. The distribution about the local-population regression line of all the individual values in the 13 local samples. The regression line is reproduced identical in each array. The arrangement of the figure is such as to bring samples from the same region together for comparison. The figure has been condensed by combining two samples into one array where possible without obscuring the identity of the individual values

TABLE 4

The Relative Average Distance, Expressed in Squared Millimeters, Between Each Local Sample Regression Line and the Corresponding Local Population Regression Line. The Figures in the Last Column Are the Sums of the Five Individual Sample Values

Sample	Difference in mean squares from sample and total regression					Sum of individual differences
	Head length	First dorsal	Second dorsal	Anal	Ventral	
1	0.853	0.349	2.318	10.755	5.027	19.302
2	0.411	0.938	6.943	4.428	1.081	13.801
3	0.351	1.773	1.267	14.946	0.702	19.039
4	1.761	0.979	0.797	1.964	0.700	6.201
5	0.754	0.292	0.334	0.190	0.541	2.111
6	0.124	0.853	1.373	1.388	2.513	6.251
7	1.427	3.471	2.067	3.784	6.079	16.828
8	1.754	2.876	2.353	4.798	1.272	13.053
9	0.673	0.809	0.876	3.367	0.336	6.061
10	0.287	0.077	0.024	2.166	0.958	3.512
11	0.881	1.283	2.814	10.864	0.166	16.008
12	2.333	1.778	2.793	7.795	1.204	15.903
13	1.568	0.616	0.237	3.115	0.841	6.377

TABLE 4

The Relative Average Distance, Expressed in Squared Millimeters, Between Each Local Sample Regression Line and the Corresponding Local Population Regression Line. The Figures in the Last Column Are the Sums of the Five Individual Sample Values

Inspection of this table, supplemented by a study of the graphs (Figs. 3 4 5 6 7), supplies three primary items of information.

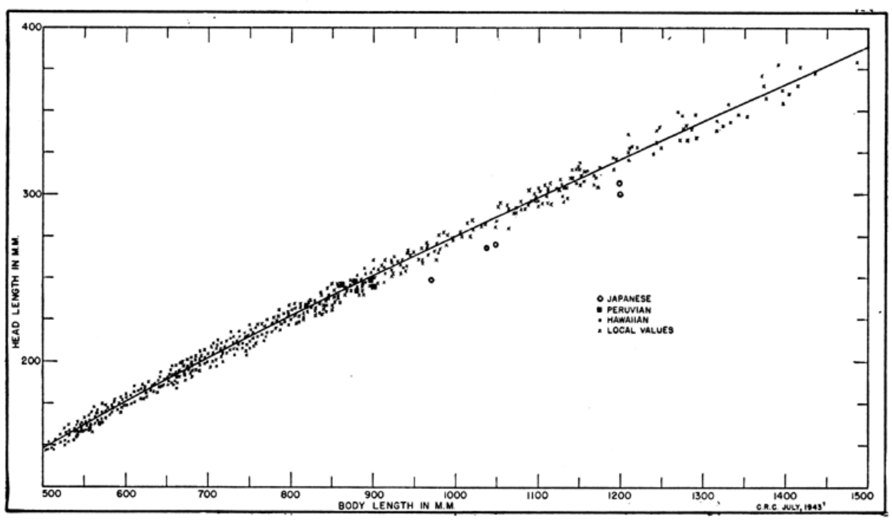

FIGURE 3. Yellowfin Tuna. The regression of head length upon body length. The local-population regression line, showing the distribution about this line of all the individual foreign and most of the local values.

FIGURE 3. Yellowfin Tuna. The regression of head length upon body length. The local-population regression line, showing the distribution about this line of all the individual foreign and most of the local values

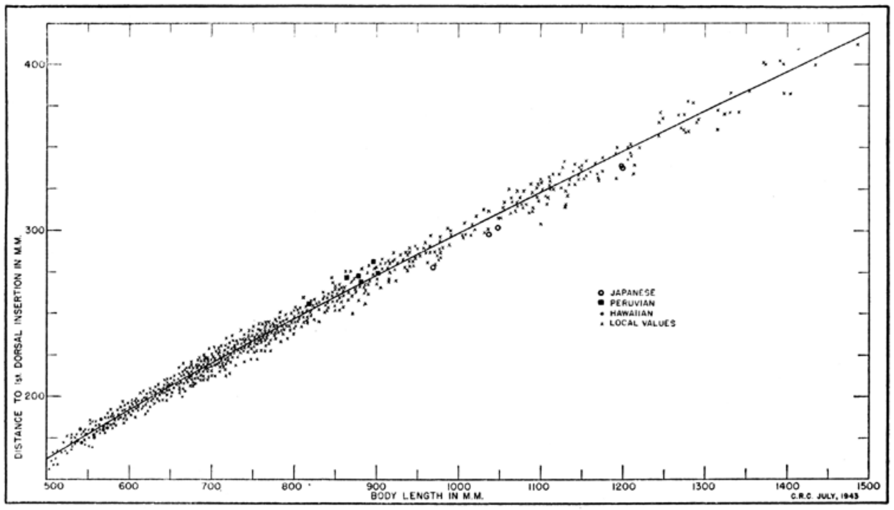

FIGURE 4. Yellowfin Tuna. The regression of first dorsal insertion upon body length. The local-population regression line, showing the distribution about this line of all the foreign and most of the local values.

FIGURE 4. Yellowfin Tuna. The regression of first dorsal insertion upon body length. The local-population regression line, showing the distribution about this line of all the foreign and most of the local values

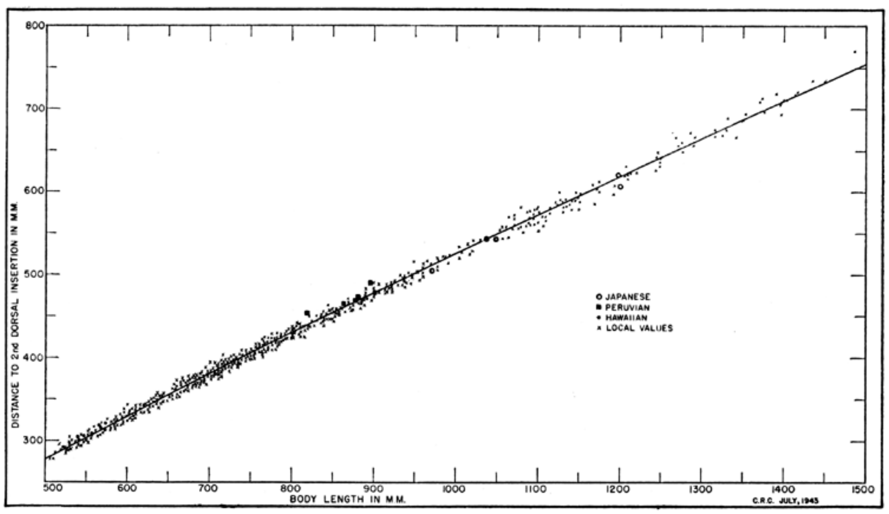

FIGURE 5. Yellowfin Tuna. The regression of second dorsal insertion upon body length. The local-population regression line, showing the distribution about this line of all the foreign and most of the local values.

FIGURE 5. Yellowfin Tuna. The regression of second dorsal insertion upon body length. The local-population regression line, showing the distribution about this line of all the foreign and most of the local values

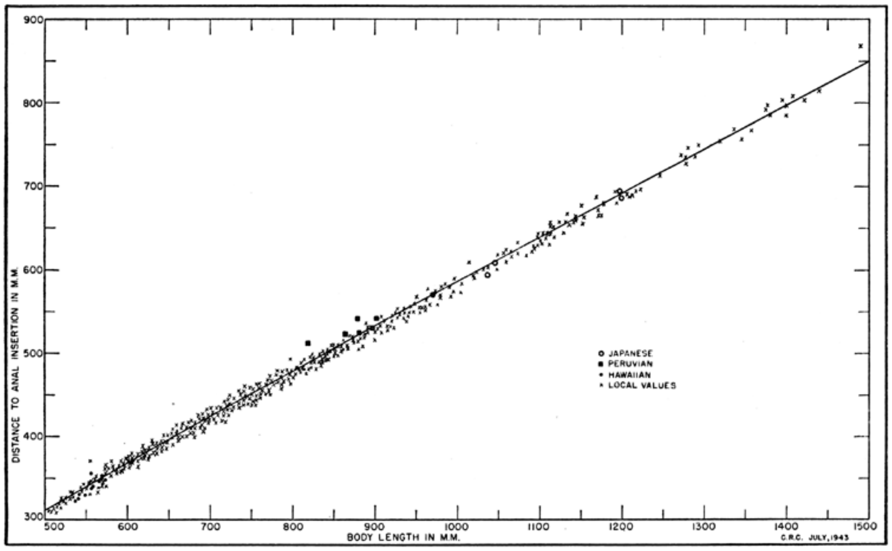

FIGURE 6. Yellowfin Tuna. The regression of anal insertion upon body length. The local-population regression line, showing the distribution about this line of all the foreign and most of the local values.

FIGURE 6. Yellowfin Tuna. The regression of anal insertion upon body length. The local-population regression line, showing the distribution about this line of all the foreign and most of the local values

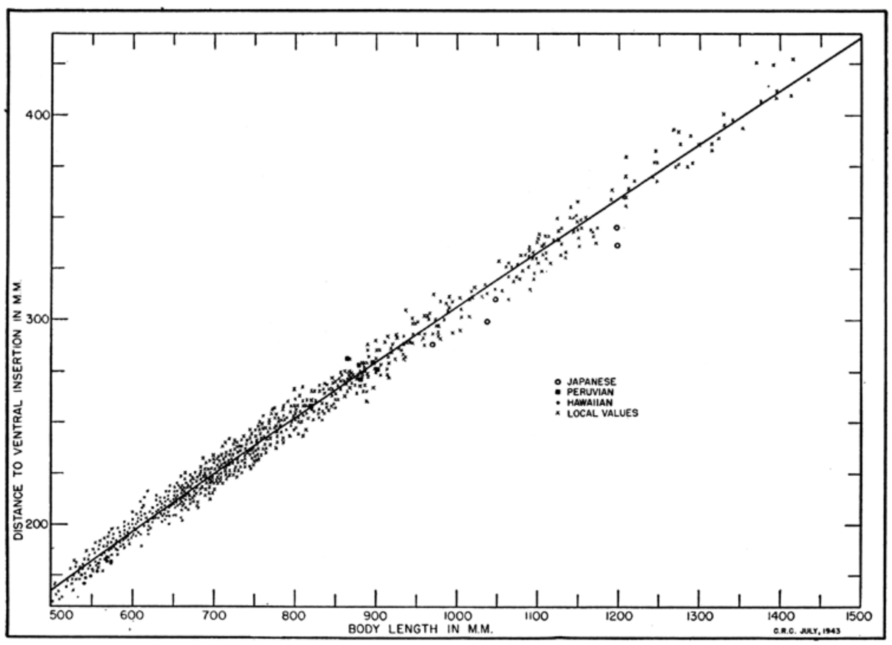

FIGURE 7. Yellowfin Tuna. The regression of ventral insertion upon body length. The local-population regression line, showing the distribution about this line of all the foreign and most of the local values.

FIGURE 7. Yellowfin Tuna. The regression of ventral insertion upon body length. The local-population regression line, showing the distribution about this line of all the foreign and most of the local values

1. In the case of four regressions the individual sample regression lines are closely and in general consistently similar to the total-sample regression line, and the existing average differences are small and reasonably comparable. In the case of the last regression, that of anal insertion upon body length, the sample regression lines differ to a greater extent from the total-sample regression line, indicating a greater variability in this character. It is for this reason that the anal insertion was used to illustrate the distribution of variates in Figure 2.

2. The table indicates a lack of relationship between any of the samples. Had any one or more samples borne a definite relationship to a second sample, this relationship would be revealed in a correspondence in the magnitude of the observed differences in the five regressions. As far as the writer can determine, such relationships are lacking. This leads to conclusions similar in general to those derived from the preceding statistical analysis, namely, there is inadequate evidence to support the assumption that the stock is segregated into distinct, geographic and nonintermingling populations. The data are more comprehensible on the assumption that the stock consists of a single, intermingling population of which the above samples are inadequate to explain fully the observed statistical differences.

3. On the above assumption the tabulated values afford an estimate of the extent to which subsequent sample regression lines may be expected to differ from the accepted total-sample regression line postulated for this population. In other words, the estimated range of anticipated variation of individual sample regressions for fish of this population is indicated for each regression by the maximum values observed in these 13 samples. If subsequent samples are derived from the same population, then the degree of divergence of the sample regression lines from that postulated for this population should correspond in general with the tabulated values. A sample of 50 fish taken in June 1943, to check this assumption yielded, in the two regressions investigated, values well within the range of this table.

With the foregoing knowledge it is now possible to evaluate the divergence of the Japanese, Hawaiian and Peruvian samples from the local population. Values comparable with those of Table 4 were computed for these three samples, and are reproduced in Table 5. The first line of

TABLE 5

The Relative Average Distance, Expressed in Squared Millimeters, Between Each Foreign Sample Regression Line and the Corresponding Local Population Regression Line. The Figures in the Last Column Are the Sums of the Five Individual Sample Values

Sample	Difference in mean square from sample and lōcal regression					Sum of individual differences
	Head length	First dorsal	Second dorsal	Anal	Ventral	
Maximum local	2.333	3.471	6.943	14.946	6.079	19.302*
Japan	284.809	92.283	21.588	17.381	214.860	630.921
Hawaii	20.255	1.330	0.249	27.638	37.622	87.094
Peru	6.143	22.652	38.333	160.112	5.026	232.266

* See Table 4, last column, sample No. 1.

TABLE 5

The Relative Average Distance, Expressed in Squared Millimeters, Between Each Foreign Sample Regression Line and the Corresponding Local Population Regression Line. The Figures in the Last Column Are the Sums of the Five Individual Sample Values

the table gives for comparison the maximum values observed for the 13 local samples; and the last column shows the sum of differences observed in all five regressions investigated. Read in conjunction with the graphs presented in Figures 3 to 7, these figures supplement the results of the statistical analysis.

Consider first the Japanese sample. The statistical analysis showed that this differed significantly from the local population in three regressions. The graphs depicting these characters reveal that all the individual Japanese values are unmistakably and considerably below the line of regression of the local population; whereas in the two remaining regressions the Japanese values are comparable in position with the local specimens. Table 5 supplies an estimate of the relative magnitude of these differences. Whereas the most different of the 13 local samples diverged, in the case of head length, from the postulated regression line for the local population by the quantity 2.33 mm., the corresponding value for the Japanese regression line is 284.81 mm., or 122 times as great. In the case of the first dorsal insertion the maximum local divergence was 3.47 mm., and that of the Japanese sample 92.28 mm., or a value 26.6 times as great. For the regression of ventral insertion upon body length the divergence of the Japanese sample is 35 times as great as the maximum local value. Summing the individual values for the five separate regressions, it appears that the Japanese fish diverge from the postulated regression lines for the local population 33 times more than any of the 13 local samples. Therefore the probability is extremely high that the local and Japanese fish are of distinct and nonintermingling populations.

A comparison of the local and Hawaiian fish indicates the same conclusion to a less pronounced extent. The statistical analysis shows that the Hawaiian fish differ significantly from the local population in three regressions also, and the distribution of individual values in Figures 3 to 7 definitely supports this result in the case of two regressions, i.e., head length and ventral insertion. In the case of the anal insertion—shown to be the most variable character—the graph is not as corroborative. Moreover, Table 5 shows that whereas the divergence of the Hawaiian sample from the postulated local regression line is 8.7 and 6.2 times as great as that of the most divergent local sample in the case of head length and ventral insertion respectively, the Hawaiian fish, in the case of the anal insertion, diverge by a quantity less than twice that of the maximum local divergence. Nevertheless, with two characters differing to this extent, the Hawaiian specimens must be considered as distinct from the local population. The total divergence for the five regressions is in this comparison only 4.5 times as great as that of the maximum local value (c.f. 33 times in the case of the Japanese fish) which indicates that the Hawaiian population may be considered tentatively as intermediate between the local and the Japanese population.

The distinct and nonoverlapping size range of fish within the two samples precludes a valid statistical analysis of the relationship between the Japanese and Hawaiian specimens. Nevertheless a study of the graphs suggests a closer relationship between the Japanese and Hawaiian yellowfin than exists between either of these samples with the local yellowfin. Each of these two foreign samples differs from the local fish in three of the five regressions investigated, and of these two characters are similar in both samples. Moreover, in all cases where differences exist both the

Japanese and Hawaiian values fall below the line of local regression, suggesting that in both the Japanese and Hawaiian populations the head is slightly smaller than in the local fish and the insertion of the ventral fin is more anterior. In any future and more comprehensive investigation of the Pacific tunas, the relationship of the Japanese and Hawaiian populations of yellowfin should be investigated in terms of the three regressions, head length, first dorsal insertion and ventral insertion, all upon body length.

Consider finally the relationship of the Peruvian to the local yellowfin. The statistical analysis indicates that the two groups are similar in four regressions and differ only in the case of the anal insertion. Although this proved to be the most variable of the characters, yet Table 5 shows that the Peruvian fish diverged from the local regression 10.7 times more than any local sample. In two of the four remaining characters both the table and the graphs suggest possible differences, and summing the five individual values shows that this Peruvian sample diverges from the postulated local regressions 12 times more than any individual local sample, thus making it more divergent in the aggregate than the Hawaiian sample. In view of these facts one must conclude (although contiguity of grounds argues against it) that there is evidence of real differences between the two groups; and until further samples are available for a more extensive analysis, the Peruvian and local populations should be regarded as distinct.

2.3. SOME OBJECTIONS DISCUSSED

Earlier in this paper some criticisms were suggested which might have a bearing upon the results. These will now be discussed.

Consider first the possible effects of freezing, cold storage and thawing upon the measurements involved in the various regressions. In view of the bulk of specimens and the rigidity of the skeleton, one would not anticipate material change. However, to meet possible criticism the following trial was made.

Thirty-eight specimens from various local grounds were, in the course of this work, frozen, stored and saved for detailed anatomical comparison. Later when these dissections were made in the laboratory, measurements identical with those used in this population study were made upon each thawed specimen. If the freezing, storage and subsequent thawing of specimens has any effect upon the measurements, then a plot of such measurements upon a graph depicting the distribution of measurements made upon fresh material should reveal such effects. Such a plot in fact shows that the 38 "frozen" values fall well within the distribution of "fresh" measurements. However, there are suggestions in two or three regressions that freezing may cause a slight effect inasmuch as the majority of values in these cases fall either above or below the population regression line. But this is also true of some "fresh" samples, so that nothing is proven. Nevertheless, in an attempt to evaluate the possible effects of freezing, separate regression lines were computed for the sample of 38 frozen specimens and the divergence of these lines from the population regression line was measured and compared with the values derived from fresh samples. In the case of head length, insertion of first dorsal fin and insertion of ventral fin there was no apparent difference, and the regression lines of the frozen sample diverged from the population regression less than those of the majority of fresh samples. In the case of the second dorsal insertion, and more so in the case of the anal insertion, it is possible (although the writer considers it improbable) that the freezing may affect the measurements, because in these two cases the majority of values fall slightly above the population regression, and the regression line of the frozen sample diverges by an amount equal to in one case and exceeding in the other the maximum value encountered in the 13 samples handled fresh. Even though the entire divergence is attributed to freezing, analysis will show that this does not invalidate the conclusions reached.

The three characters which differentiate the Japanese from the local specimens are those not affected in the above test of freezing, so that any such effect is irrelevant in this comparison. In the case of the Hawaiian tuna the possible effect of freezing applies to one of the three characters shown to differ. Figure 6 shows that the majority of Hawaiian values for anal insertion fall slightly below the local population regression line. The assumed effect of freezing upon this proportion is such that had these Hawaiian specimens been measured fresh, the values thus obtained would be slightly lower than those actually obtained from the frozen specimens; so that the differences between Hawaiian and local specimens would be greater than those actually determined.

With regard to the Peruvian specimens the case is different. Here the analysis of variance showed that these fish differed significantly only in the case of the anal insertion. The comparison of regression lines indicated appreciable differences in two other characters, namely, the insertion of first and second dorsal fins. Consider the distribution of Peruvian values in Figures 5 and 6, depicting the regression of second dorsal and anal insertion respectively. In both cases the Peruvian values are in general above the local regression line. The effects of freezing are such as to raise the values above the regression lines, which might explain a part of the divergence of the Peruvian specimens. If it be assumed that the entire difference between the regression line of the 38 frozen specimens and the population regression line is due to the effects of freezing, a correction could be applied in the present discussion. Thus for the second dorsal and anal insertion respectively, the average squared distance between population and frozen-sample regression lines was 5.89 and 26.20 millimeters. If these values are subtracted from the observed differences between Peruvian and local population regression lines, the resulting corrected values are: 38.33 - 5.89 = 32.44mm. and 160.11 - 26.20 = 133.91mm. That is, after allowing for the possible effects of freezing there remains a residual divergence between the Peruvian and local regression lines amounting to

$$\frac{32.44}{6.94} = 4.67 \text{ and } \frac{133.91}{14.95} = 8.9$$

EQUATION

times the maximum divergence encountered in any local sample. Hence the overall result is not materially affected and the derived conclusions are unchanged.

Another criticism suggested was that the statistical heterogeneity of the 13 local samples might be due to the varying size-range of individuals within the several samples, or possibly to the affects of variates at either extreme of range. Accordingly from Figure 8 that portion of the size-range

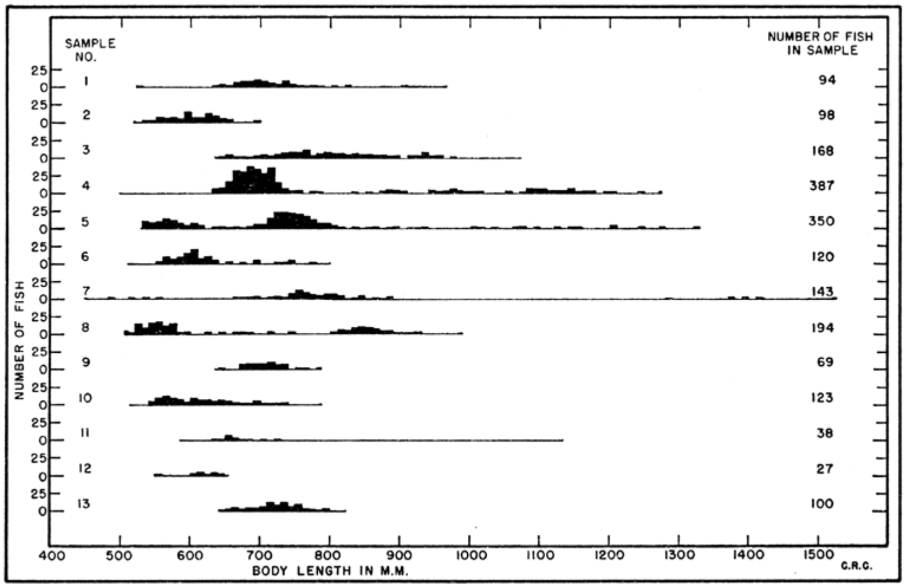

FIGURE 8. Yellowfin Tuna. Length frequency distribution, by sample, of all the local specimens to show the range in size of the fish included in the various samples.

FIGURE 8. Yellowfin Tuna. Length frequency distribution, by sample, of all the local specimens to show the range in size of the fish included in the various samples

including the majority of individuals in all samples was selected and all individuals beyond this range were eliminated.

The range selected was from 550 to 900 millimeters body length, and new regressions were calculated for all samples, using only those variates included within this range. On this basis the entire analysis was repeated and each comparison duplicated. Although individual probabilities were thus altered not a single conclusion was affected and the results of the analysis were identical with those based on the full samples. A plot of the total population regression line based on fish in all samples within the restricted range coincided throughout the greater part of its extent with the total regression line based upon all fish, and the average squared distance between the two regression lines was only 0.56 millimeters. It is obvious therefore that this suggestion fails to explain the statistical results.

The final criticism to be considered deals with the validity of results derived from the small, foreign samples. This is the most serious deficiency in the present study. In order, therefore, to evaluate that component of the observed differences attributable to unduly small samples the following trial was performed.

The anal insertion was selected as the most variable character. Sample No. 11 was chosen for the experiment because it was one of the smallest, with the 38 included variates covering an extensive range in body length, and because it was the second most variable sample in this regression. From this sample four sub-samples were picked at random including 6, 8, 5 and 5 fish arranged consecutively in order of body length, with sub-sample ranges covering 65, 100, 94 and 225 millimeters of body length respectively. Thus both the range and size of the foreign samples were approximately duplicated in this trial, which was designed solely to explore the effects of small numbers upon the resulting numerical divergence between the population regression line and the respective small-sample regression line. If the numerical divergence of the foreign samples was due to any appreciable extent to the size of the foreign samples, then one would expect the numerical divergence between the population regression line and the sub-sample regression line to increase disproportionately as the sub-samples were progressively reduced in size. To test this, regression lines for the above four sub-samples were calculated and the divergence of these lines from the population regression line computed with the following results:

Sample	*Number in sample*	*Range in size (mm. body length)*	*Av. divergence from population regression line (sq. mm.)*	*Ratio: Sample divergence ÷ maximum local divergence*
11-a	6	65	21.134	1.41
11-b	8	100	4.844	0.32
11-c	5	94	19.434	1.30
11-d	5	225	3.505	0.24
11 (entire)	38	551	10.864	0.727
Maximum divergence observed in 13 local samples				
3	168	439	14.946	1.0

This table shows:

1. That very small samples may (but do not necessarily) yield regression lines more divergent than larger samples.

2. However, this increase in divergence is not disproportionate, and is of the same general magnitude as may be expected from larger samples. Thus the maximum increase noted above was not over 50 percent of the maximum value observed in the original 13 samples.

3. In general (and apart from number in the samples) there is a decrease in divergence as the range in size increases, although in this small trial this admittedly may be coincidence.

As the divergence of the foreign sample regression lines from the local population lines was (where significant) from 6 to 122 times the maximum local value, it appears from the foregoing table that such magnitudes cannot be attributed to the small size of the foreign samples. Accordingly the conclusions are not affected.

The foregoing criticisms have been sufficiently discussed to show that they do not affect the conclusions, and because no more precise information pertaining to the albacore is available, they will not be discussed again in that section.

In appraising these results one must bear in mind the relationship of this study to the primary objective of the tuna investigation. Essentially this is to determine the maximum tonnage of yellowfin which may be taken safely from the stock of fish now exploited by the California industry, without endangering the supply. If this stock is continually recruited from outside unexploited areas, the probability of depletion is reduced in proportion to the extent of the total unexploited reservoir. If on the contrary the stock is self-contained and restricted to the area fished, then overfishing is more probable. An immediate answer to this question is needed for intelligent fisheries management because the tuna fishery now faces a period of intensive development. For this reason a tentative answer has been sought in the limited data available, with a full realization that results are not final and conclusive and will be necessarily modified as new facts come to light. Based upon available data the most probable answer to the question is therefore summarized as follows:

CONCLUSIONS

1. The stock of yellowfin tuna in the eastern Pacific now exploited by the California fleet between Southern California and the equator is, in all probability, composed of a single, intermingling population, which shows no evidence of being divided into distinct and separate geographic units. Although significant statistical differences exist between samples, these admit of no present explanation, and the writer is of the opinion that such differences are not of major biological significance.

2. The five Japanese specimens differ significantly from the local stock in three regressions in which the differences are appreciable. The total extent of divergence between the Japanese and the postulated local regression lines is 33 times that of the most divergent local sample. This indicates with a high degree of probability that the local and Japanese populations are entirely separate and distinct.

3. The Hawaiian specimens differ significantly from the local yellowfin in three regressions. Although the differences are not as great as those of the Japanese fish, the distribution of individual values strongly favors the assumption that the Hawaiian fish are of a separate and distinct population from the local yellowfin.

4. The data suggests that the Japanese and Hawaiian yellowfin are more closely related to one another than to the local fish. However, the distribution of values for the first dorsal insertion apparently differs in the two groups.

5. The Peruvian fish are very similar to the local yellowfin but differ significantly in one regression. This difference, added to suggestive minor differences in the other regressions, is sufficient to preclude the assumption that the Peruvian and local populations are identical, and they must be considered separate until the problem is further investigated.

6. Therefore, the analysis of the sustained, potential yield of the local fishery should temporarily be based on the assumption that the stock of yellowfin in the eastern Pacific is confined to the present area of exploitation, and does not receive external recruitment from any of the investigated areas.

3. ALBACORE

Thunnus germo

The purpose of the present study is to determine, within the limitations of the data, whether or not the local albacore are collectively distinguishable as a distinct and separate population from the Japanese and Hawaiian fish, and the relationship of the latter two groups.

The present enquiry is preliminary and not exhaustive. It is based upon a single, small sample comprising nine fish from Japan, a smaller one of only three fish from the Hawaiian Islands and two larger, local samples comprising 42 and 66 fish taken off the west coast of America in the summers of 1941 and 1942.

Upon each of these fish the following 14 measurements were made according to methods described in Appendix A.

1. Body length
2. Head length
3. Insertion of second dorsal fin
4. Insertion of anal fin
5. Insertion of ventral fin
6. Body depth
7. Dorsal-ventral-distance
8. Dorsal-anal-distance
9. Length of first dorsal base
10. Length of pectoral fin
11. Height of first dorsal fin
12. Length of second dorsal base
13. Length of anal base
14. Diameter of iris

A fifteenth measurement, namely the length of the body cavity, was made on 28 of the above specimens.

With one exception the above measurements were related to body length as the independent variable. The diameter of the iris, however, was correlated with head length. The methods used in the analysis are identical with those already described, and the explanatory remarks in the general introduction will suffice to introduce the results.

3.1. STATISTICAL ANALYSIS

For purposes of comparing the Japanese with the local albacore, the one Japanese and two local samples were combined to obtain a total-sample regression line, and using methods of analysis of variance the two groups, local and Japanese, were tested for homogeneity. In the following comparisons there are, therefore, consistently two individual (local and Japanese) regressions with the loss of six degrees of freedom, and one total-sample regression with the loss of three degrees of freedom, so that the "between regression" degrees of freedom is uniformly three. The total number of fish in the various regressions fluctuates between 112 and 117, thus explaining the varying number of degrees of freedom shown. The last regression listed is an exception, inasmuch as there are only 16 local and 9 Japanese, a total of 25 specimens included.

Table 6 demonstrates that the Japanese and local populations are statistically distinct from one another, for in 10 of the 14 characters the existing differences exceed the 1 percent level and in 12 they exceed the 5 percent level of significance.

Regression	D. of freedom	"F" value	Significance
Body length—Head length	3 and 110	2.419	No
Body length—Second dorsal	3 and 110	226.524	Significant
Body length—Anal insertion	3 and 110	7.804	Significant
Body length—Ventral insertion	3 and 108	2.895	Between 1% and 5%
Body length—Body depth	3 and 111	7.115	Significant
Body length—Dorsal ventral dist.	3 and 111	5.588	Significant
Body length—Dorsal anal dist.	3 and 111	11.400	Significant
Body length—First dorsal base	3 and 111	8.357	Significant
Body length—Pectoral length	3 and 110	4.647	Significant
Body length—Height first dorsal	3 and 106	3.804	Between 1% and 5%
Body length—Second dorsal base	3 and 110	6.709	Significant
Body length—Anal base	3 and 110	1.350	No
Head length—Iris	3 and 110	14.985	Significant
Body length—Body cavity	3 and 19	19.421	Significant

TABLE 6

Analysis of the Homogeneity of the Local and Japanese Albacore. "Significant" Indicates a Probability Below the 1 Percent Level, and "No" Means That the Observed Differences Are Not Significant When Judged From the Same Level

3.2. GRAPHS AND DIVERGENCE

If one postulates a local-population regression line based upon all individuals in the two available local samples, the relative magnitudes of the divergence from this line of the individual sample regressions become more apparent. Table 7 shows for each regression the average squared distance in millimeters separating the postulated local population regression line from the individual sample regression lines. In the last column are tabulated for comparison the ratios of the Japanese differences to the greater of the two local differences. Thus, for example, the Japanese sample regression line of the second dorsal insertion upon body length diverges from the postulated local regression line 150.07 (or 183.09 ÷ 1.22) times as much as does the more divergent local sample.

Regression	Difference in average square from postulated and individual regression lines			Ratio of Japanese difference ÷ greater local difference
	1941 local (mm.)	1942 local (mm.)	Japanese (mm.)	
Head length	2.56	1.06	12.82	5.01
Second dorsal	1.22	0.42	183.09	150.07
Anal insertion	3.55	1.19	96.34	27.14
Ventral insertion	19.11	7.82	52.45	2.74
Body depth	1.30	0.92	78.75	60.58
Dorsal ventral dist.	1.11	0.59	47.00	42.34
Dorsal anal dist.	4.30	1.51	92.71	21.56
First dorsal base	2.94	0.96	54.93	18.68
Pectoral length	11.85	3.28	362.46	30.59
Height first dorsal	0.47	0.12	18.64	39.66
Second dorsal base	4.48	1.44	103.69	23.15
Anal base	0.61	0.27	4.70	7.70
Iris on head	0.11	0.03	5.53	50.27
Total difference	53.61	19.61	1,113.11	20.76

TABLE 7

The Relative Average Distance, Expressed in Squared Millimeters, Between Each Sample Regression Line and the Corresponding Local Population Regression Line. The Figures in the Last Column Are the Ratios of the Divergence of the Japanese Sample Regression Line to the Divergence of the More Variable of the Two Local Sample Regression Lines, When Both Divergences Are Measured From the Assumed Local-Population Regression Line

The sums of the individual sample differences are shown footing each column, and they indicate that for the 13 regressions discussed those of the Japanese sample diverge from the standard local regression 20.76 times as much as the more divergent of the two local samples. Substantiating the statistical analysis, these results lend a high degree of probability to the conclusion that a real (as well as a statistical) difference exists between the Japanese and local populations.

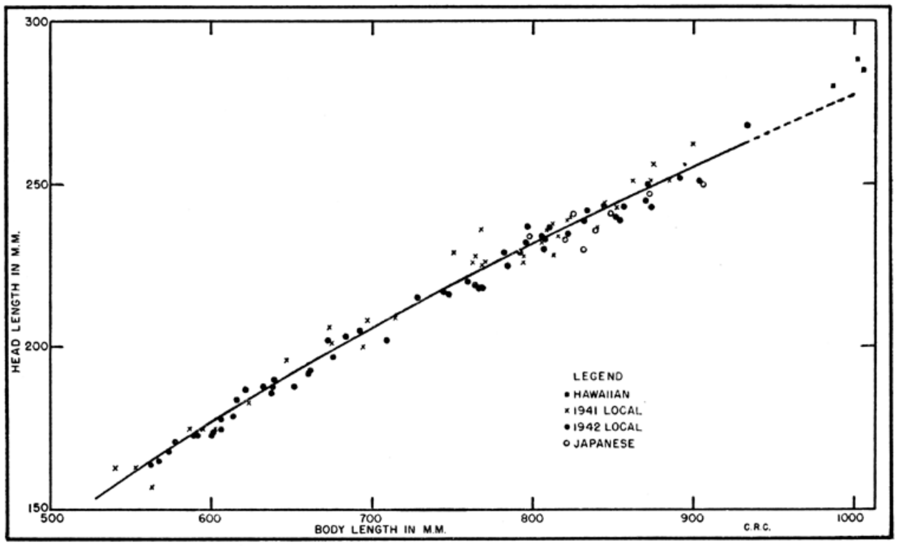

FIGURE 9. Albacore. The regression of head length upon body length. The local-population regression line and the distribution about it of all the individual values. The broken portion of the curve is extrapolated beyond the limits of the local data.

FIGURE 9. Albacore. The regression of head length upon body length. The local-population regression line and the distribution about it of all the individual values. The broken portion of the curve is extrapolated beyond the limits of the local data

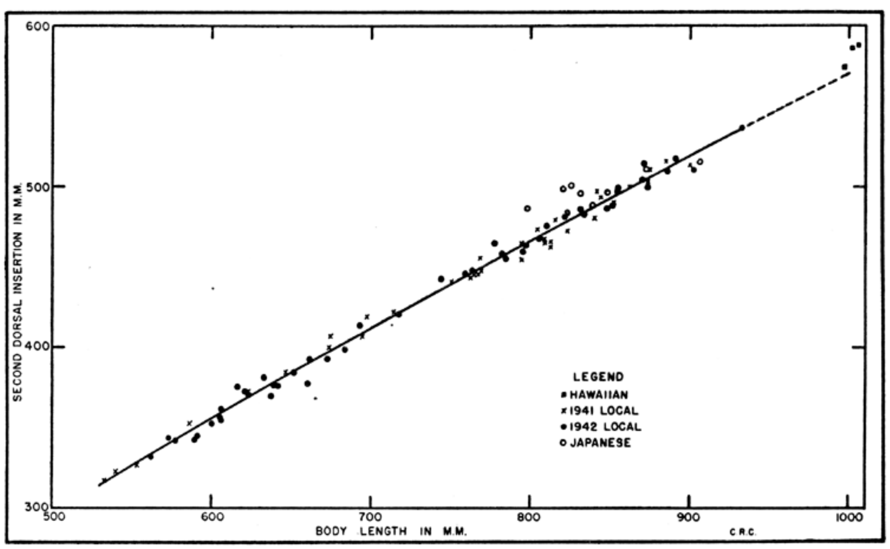

FIGURE 10. Albacore. The regression of second dorsal insertion upon body length. The local-population regression line and the distribution about it of all the individual values. The broken portion of the curve is extrapolated beyond the limits of the local data.

FIGURE 10. Albacore. The regression of second dorsal insertion upon body length. The local-population regression line and the distribution about it of all the individual values. The broken portion of the curve is extrapolated beyond the limits of the local data

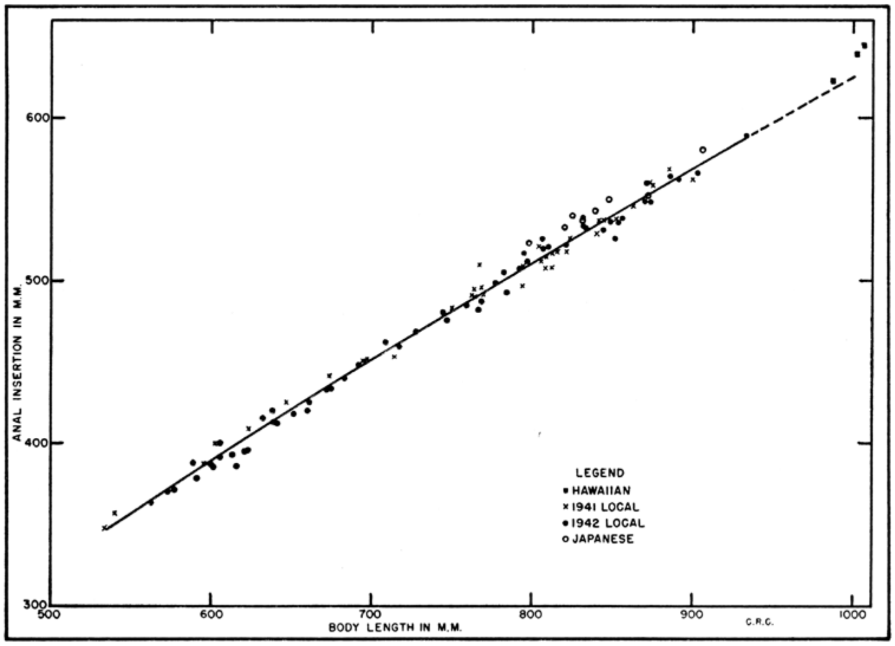

FIGURE 11. Albacore. The regression of anal insertion upon body length. The local-population regression line and the distribution about it of all the individual values. The broken portion of the curve is extrapolated beyond the limits of the local data.

FIGURE 11. Albacore. The regression of anal insertion upon body length. The local-population regression line and the distribution about it of all the individual values. The broken portion of the curve is extrapolated beyond the limits of the local data

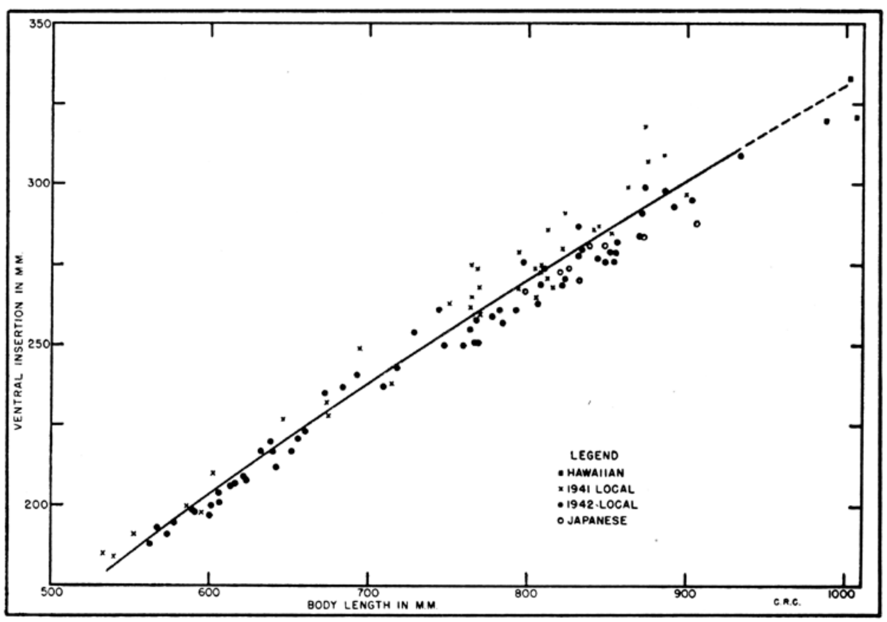

FIGURE 12. Albacore. The regression of ventral insertion upon body length. The local-population regression line and the distribution about it of all the individual values. The broken portion of the curve is extrapolated beyond the limits of the local data.

FIGURE 12. Albacore. The regression of ventral insertion upon body length. The local-population regression line and the distribution about it of all the individual values. The broken portion of the curve is extrapolated beyond the limits of the local data

The nature of this difference is apparent from a study of the plotted distributions. In Figures 9 to 21 inclusive, are shown the standard local regression lines for each character and the distribution of all the Japanese and most of the local values about this line. The only values not shown are those that coincide with, or are contiguous with plotted points. In all cases the distribution of Japanese and local variates overlap, but there is nevertheless a consistent indication that the two distributions differ slightly. Thus, all or the majority of Japanese variates fall below the local regression line in the case of head length, ventral insertion, second

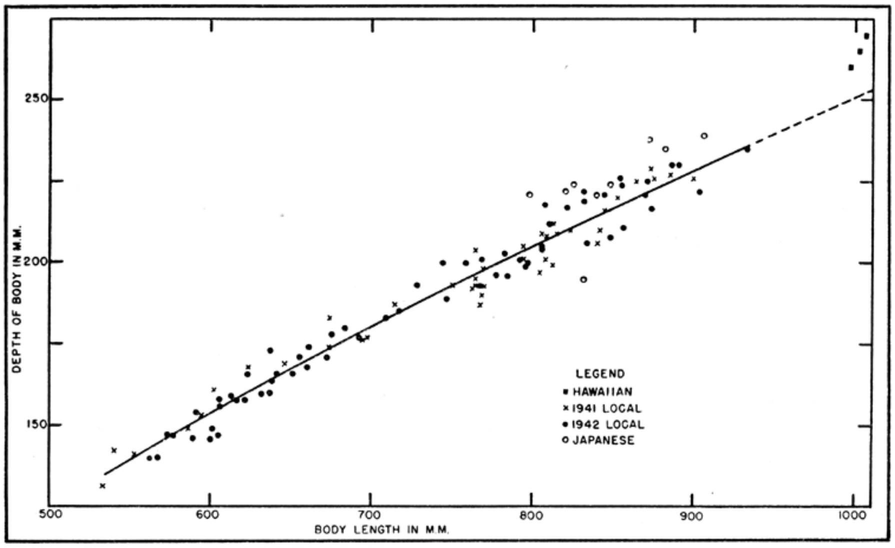

FIGURE 13. Albacore. The regression of body depth upon body length. The local-population regression line and the distribution about it of all the individual values. The broken portion of the curve is extrapolated beyond the limits of the local data.

FIGURE 13. Albacore. The regression of body depth upon body length. The local-population regression line and the distribution about it of all the individual values. The broken portion of the curve is extrapolated beyond the limits of the local data

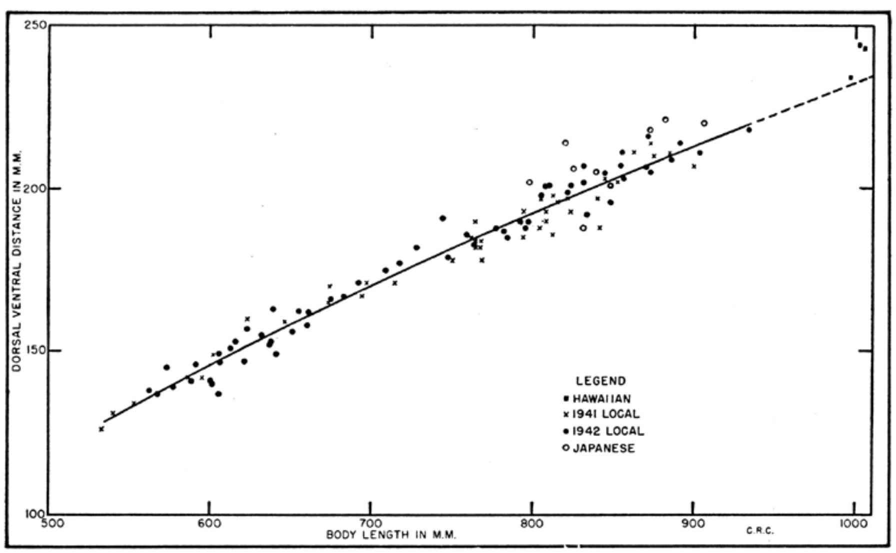

FIGURE 14. Albacore. The regression of dorsal-ventral distance upon body length. The local-population regression line and the distribution about it of all the individual values. The broken portion of the curve is extrapolated beyond the limits of the local data.

FIGURE 14. Albacore. The regression of dorsal-ventral distance upon body length. The local-population regression line and the distribution about it of all the individual values. The broken portion of the curve is extrapolated beyond the limits of the local data

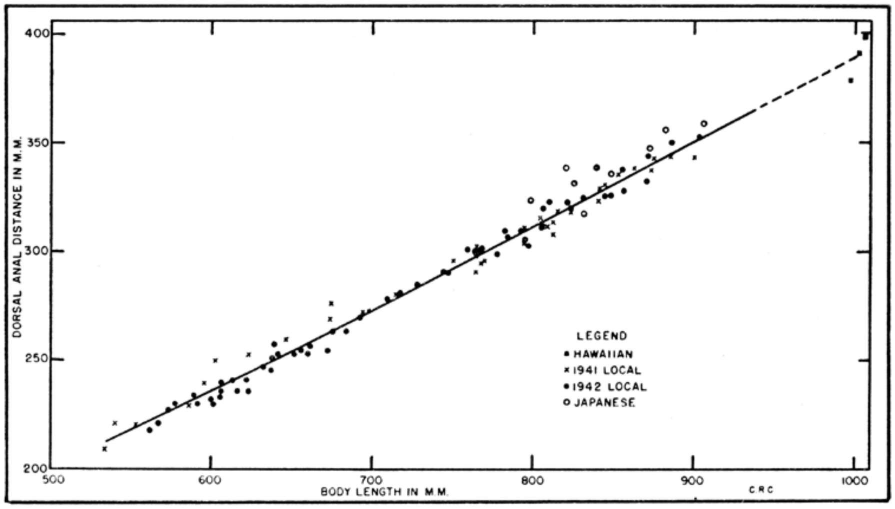

FIGURE 15. Albacore. The regression of dorsal-anal distance upon body length. The local-population regression line and the distribution about it of all the individual values. The broken portion of the curve is extrapolated beyond the limits of the local data.

FIGURE 15. Albacore. The regression of dorsal-anal distance upon body length. The local-population regression line and the distribution about it of all the individual values. The broken portion of the curve is extrapolated beyond the limits of the local data

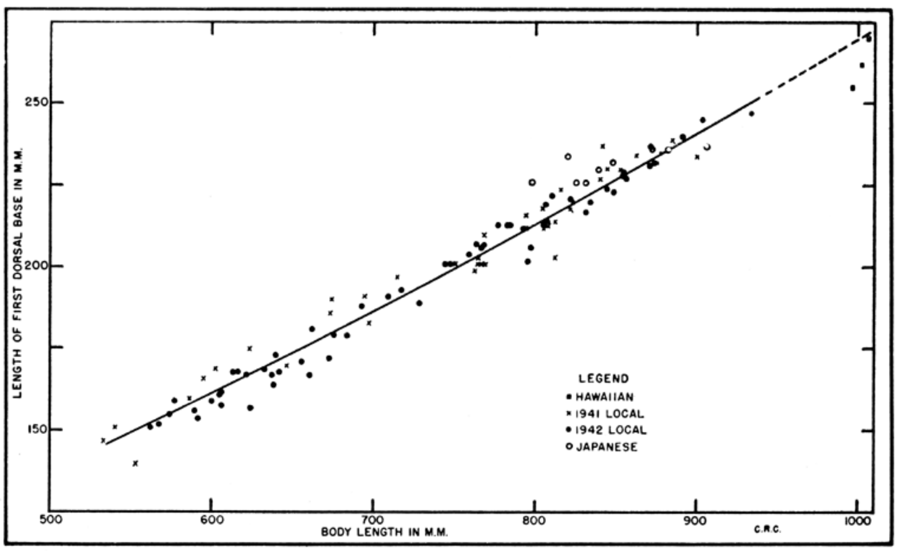

FIGURE 16. Albacore. The regression of length of 1st dorsal base upon body length. The local-population regression line and the distribution about it of all the individual values. The broken portion of the curve is extrapolated beyond the limits of the local data.

FIGURE 16. Albacore. The regression of length of 1st dorsal base upon body length. The local-population regression line and the distribution about it of all the individual values. The broken portion of the curve is extrapolated beyond the limits of the local data

dorsal and anal base. In the remaining characters the majority of Japanese variates are distinctly above the local line of regression. Analyzing these differences reveals that in the Japanese specimens both the head and the caudal regions are relatively shorter than in local albacore, whereas the abdominal or central portion of the Japanese fish is relatively longer than in local albacore. In other words, the central section of the body of the Japanese fish has been relatively elongated at the expense of head and caudal regions. That such is the case is confirmed by Figure 22.

Also the body is relatively deeper in the Japanese fish, the first dorsal fin is higher, the eye is larger and the pectoral fin is proportionately longer.

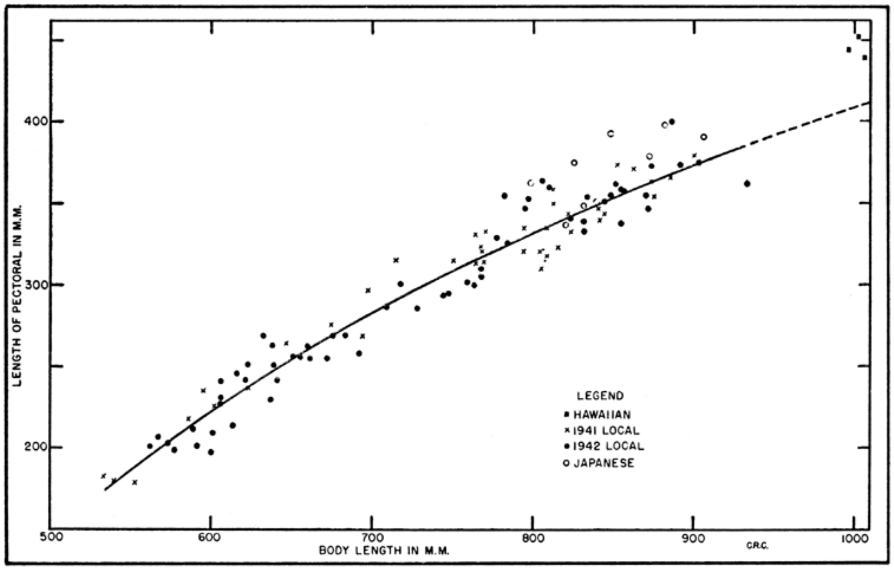

FIGURE 17. Albacore. The regression of pectoral length upon body length. The local-population regression line and the distribution about it of all the individual values. The broken portion of the curve is extrapolated beyond the limits of the local data.

FIGURE 17. Albacore. The regression of pectoral length upon body length. The local-population regression line and the distribution about it of all the individual values. The broken portion of the curve is extrapolated beyond the limits of the local data

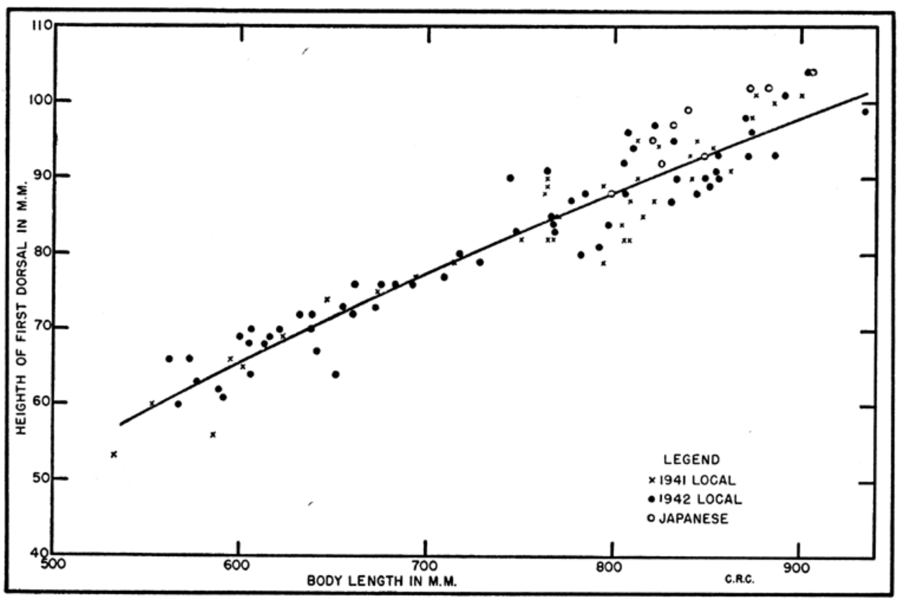

FIGURE 18. Albacore. The regression of heighth of 1st dorsal fin upon body length. The local-population regression line and the distribution about it of all the individual values.

FIGURE 18. Albacore. The regression of heighth of 1st dorsal fin upon body length. The local-population regression line and the distribution about it of all the individual values

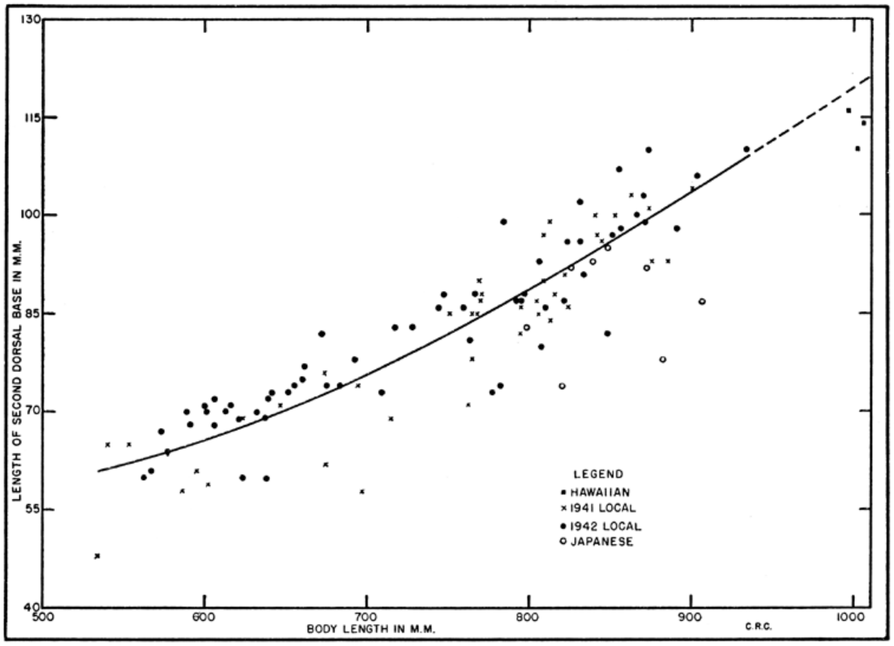

FIGURE 19. Albacore. The regression of length of second dorsal base upon body length. The local-population regression line and the distribution about it of all the individual values. The broken portion of the curve is extrapolated beyond the limits of the local data.

FIGURE 19. Albacore. The regression of length of second dorsal base upon body length. The local-population regression line and the distribution about it of all the individual values. The broken portion of the curve is extrapolated beyond the limits of the local data

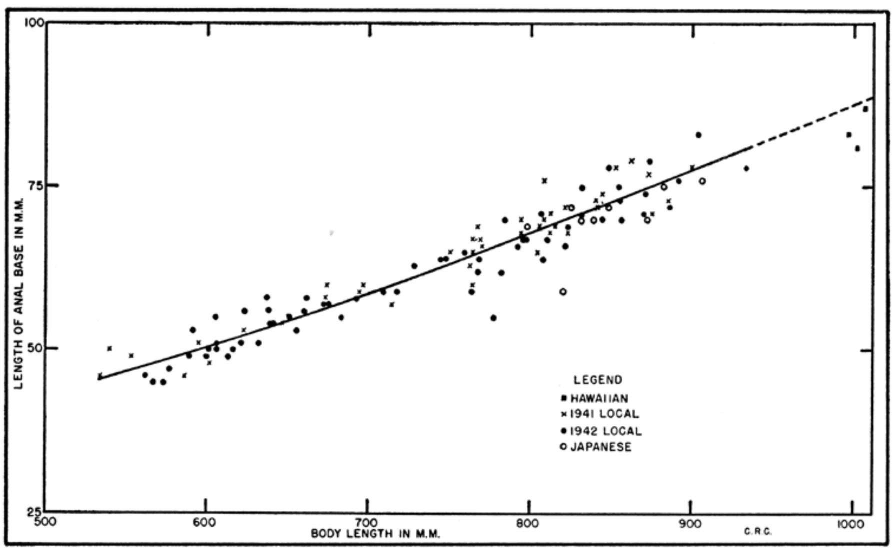

FIGURE 20. Albacore. The regression of length of anal base upon body length. The local-population regression line and the distribution about it of all the individual values. The broken portion of the curve is extrapolated beyond the limits of the local data.

FIGURE 20. Albacore. The regression of length of anal base upon body length. The local-population regression line and the distribution about it of all the individual values. The broken portion of the curve is extrapolated beyond the limits of the local data

In the course of the systematic study of the albacore the length of the abdominal cavity was measured in all the Japanese and Hawaiian specimens, and in 16 local albacore. This measurement was made from the posterior tip of the heart to the anterior margin of the vent, and it thus closely approximates the central or abdominal region of the body. The distribution of these measurements is portrayed in Figure 22, which shows also the regression line based upon the 16 local specimens. From this it is apparent that the distributions of Japanese and local values are distinct, thus clarifying the indicative differences in the remaining proportions. The average squared deviation of the local variates about the local regression line is 22.13 mm., whereas the average squared deviation of the Japanese variates from the local regression line is 1,022.26, or a value 46 times as great. If, therefore, this small sample is representative of the distribution of the Japanese population values, there can be little doubt that the latter is separate and distinct from the local population of albacore. The probability of securing nine specimens abnormal or aberrant in 14 characters is too remote to warrant serious consideration.

3.3. HAWAIIAN ALBACORE

Because there are only three Hawaiian specimens, all larger than any Japanese or local fish, an analysis of the relationships of these groups is not possible. Nevertheless the graphs contain some information concerning possible affinities. A study of Figures 9 to 21 inclusive, results in

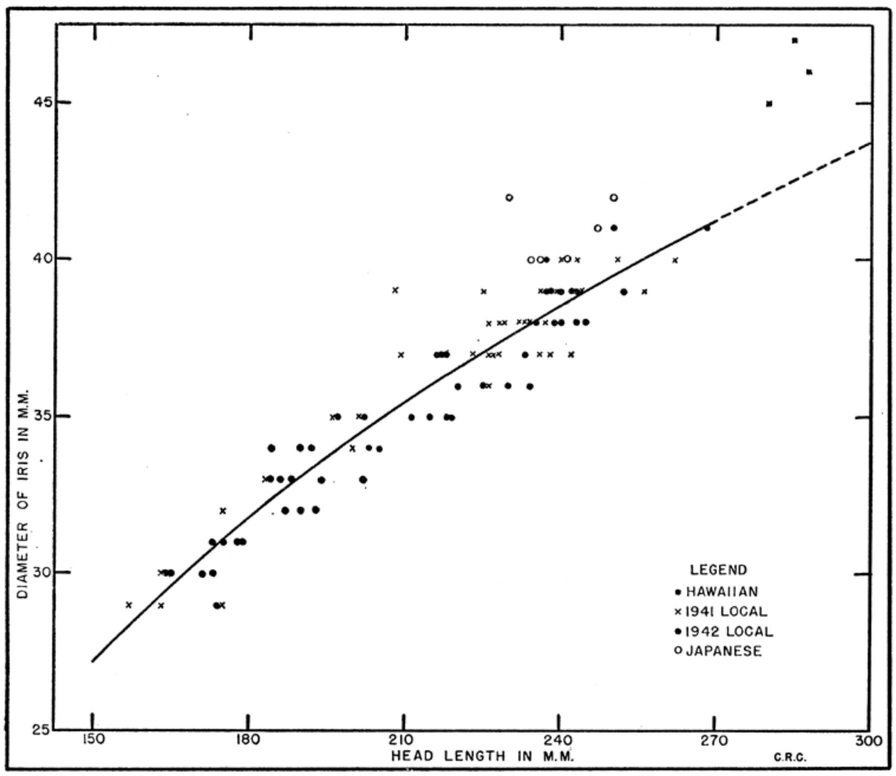

FIGURE 21. Albacore. The regression of diameter of iris upon head length. The local-population regression line and the distribution about it of all the individual values. The broken portion of the curve is extrapolated beyond the limits of the local data.

FIGURE 21. Albacore. The regression of diameter of iris upon head length. The local-population regression line and the distribution about it of all the individual values. The broken portion of the curve is extrapolated beyond the limits of the local data

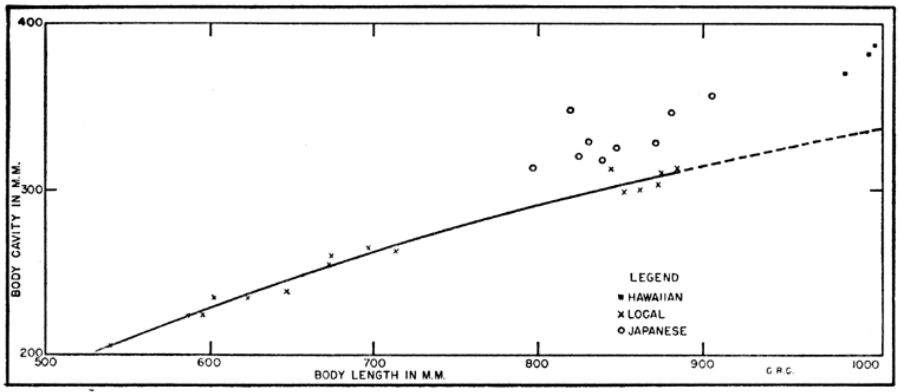

FIGURE 22. Albacore. The regression of length of body cavity upon body length. The local-population regression line based on 16 individuals, and the distribution about it of the local and foreign values. The broken portion of the curve is extrapolated beyond the limits of the local data.

FIGURE 22. Albacore. The regression of length of body cavity upon body length. The local-population regression line based on 16 individuals, and the distribution about it of the local and foreign values. The broken portion of the curve is extrapolated beyond the limits of the local data

an impression of general similarity between the Japanese and Hawaiian specimens. The broken portion of each regression line represents that portion extrapolated beyond the data. Results are not materially changed when the two separate local sample regression lines are similarly extended. In general the three Hawaiian values show a distribution, with reference to the standard local regression, comparable with the Japanese values. Thus in 10 of the 12 characters the Hawaiian values are on the same side of the local regression line as the majority of the Japanese values, and in only two cases do these two groups differ. In particular, note the similarity in the two regressions, iris upon head length and length of pectoral fin upon body length. Finally, Figure 22 enhances the probability of this relationship of Hawaiian with Japanese fish.

It will be recalled that the essential difference between the local and Japanese albacore consists of a relatively longer abdominal or central portion of the body at the expense of head and caudal regions in the Japanese fish. The length of the body cavity therefore in relation to body length exemplifies this difference. Figure 22 reveals that the distribution of the nine Japanese values is quite distinct from the local ones, and that the extrapolated portion of the curve is considerably removed from the three Hawaiian values. Admitting that the extrapolation is subject to an indeterminate error, it is nevertheless highly improbable that this error is sufficiently large to bring the actual regression line appreciably closer to the Hawaiian values. While no conclusions are warranted, the results of this survey suggest that the Hawaiian specimens are more closely related to the Japanese than to the local population.

3.4. CONCLUSIONS

It is unfortunate that this study was necessarily based upon so few foreign specimens. At the time of its inception it proved extremely difficult to secure adequate material from Japan. Events of the intervening years have delayed the project and it now appears that considerable time will elapse before the study can be duplicated or extended. It therefore seems desirable to publish this preliminary report to supply the most plausible working hypothesis for the further investigation of the albacore populations, and to make available to others such data as exists. In the light of the foregoing indicative results it is concluded that:

1. The local and Japanese populations of albacore are probably distinct and nonintermingling. The Japanese albacore are characterized by a relatively shorter head and caudal region and a longer abdominal or central trunk.

2. The Hawaiian albacore appear to resemble the Japanese more than the local fish, but a larger sample of more comparably-sized fish is needed to justify any conclusions.

APPENDIXES

APPENDIX A
A Description of Methods Used in Making the Measurements

Most measurements were made with calipers and all are straight line distances between the reference points as follows:

Body Length. The body length was measured with the tip of the fixed arm of the caliper resting on the table against the tip of the upper jaw of the fish. The sliding arm was moved until the anterior face made a firm contact over its entire width with the cartilaginous tissue in the fork of the tail.

Head Length. The tip of the fixed arm of the caliper was held with one hand against the tip of the upper jaw of the fish, and the sliding arm was moved until its anterior face rested squarely against the most distant point on the margin of the subopercle. The measurement was made to the bone rather than to the dermal flap, which often projects slightly.

Insertion of First Dorsal Fin. The dorsal fin was held erect with the fingers of the left hand, and the tip of the sliding arm of the caliper was placed firmly against the ball of the left thumb, which in turn was held against the face of the first spine at its insertion. The scale of the caliper was then moved with the free hand until the tip of the fixed arm touched the tip of the upper jaw. Using the sliding arm as a fulcrum, the tip of the fixed arm was then swung through a slight arc to insure that the caliper just touched the tip of the snout.

Insertion of the Second Dorsal Fin. The second dorsal fin was held erect and a mark made at its base to indicate its anterior extent. The point of insertion thus determined is subject to a slight error because the fin meets the outline of the body in an even curve, due to the inclination of the first short ray. The tip of the fixed arm of the caliper was held against the tip of the upper jaw and the sliding arm was then moved anteriorly until its forward face reached the above mark.

Insertion of the Anal Fin. The fin was held erect and its insertion marked. The location of this point is subject to the same slight error described in the foregoing measurement. The tip of the fixed arm of the caliper was then held in place against the tip of the upper jaw and the sliding arm moved anteriorly until it reached the insertion of this fin.

Insertion of the Ventral Fin. The fin was held extended with one hand and the sliding arm of the caliper was pressed against the thumb, which was so placed as to mark the insertion of the first ray. The scale was then moved until the tip of the fixed arm touched the tip of the upper jaw and the caliper was swung through a small arc to insure accuracy.

Greatest Body Depth. With the first dorsal fin depressed into its groove, the greatest body depth was measured perpendicular to the axis of the body. The point of greatest depth was recorded in terms of the spines of the first dorsal fin. This measurement was influenced to a large extent by the condition of the fish.

Dorsal-Ventral Distance. This measurement was made with the fixed arm of the caliper resting firmly against the contour of the body and the lateral face of the arm against the anterior spine of the first dorsal fin, which was held erect. With an assistant holding the ventral fin erect and perpendicular to the body, the sliding arm was then moved inwards along the first ray of this fin until the face of the arm touched the outline of the body. The measurement was quite satisfactory except in the case of soft fish.

Dorsal-Anal Distance. This measurement was taken with the tip of the fixed arm of the caliper resting against the base of the anterior spine of the erect first dorsal fin and the contour of the body. The sliding arm of the caliper was then moved until it came in contact with the ventral body margin at the insertion of the anterior anal ray. Two slight errors affect this measurement. One is discussed under the heading of the anal fin, and the second is due to the width of the caliper arm, which is 6 millimeters. Held as in this measurement the inner face of the fixed arm does not touch the actual insertion of the first dorsal fin. Due to the width of the arm, its inner face in reality forms the hypotenuse of a small triangle of which the other two sides are the contour of the body and the face of the first dorsal spine, so that there is a constant error equal to the altitude of this triangle. Both these errors, however, are negligible in relation to the distance separating the two points of reference.

Length of First Dorsal Base. With the first dorsal fin held erect, the tip of the fixed arm of the caliper was placed against the contour of the body with the inner face against the anterior margin of the first spine. The sliding arm was then moved anteriorly until it reached the mark previously made to indicate the insertion of the second dorsal fin. This measurement is therefore the distance between the insertion of the first and second dorsal fins, and it was used because it can be measured more accurately than can the length of the fin itself.

Length of Pectoral Fin. The fixed arm of the caliper was held against the body of the fish at the anterior termination of the dorsal margin of the pectoral fin. Inspection of a tuna will show that this point is quite precise. The sliding arm was then moved until it touched the extremity of the pectoral fin. The posterior extent of the fin was also recorded in terms of the first dorsal spines in the case of the bluefin, with reference to the origin of the second dorsal fin in the case of the yellowfin, and in terms of the anal base and anal finlets in the case of the albacore and the bigeyed tuna.

Height of First Dorsal Fin. This measurement was made with dividers, one point of which was inserted against the contour of the body at the point of insertion of the first dorsal spine, with the fin held erect. The dividers were then opened until the second point touched the extremity of the longest spine, and the spread of the dividers was recorded as the height of the fin.

Length of Second Dorsal Base. Although this was measured as a routine, the measurement has limited value because the length of the base is really a matter of interpretation. In about half the cases examined, of all species, the first finlet was actually connected with the second dorsal fin by a slight continuation of the fin membrane. In view of this the following standard procedure was adopted. If, when the second dorsal fin was alternately raised and depressed, the first dorsal finlet moved slightly up and down with it, thus demonstrating a connection, then such a finlet was counted as an integral part of the second dorsal fin and the base of this fin was measured accordingly. Obviously this affected the count of the finlets as well as the measurement of the base of the fin. Every degree of variation was found, from a broad and unmistakable membranous connection at one extreme to a barely perceptible fold of tissue against the body contour at the other extreme. Under such circumstances some arbitrary rule was necessary, and the length of the second dorsal base was accordingly measured with one point of the dividers located at the insertion of this fin and the other point placed against the insertion of the last ray of the fin, or against the insertion of the ray of the first finlet if this was attached to the fin.

Length of Anal Base. The condition in this case was entirely comparable with that of the second dorsal base. The measurement was made in a similar manner and the discussion and conclusion above apply equally to this fin.

Diameter of Iris. By means of dividers a measurement was made of the greatest distance between the opposite external margins of the yellow iris, as that was delimited by the black surrounding tissue. This diameter, which is not parallel to the axis of the body but decidedly at an oblique angle to the axis, gives a good indication of the size of the eye and may be measured more accurately than the diameter of the orbit.

Length of Body Cavity. This measurement was made with the belly flesh cut away sufficiently to expose the entire viscera without, however, disturbing any organ. With the fish horizontal, belly up, the length of the body cavity was arbitrarily defined as the straight-line distance, measured with calipers, between the posterior tip of the heart and the anterior margin of the vent.

APPENDIX B
YELLOWFIN TUNA

Tabulation of original measurements by sample, with sums and products of variates used in calculating the regression lines (upon body length in each case) listed under respective headings. All measurements are in millimeters.

SAMPLE NO. 1

Yellowfin Tuna: Origin, White Friars, Mexico

Body length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
521	152	168	294	326	172
526	151	165	285	321	173
612	182	198	339	378	208
626	186	200	346	377	208
636	186	204	349	389	206
638	188	205	349	391	213
641	191	206	354	393	216
643	186	201	348	389	209
648	190	207	361	402	212
658	189	211	360	404	211
658	194	208	367	408	218
659	197	207	353	403	213
663	195	220	363	406	215
664	191	211	360	409	217
664	193	211	368	411	214
665	192	211	364	407	212
666	195	210	364	408	220
667	197	214	370	407	218
671	194	211	368	410	219
671	196	217	370	413	221
671	196	209	364	409	224
671	199	213	370	412	222
672	195	209	369	407	217
673	194	214	370	417	217
673	194	212	366	410	223
680	197	215	377	414	217
682	197	211	378	423	221
683	197	217	374	419	224
685	194	214	371	411	219
686	195	213	375	417	222
686	197	217	374	418	224
686	200	220	378	422	224
688	200	215	374	419	227
689	201	217	384	427	227
691	198	211	381	421	223
691	200	214	376	424	224
694	202	219	382	423	225
694	205	215	378	425	230
696	199	219	377	423	223
696	204	220	381	425	226
696	206	229	384	433	231
698	201	219	386	431	227
698	203	225	386	431	226
699	208	226	387	429	232
701	202	218	387	425	226
701	204	221	389	433	229
702	202	221	379	428	229
703	202	223	385	432	232
705	202	218	380	430	223
705	206	223	386	427	231
708	197	215	386	426	221
709	207	224	382	433	234
710	208	228	389	432	229
712	205	224	386	435	232
712	207	226	395	433	232
714	204	224	390	437	231
717	207	235	405	444	233
718	205	226	397	434	231
719	204	228	389	434	234
723	205	227	391	437	232

SAMPLE NO. 1
Yellowfin Tuna: Origin, White Friars, Mexico
(continued)

Body length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
723	206	229	398	440	230
726	211	228	395	444	237
728	210	227	393	441	237
731	208	229	400	448	230
733	213	235	404	454	239
734	210	228	390	439	235
735	210	230	397	450	235
736	211	228	404	452	236
738	209	231	401	446	231
738	216	238	409	450	243
739	211	236	411	454	235
740	212	233	404	451	239
744	215	231	398	448	240
746	208	230	400	443	235
746	214	235	397	449	245
746	215	239	408	453	238
756	218	237	418	464	240
757	217	236	414	461	246
757	221	240	411	464	250
766	217	236	414	461	246
770	220	242	421	468	246
772	223	239	421	466	246
775	221	237	425	466	245
775	222	243	430	476	247
781	221	248	426	480	250
786	221	246	426	469	242
805	223	244	436	480	251
808	224	242	429	478	254
821	233	254	445	491	262
830	234	257	444	491	265
850	231	252	454	501	260
902	251	267	480	537	285
906	251	283	491	545	278
965	264	289	509	559	288
Totals					
[E]Y	19,285	21,058	36,593	40,781	21,635
No.	94	94	94	94	94
[E]X	66,999	66,999	66,999	66,999	66,999
[E] X2	48,155,921	48,155,921	48,155,921	48,155,921	48,155,921
[E] 1/X	0.1329674	0.1329674	0.1329674	0.1329674	0.1329674
[E] 1/X2	0.00018963703	0.00018963703	0.00018963703	0.00018963703	0.00018963703
[E] 1/X Y	27.0888486	29.5750824	51.3712477	57.2606496	30.3954949
[E] X Y	13,843,238	15,118,287	26,284,013	29,286,257	15,527,080
[E] Y2	3,980,991	4,748,376	14,348,697	17,814,025	5,008,979

SAMPLE NO. 2
Yellowfin Tuna: Origin, Gorda Bank, Mexico

Body length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
517	152	166	297	321	173
518	151	168	290	322	173
529	156	167	292	328	178
531	159	178	305	329	180
533	155	171	301	332	174
535	157	172	301	331	173
547	158	171	302	343	180
548	164	181	308	340	186
549	162	180	309	343	187
551	162	184	312	334	180
553	162	179	309	335	179
553	164	181	308	340	184
553	165	186	313	344	181
556	163	184	314	346	185
559	164	180	310	345	188
559	164	184	313	342	181
560	165	182	317	349	186
562	163	182	317	357	184
567	168	182	317	354	188
569	171	187	322	349	190
569	171	187	313	357	190
570	166	182	320	354	188
570	169	184	321	354	191
571	167	182	317	354	190
572	165	183	318	361	187
573	170	187	323	366	190
576	170	181	319	359	193
577	172	192	328	362	195
580	172	189	324	363	195
580	173	186	325	371	193
582	166	187	323	354	187
583	171	187	321	359	196
586	171	186	325	365	192
587	172	190	327	355	191
589	169	189	329	365	192
591	171	188	328	370	191
591	175	197	333	369	196
592	170	184	321	365	194
592	173	193	331	363	198
592	174	186	325	365	194
593	177	195	334	367	196
595	175	196	331	367	192
596	170	189	328	364	190
596	173	193	334	367	192
596	173	193	336	364	197
596	174	193	340	369	198
596	174	186	323	364	197
597	175	196	332	372	201
599	177	194	345	378	200
599	181	195	330	371	206
601	173	192	333	368	193
602	176	198	336	373	195
602	179	196	327	363	200
603	172	192	338	371	196
604	172	195	334	380	198
608	182	200	340	375	203
609	177	195	340	374	204
611	175	194	338	367	189
611	178	193	338	375	204

SAMPLE NO. 2
Yellowfin Tuna: Origin, Gorda Bank, Mexico
(continued)

Body length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
613	183	196	342	376	209
614	183	197	338	378	199
617	179	193	344	382	203
617	180	199	342	379	200
620	179	195	341	372	202
623	184	200	341	381	204
624	182	201	342	383	205
624	183	205	343	384	207
624	184	206	342	378	206
628	183	204	345	385	206
628	184	203	351	392	205
628	187	203	351	395	212
629	186	201	346	380	206
629	187	201	348	389	213
629	188	202	344	384	209
630	183	203	342	383	205
630	183	204	350	385	205
630	187	200	348	389	208
631	184	203	347	386	207
631	186	196	346	391	210
631	187	206	351	394	213
632	184	202	350	388	208
634	185	205	356	392	209
634	187	200	346	387	207
636	182	199	349	387	201
636	188	206	359	387	208
640	188	205	352	392	211
643	187	203	355	402	213
643	188	203	357	393	212
643	188	210	358	400	207
644	183	206	357	388	204
645	187	201	353	390	214
651	192	212	357	396	212
652	189	211	364	404	218
652	190	204	359	396	216
656	190	208	356	399	214
666	199	215	364	408	217
692	202	219	379	418	221
698	198	223	382	421	221
Totals					
[E] Y	17,234	18,940	32,682	36,258	19,371
No.	98	98	98	98	98
[E] Y	58,813	58,813	58,813	58,813	58,813
[E] X2	35,428,985	35,428,985	35,428,985	35,428,985	35,428,985
[E] 1/X	0.1639228	0.1639228	0.1639228	0.1639228	0.1639228
[E] 1/X2	0.00027525334	0.00027525334	0.00027525334	0.00027525334	0.00027525334
[E] 1/X Y	28.7221224	31.5706474	54.4825971	60.4384004	32.2891680
[E] X Y	10,379,903	11,405,535	19,678,922	21,833,900	11,664,972
[E] Y2	3,041,654	3,672,828	10,932,400	13,457,978	3,841,953

SAMPLE NO. 3
Yellowfin Tuna: Origin, Cocos Island

Body length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
634	187	203	346	379	207
636	186	202	347	386	208
641	187	204	348	387	207
647	190	204	349	386	209
650	191	206	349	394	212
652	192	207	359	397	214
653	190	210	357	392	211
653	192	212	363	398	216
653	192	210	357	394	213
654	190	207	352	390	211
663	192	208	367	404	215
664	194	216	370	406	215
665	187	208	359	399	208
675	194	211	366	404	211
676	197	216	365	411	219
680	191	212	367	399	211
681	199	214	371	417	222
682	198	217	372	411	218
692	198	218	378	415	219
693	200	218	379	414	221
693	200	220	377	424	219
694	199	215	379	419	218
702	205	222	386	428	228
705	203	224	381	423	224
706	200	224	385	417	223
707	203	229	385	423	231
708	206	228	388	432	231
711	209	231	393	432	233
717	201	222	380	418	222
718	205	227	393	435	228
720	209	229	399	445	232
721	205	229	393	430	227
726	208	233	403	441	229
727	206	229	399	439	226
727	208	228	391	435	231
729	212	229	388	438	239
731	213	232	398	435	234
733	210	229	395	440	237
733	212	228	397	440	232
735	212	227	393	441	236
739	209	228	399	438	233
739	211	221	400	438	236
739	216	238	401	446	235
741	211	235	396	443	233
743	215	237	405	454	239
746	216	235	406	451	242
746	216	236	403	446	238
748	212	237	404	443	233
748	222	238	406	450	244
749	208	228	398	438	229
749	212	234	403	443	233
750	210	235	405	443	231
751	208	231	399	443	230
751	219	237	407	448	236
752	215	237	406	447	238
753	213	238	403	448	236
753	217	238	406	448	243
755	216	238	410	450	240
756	211	233	407	447	232

SAMPLE NO. 3
Yellowfin Tuna: Origin, Cocos Island (continued)

Body length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
758	216	240	416	459	242
760	220	241	412	451	242
761	218	235	413	456	241
761	222	244	413	463	247
763	217	237	409	454	244
764	213	237	413	456	238
764	218	235	409	457	247
765	217	239	417	456	241
766	212	236	407	452	236
767	218	239	411	458	245
768	215	232	408	453	238
770	218	240	417	457	242
770	222	244	422	462	244
772	216	241	414	451	241
776	223	246	420	469	248
776	225	244	422	463	247
778	221	235	417	459	248
781	223	242	424	470	244
782	225	247	425	466	250
785	224	239	420	467	252
786	219	241	416	458	246
786	222	241	421	463	249
788	227	249	427	474	249
796	222	239	423	464	248
797	226	249	428	469	250
797	234	250	434	479	254
799	223	248	429	472	253
799	227	246	429	479	254
799	230	252	434	478	254
800	227	252	439	484	251
800	231	253	436	481	252
801	231	252	438	480	254
802	230	253	436	475	254
803	232	253	437	478	258
803	235	254	431	481	261
805	228	253	440	479	250
805	228	252	435	476	252
807	226	251	436	482	253
811	228	246	431	481	254
815	229	254	438	483	255
815	232	252	434	481	257
816	231	251	436	477	256
818	230	255	435	482	257
819	233	251	439	485	259
819	234	254	436	485	259
822	234	255	438	490	265
828	228	246	438	483	251
824	237	256	446	495	265
828	227	253	438	481	254
830	234	257	451	489	256
834	241	263	451	499	262
835	229	256	442	490	255
835	235	257	454	493	266
838	231	255	448	497	257
839	235	255	445	497	263
840	235	257	448	500	264
841	237	259	449	495	260
846	245	269	460	498	272
850	235	260	455	497	261
850	238	265	457	511	257

SAMPLE NO. 3
Yellowfin Tuna: Origin, Cocos Island (continued)

Body length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
850	247	265	458	506	270
852	236	264	451	500	261
853	236	268	461	508	261
853	238	265	456	509	268
855	246	260	458	498	269
858	242	264	459	512	268
861	243	267	463	508	270
865	242	263	455	507	271
865	245	263	462	514	271
867	245	271	465	508	273
872	246	271	468	516	274
873	245	265	462	515	272
874	243	263	459	514	268
880	245	273	468	518	271
881	250	271	467	521	276
883	245	265	460	509	274
889	248	274	476	526	274
897	246	273	470	516	267
897	254	278	479	529	279
899	256	274	485	542	290
901	253	270	475	527	286
913	253	277	483	533	276
915	248	275	490	536	279
918	256	282	485	539	286
922	256	276	480	531	285
925	263	281	494	553	293
928	260	286	489	547	286
933	253	278	489	543	283
934	259	282	497	554	289
934	261	282	497	549	288
935	256	287	497	548	281
937	260	282	487	538	282
938	254	282	488	538	282
938	257	287	492	545	289
940	265	290	498	550	290
943	262	282	503	549	289
944	263	281	489	560	301
947	264	291	498	558	293
953	261	286	497	549	293
956	259	290	493	556	293
958	261	294	504	561	291
959	268	288	509	557	302
965	269	297	519	578	300
976	261	289	507	559	292
977	271	297	506	571	297
989	273	300	515	569	306
992	274	297	525	570	306
1,030	281	313	543	602	312
1,072	292	315	569	622	319
Totals					
[E] Y	38,160	41,793	72,335	79,970	42,348
No.	168	168	168	168	168
[E] X	134,799	134,799	134,799	134,799	134,799
[E] X2	109,581,203	109,581,203	109,581,203	109,581,203	109,581,203
[E] 1/X	0.2121066	0.2121066	0.2121066	0.2121066	0.2121066
[E] 1/X2	0.00027122349	0.00027122349	0.00027122349	0.00027122349	0.00027122349
[E] 1/X Y	47.6444685	52.1808277	90.2667311	99.7872623	52.8696909
[E] X Y	30,964,702	33,912,254	58,726,052	64,929,983	34,365,562
[E] Y2	8,753,794	10,499,623	31,479,689	38,481,714	10,782,630

SAMPLE NO. 4
Yellowfin Tuna: Origin, Costa Rica

Body Length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
497	149	159	274	308	164
573	168	183	319	356	189
600	174	191	329	376	193
601	180	193	330	374	200
618	179	195	337	374	197
623	186	201	341	384	203
632	185	196	348	390	206
633	185	203	352	382	203
639	188	204	352	393	207
639	189	198	349	387	208
640	187	199	349	391	209
640	188	198	346	395	211
642	187	202	354	386	204
643	192	205	354	402	214
645	192	211	352	389	209
647	189	206	352	393	211
648	191	204	356	400	212
649	192	207	363	402	212
650	188	208	359	397	210
651	193	202	354	399	214
652	192	206	358	402	209
652	193	202	359	404	209
653	192	208	357	396	204
653	195	208	362	404	211
654	194	207	353	410	216
655	191	205	355	399	214
655	194	205	356	402	211
655	198	211	364	406	215
656	195	209	370	404	213
659	191	205	362	408	215
659	193	204	356	399	212
659	197	214	374	407	215
660	189	202	354	403	203
660	191	205	360	402	207
660	194	206	365	406	216
661	190	210	362	410	217
661	192	209	359	400	213
661	192	205	358	396	211
661	192	209	363	410	212
661	193	210	367	403	211
661	197	207	361	409	219
661	198	215	372	412	217
662	193	214	367	395	208
662	194	209	368	409	216
662	197	207	367	404	213
663	192	200	353	405	219
663	195	201	354	405	210
664	192	210	373	407	210
665	191	206	355	403	217
665	199	214	365	410	218
666	195	210	369	406	210
666	197	208	360	406	214
666	197	212	372	406	218
666	198	208	367	405	218
666	198	213	377	417	215
667	194	207	360	402	209
667	195	216	363	401	214
667	196	210	365	400	214
667	197	203	365	406	220

SAMPLE NO. 4
Yellowfin Tuna: Origin, Costa Rica
(continued)

Body Length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
668	193	217	375	404	207
668	199	216	374	400	215
668	200	210	362	414	219
669	198	215	367	415	216
670	192	209	365	408	212
670	193	213	372	401	214
670	194	212	364	403	207
670	196	210	366	410	213
671	193	214	371	403	210
672	196	218	370	417	218
672	196	214	365	408	212
672	198	216	373	410	222
673	193	206	361	410	213
673	194	210	372	409	211
673	197	216	372	408	213
673	198	214	371	415	219
673	201	216	373	410	220
674	195	214	371	405	216
674	199	215	374	414	217
674	201	219	378	405	214
675	194	212	370	413	218
675	200	213	370	414	218
676	195	211	369	415	216
677	194	209	370	410	214
677	196	218	371	416	210
677	200	216	372	419	221
677	200	217	376	408	225
677	201	213	371	411	215
678	195	208	366	413	217
678	196	213	367	414	215
678	203	217	377	413	221
679	195	215	363	405	216
679	197	212	363	411	219
679	197	215	374	406	209
679	199	208	375	416	221
679	201	210	365	419	222
680	201	217	379	413	223
680	203	219	370	411	221
681	193	214	370	410	211
681	195	213	373	410	208
681	202	221	380	416	221
682	199	214	378	419	218
682	199	210	370	423	221
682	201	220	372	418	224
683	199	211	374	417	226
683	201	219	369	415	223
683	201	221	374	410	217
683	203	212	373	423	225
683	204	213	371	420	228
684	198	217	375	410	216
684	203	224	380	420	221
685	198	215	368	418	219
685	200	221	376	420	217
685	203	217	377	427	220
686	198	210	371	413	216
686	200	216	374	419	220
686	203	220	376	428	220
686	203	218	376	420	224
687	201	218	367	411	220
687	201	214	378	415	217
687	202	222	378	423	217
687	203	213	365	422	223

SAMPLE NO. 4
Yellowfin Tuna: Origin, Costa Rica
(continued)

Body Length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
687	204	221	380	419	225
687	204	216	369	422	232
688	194	210	372	421	214
688	200	210	366	429	224
688	201	218	377	421	221
688	202	217	374	417	223
688	205	217	378	425	221
688	206	225	380	421	225
688	206	222	381	418	223
689	197	210	370	420	220
689	199	214	373	418	223
689	207	219	377	425	222
690	202	218	379	418	221
690	203	222	385	420	217
690	207	222	383	421	230
691	204	217	377	416	225
691	205	224	384	417	222
692	199	215	382	421	222
692	204	217	383	428	226
693	200	215	375	411	224
693	201	215	373	419	217
693	201	210	372	409	220
693	203	219	379	428	227
694	198	216	380	422	215
694	202	219	379	420	220
694	204	219	390	421	224
694	205	216	376	422	224
694	206	215	379	424	217
694	207	222	378	433	226
695	201	220	380	422	220
695	207	217	379	413	228
696	203	212	379	428	222
696	204	222	379	422	225
696	205	223	384	432	224
697	201	219	378	423	220
697	202	221	381	417	219
697	208	219	387	432	230
698	199	213	378	416	215
698	200	216	378	425	221
698	203	218	383	427	223
698	205	220	378	420	227
698	206	220	382	426	226
699	203	222	390	420	218
699	203	222	385	428	220
699	207	220	388	428	224
700	200	215	382	416	222
700	203	218	389	421	221
700	205	218	382	414	222
700	207	215	387	428	220
701	200	218	382	430	222
701	202	218	388	415	217
701	202	218	378	417	215
701	205	223	387	430	222
701	205	222	381	431	224
701	205	223	385	428	217
703	201	212	378	426	226
703	203	217	384	425	217
703	204	224	384	427	225
703	206	221	385	429	223

SAMPLE NO. 4
Yellowfin Tuna: Origin, Costa Rica
(continued)

Body Length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
704	207	222	381	420	223
704	207	227	387	425	226
705	206	223	387	432	224
706	203	222	385	424	224
706	205	223	382	416	224
706	208	220	389	429	226
706	211	227	395	430	232
707	210	226	383	435	230
708	201	214	382	432	225
708	203	223	383	431	227
708	206	222	382	432	231
708	206	221	394	425	223
708	207	224	392	427	225
708	207	223	384	432	231
708	207	225	387	434	225
708	208	226	394	434	232
709	204	218	389	432	229
710	210	227	391	437	238
711	203	228	394	427	220
711	207	223	376	429	228
711	207	218	384	428	221
711	208	222	381	433	229
711	208	218	389	435	224
711	213	221	392	436	230
712	201	220	391	431	224
712	203	221	386	427	219
712	207	226	390	434	226
712	208	223	394	434	225
712	208	220	386	434	227
713	206	224	393	436	230
713	207	219	384	420	225
713	209	223	391	427	231
713	210	223	398	432	226
714	203	217	387	433	225
714	211	229	399	438	230
715	206	216	384	433	233
715	207	226	391	___	233
715	208	225	396	438	230
715	208	219	385	429	225
715	212	228	390	437	235
716	209	218	390	435	228
716	211	230	398	442	225
717	207	212	389	436	224
717	211	221	387	440	236
717	212	230	397	436	232
718	207	226	397	443	229
718	207	226	392	439	231
718	207	228	395	439	230
719	209	224	396	439	242
719	210	225	395	440	229
719	210	219	388	434	229
719	210	229	398	434	228
720	207	228	394	434	227
720	209	228	394	430	227
721	207	214	390	431	224
721	210	226	393	431	229

SAMPLE NO. 4
Yellowfin Tuna: Origin, Costa Rica
(continued)

Body Length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
722	210	222	389	436	230
722	211	230	390	437	231
723	206	223	395	451	226
723	212	223	400	440	233
725	212	229	399	442	234
725	214	225	395	441	238
726	211	224	394	440	231
727	210	231	395	434	229
727	212	224	389	444	234
728	208	228	396	444	231
728	214	231	391	437	227
728	214	223	398	447	239
730	209	227	401	448	229
731	207	223	391	436	226
734	207	233	403	444	225
734	208	224	401	443	229
737	214	231	394	441	233
738	214	233	397	449	230
738	219	233	406	446	237
740	212	225	400	444	235
741	216	230	405	462	241
746	216	230	398	450	245
750	217	243	414	447	238
750	219	239	411	457	240
753	214	235	408	450	232
754	214	228	400	447	238
754	215	232	405	456	238
756	218	232	409	460	242
758	217	240	410	451	234
763	217	227	405	456	239
771	224	243	420	474	245
772	218	232	410	472	248
776	222	244	431	473	243
778	226	241	420	475	245
786	219	238	423	473	240
786	230	241	423	479	258
828	233	254	445	493	255
836	239	261	448	503	262
837	240	255	445	503	269
851	243	262	457	511	271
854	236	252	453	512	271
871	246	250	462	521	271
871	249	265	466	516	269
878	249	267	472	515	274
880	248	266	472	505	268
881	252	270	475	527	277
887	247	266	471	524	275
888	246	274	472	524	265
889	253	271	485	532	288
889	256	275	480	537	285
900	250	272	474	526	281
900	251	269	483	537	275
900	252	268	483	535	274
900	261	276	491	536	281
901	256	272	479	531	285
905	252	266	480	535	281

SAMPLE NO. 4
Yellowfin Tuna: Origin, Costa Rica
(continued)

Body Length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
910	258	276	484	541	282
919	260	277	487	546	284
926	262	279	491	543	291
937	261	286	500	553	293
942	267	287	503	558	289
943	264	281	500	545	290
945	264	279	501	550	289
946	263	284	499	562	298
949	266	289	517	569	298
952	267	285	505	556	299
959	259	287	499	553	288
960	267	293	514	565	293
963	268	291	509	569	302
964	270	287	518	573	303
966	272	290	511	572	303
970	268	287	514	569	293
971	265	280	504	575	313
974	265	283	514	574	297
977	265	284	516	572	294
977	266	287	512	568	295
977	270	294	521	573	297
979	276	290	518	581	309
983	277	294	523	584	300
988	270	292	520	580	304
990	276	298	520	589	311
994	274	297	524	591	309
995	273	297	524	575	294
1,003	277	298	522	585	311
1,003	278	298	534	585	295
1,014	283	298	538	611	302
1,017	275	304	526	594	310
1,022	279	309	542	598	316
1,035	282	301	541	604	317
1,048	281	308	544	619	319
1,053	295	314	555	621	328
1,057	287	317	545	610	314
1,057	287	317	559	625	314
1,063	291	320	555	623	328
1,072	289	317	573	633	321
1,078	296	324	582	630	320
1,082	291	316	552	619	324
1,085	293	311	560	633	332
1,087	294	328	577	634	332
1,088	303	327	564	623	326
1,090	296	321	578	630	315
1,090	297	323	568	631	331
1,090	298	314	563	626	336
1,094	299	326	574	640	330
1,095	296	320	561	631	333
1,095	301	320	568	631	334
1,096	303	328	579	645	320
1,098	296	330	580	637	330
1,100	293	304	553	633	328
1,105	295	321	571	639	324
1,106	296	316	560	639	336
1,107	302	320	576	645	332

SAMPLE NO. 4
Yellowfin Tuna: Origin, Costa Rica (continued)

Body Length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
1,108	306	325	576	647	335
1,109	300	332	566	632	341
1,110	302	327	578	654	337
1,111	295	325	579	644	333
1,111	304	330	578	658	330
1,114	307	334	581	652	341
1,115	294	325	575	640	328
1,122	304	334	588	658	339
1,127	306	342	592	645	339
1,129	299	314	589	659	332
1,130	300	316	576	662	337
1,131	296	321	584	669	364
1,131	300	325	580	661	338
1,133	304	328	592	658	331
1,138	310	336	586	658	343
1,141	310	328	578	661	355
1,141	315	340	590	666	350
1,148	317	330	594	679	351
1,149	315	337	596	666	348
1,150	306	337	578	657	344
1,150	319	339	594	665	358
1,151	311	331	588	663	340
1,152	306	331	599	666	336
1,167	311	340	609	688	344
1,168	306	334	586	___	343
1,169	310	332	588	667	341
1,172	304	330	604	667	338
1,175	316	344	613	680	345
1,175	316	336	601	678	352
1,191	322	346	615	694	359
1,192	315	331	598	689	364
1,207	322	350	632	690	360
1,209	324	344	617	691	360
1,213	329	339	623	696	364
1,243	331	357	627	713	370
1,244	338	365	643	719	377
1,268	349	370	666	738	393
1,274	347	361	653	737	392
1,275	339	370	659	728	376
Totals					
[E] Y	87,714	94,405	165,527	183,387	96,710
No.	387	387	387	385	387
[E] X	307,890	307,890	307,890	306,007	307,890
[E] X2	256,671,474	256,671,474	256,671,474	254,796,025	256,671,474
[E] 1/X	0.5061053	0.5061053	0.5061053	0.5038502363	0.5061053
[E] 1/X2	0.0006832555	0.0006832555	0.0006832555	0.0006805655412	0.0006832555
[E] 1/X Y	110.9797380	119.4351677	209.0220991	231.6884114	122.2146273
[E] X Y	72,569,610	78,112,650	137,252,903	151,970,718	80,126,743
[E] Y2	20,546,996	23,808,181	73,451,711	90,696,241	25,043,288

SAMPLE NO. 5
Yellowfin Tuna: Origin, Costa Rica

Body length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
528	161	173	292	326	182
529	163	175	298	330	179
531	161	174	294	334	181
532	158	176	302	328	177
536	160	172	297	328	178
537	160	173	300	330	175
538	159	174	299	331	178
538	161	176	299	332	180
539	160	170	299	332	177
539	161	171	292	328	184
539	163	174	298	329	180
540	162	175	302	334	182
540	162	173	294	328	183
541	160	174	297	334	176
543	163	173	297	338	182
543	164	178	302	337	186
543	165	178	302	334	187
545	162	174	304	338	182
546	164	176	303	335	183
547	161	174	300	336	178
548	166	177	302	340	187
550	164	178	306	336	182
551	162	179	303	338	182
551	166	180	309	339	181
554	164	181	312	342	187
555	164	175	305	341	182
557	164	178	303	341	183
558	165	181	307	341	185
558	170	183	312	351	188
559	168	177	307	346	189
559	171	185	313	345	190
560	170	185	312	344	189
561	165	184	313	344	188
561	169	185	313	341	188
561	169	185	309	340	185
562	164	182	311	347	179
562	168	180	313	340	184
564	169	182	312	348	189
565	168	186	313	339	188
565	171	178	315	351	193
566	166	185	315	348	187
567	168	186	315	350	187
568	167	182	314	349	185
568	169	181	310	349	188
568	170	186	313	348	189
569	170	181	311	346	190
570	170	185	313	354	190
571	165	180	313	347	187
572	168	183	314	346	184
572	168	186	319	351	186
573	171	187	316	360	191
574	170	190	317	355	191
576	167	192	326	351	188
576	168	188	322	353	189
576	170	185	321	356	189
577	171	188	320	353	188
579	173	187	318	358	190
580	171	190	322	360	190
580	172	184	324	358	193

SAMPLE NO. 5
Yellowfin Tuna: Origin, Costa Rica
(continued)

Body length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
581	172	183	323	355	191
581	174	189	320	354	192
584	171	183	315	357	194
585	174	187	324	359	192
585	174	183	322	362	189
585	176	192	324	358	195
588	171	189	328	355	190
589	178	194	327	364	195
592	175	192	327	360	191
593	178	196	332	365	197
593	178	191	330	365	196
594	174	190	322	362	196
596	174	191	325	363	195
601	177	193	331	368	199
603	176	196	329	366	196
603	178	195	330	373	202
604	177	191	333	371	200
604	178	192	335	369	195
606	175	191	326	364	195
609	176	191	332	370	199
610	181	193	339	377	202
618	178	197	336	375	198
618	179	189	337	372	201
618	182	197	343	380	202
619	182	197	339	372	195
619	182	194	340	376	199
622	182	199	343	381	203
635	184	199	346	390	205
639	186	202	351	390	206
640	188	202	349	397	214
644	190	204	352	400	208
645	186	203	354	391	209
645	188	206	352	389	206
649	193	210	357	393	211
656	193	208	366	410	219
658	194	212	366	409	212
663	194	205	360	405	216
665	196	213	367	407	213
666	198	214	365	408	226
670	194	210	366	409	217
676	193	213	372	409	210
676	195	213	373	414	219
684	195	216	371	411	215
684	203	217	378	417	227
685	193	214	371	412	214
689	199	212	375	418	221
694	204	215	379	419	226
695	200	216	382	425	227
695	201	215	380	425	226
696	205	220	379	422	228
700	206	222	385	425	223
700	206	220	385	420	230
700	207	225	383	430	230
701	205	221	388	428	229
702	206	219	378	425	227
703	207	223	___	426	229

SAMPLE NO. 5
Yellowfin Tuna: Origin, Costa Rica
(continued)

Body length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
704	203	223	381	426	227
704	206	223	387	428	225
706	205	229	387	434	233
709	203	223	392	426	221
711	207	221	388	436	233
713	203	221	391	432	225
713	207	227	388	431	230
713	213	224	391	434	240
714	207	230	390	429	224
715	204	223	388	436	231
715	209	220	388	435	228
715	211	231	393	432	232
716	209	230	394	433	230
716	212	224	388	434	232
717	202	227	389	434	222
717	205	227	391	434	226
718	206	227	395	447	232
719	209	222	389	432	231
720	211	230	397	441	231
721	210	230	396	437	236
723	213	228	396	438	234
724	209	229	396	435	235
724	210	229	399	439	239
724	210	224	399	434	232
724	211	235	402	441	234
725	210	224	394	432	230
726	209	224	396	442	233
726	218	226	398	446	241
727	207	227	389	436	227
727	208	226	396	444	230
727	209	230	400	444	228
727	212	225	391	442	231
728	208	229	392	434	232
728	210	230	394	435	235
728	211	230	397	437	233
728	215	232	404	447	240
729	210	229	393	445	230
729	211	226	403	440	235
729	213	226	397	444	237
730	209	228	393	438	232
730	212	234	403	444	232
730	214	233	405	439	233
730	215	229	396	439	234
731	214	228	401	437	232
731	216	228	395	438	241
732	213	227	395	440	234
733	212	228	396	443	236
734	213	227	394	453	234
735	213	232	399	452	242
735	216	232	401	445	234
735	217	230	400	444	238
735	218	228	398	442	239
736	212	231	399	444	236
736	217	232	401	448	238
737	212	233	405	444	234
737	212	235	406	445	234

SAMPLE NO. 5
Yellowfin Tuna: Origin, Costa Rica
(continued)

Body length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
737	214	234	405	439	232
737	215	227	396	440	243
738	210	229	404	442	234
738	213	230	402	445	234
738	215	230	401	439	231
738	216	234	407	447	238
740	210	227	395	444	234
740	211	230	400	444	236
740	211	228	408	444	236
740	214	227	400	442	236
740	215	235	405	449	243
741	213	231	402	446	235
742	213	230	409	446	238
742	214	234	405	444	238
742	217	236	407	448	241
743	212	232	400	444	237
743	216	237	404	443	239
744	212	235	410	448	234
744	214	227	409	453	235
744	218	240	407	446	246
745	210	230	403	441	233
747	210	223	405	448	247
747	212	235	406	441	238
747	216	236	403	448	243
747	216	240	411	450	236
747	216	232	411	455	244
747	216	234	403	443	240
747	217	232	402	452	242
748	216	235	407	453	240
748	216	230	400	451	239
748	217	240	408	446	239
748	218	230	405	455	236
749	212	228	409	446	235
749	218	241	406	454	235
751	213	227	400	450	239
751	223	236	408	454	245
753	209	231	403	446	235
753	215	237	411	455	239
753	217	237	410	456	241
753	220	237	406	453	243
754	215	235	411	451	236
754	216	231	409	449	238
754	217	239	411	454	236
755	216	234	405	447	233
755	218	234	407	453	248
756	218	239	408	449	238
757	216	236	414	453	238
757	219	245	416	459	245
757	220	240	416	461	240
757	220	237	408	460	244
758	215	236	413	454	235
758	217	233	413	455	244
758	218	235	410	453	241
759	223	241	412	461	249
760	216	241	418	455	235
760	218	237	412	453	245

SAMPLE NO. 5
Yellowfin Tuna: Origin, Costa Rica
(continued)

Body length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
761	217	240	419	450	237
762	217	235	415	450	240
763	219	241	422	463	245
763	223	239	411	464	247
764	222	245	415	459	243
765	221	246	422	457	242
766	215	235	414	457	239
766	218	237	419	460	248
766	221	235	414	459	248
767	218	238	412	453	243
767	220	234	416	459	249
767	221	243	426	468	248
767	223	244	414	463	248
767	224	242	420	457	247
768	222	238	410	460	249
768	222	245	424	453	239
769	221	240	423	466	245
770	225	239	421	472	248
771	220	246	414	451	239
773	217	239	416	463	246
773	224	244	417	464	248
774	225	241	420	457	245
775	224	242	420	462	252
775	225	241	415	465	257
777	219	242	424	466	237
777	223	238	418	464	247
779	220	244	423	462	243
779	222	242	423	460	246
779	223	240	425	476	247
779	225	242	411	462	250
780	224	244	422	459	252
782	219	245	426	475	244
782	220	233	415	461	245
782	224	251	431	469	248
783	220	240	425	467	245
784	231	243	417	473	256
787	228	248	430	472	253
788	223	241	425	477	250
790	229	240	426	473	252
794	225	240	425	472	255
795	222	240	427	472	248
795	227	246	428	477	258
798	227	238	433	484	249
799	227	245	431	478	250
799	228	246	431	480	246
799	229	238	435	481	266
800	230	248	425	479	255
801	225	245	424	471	247
802	229	244	426	488	255
806	231	248	433	478	263
810	233	248	435	485	260
810	235	260	439	493	261
820	230	249	441	492	257
820	231	250	442	488	261
829	237	245	444	495	268
837	238	251	449	499	264

SAMPLE NO. 5
Yellowfin Tuna: Origin, Costa Rica (continued)

Body length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
839	241	260	456	499	268
857	245	265	453	503	270
858	238	258	451	512	266
865	240	258	463	509	265
867	243	265	459	517	267
869	244	261	464	522	274
877	244	258	465	517	264
882	249	268	472	525	279
887	240	256	466	520	268
891	250	270	473	528	272
895	245	274	478	533	280
898	249	274	478	533	276
914	261	271	478	538	292
915	251	269	487	542	282
921	259	277	487	552	288
923	253	270	481	543	281
932	258	282	501	553	285
937	258	276	493	549	305
939	257	279	498	554	290
961	266	281	501	562	294
979	268	293	512	572	291
1,004	276	296	522	573	305
1,006	275	305	536	596	301
1,007	275	298	528	586	310
1,019	285	301	536	597	314
1,020	279	303	529	591	311
1,032	281	299	543	602	314
1,037	283	312	542	606	313
1,048	284	308	541	602	315
1,051	293	308	551	620	329
1,062	294	325	558	631	326
1,063	280	311	547	609	310
1,068	289	312	557	618	326
1,072	292	324	562	634	326
1,074	291	320	568	631	321
1,076	292	316	557	634	327
1,078	291	314	559	625	332
1,090	296	312	562	627	333
1,097	299	318	562	628	323
1,100	298	331	563	644	338
1,100	304	329	583	641	340
1,108	299	320	570	637	337
1,124	303	326	584	656	350
1,126	309	338	600	664	344
1,130	304	324	590	650	345
1,145	307	331	594	664	343
1,145	315	334	590	661	350
1,147	307	338	600	671	350
1,154	308	342	598	678	349
1,155	314	333	598	674	345
1,160	314	336	600	673	350
1,193	321	350	608	681	363
1,206	322	343	621	692	361
1,208	325	347	623	688	356
1,209	321	345	622	697	357
1,209	327	352	630	702	370
1,209	336	351	631	700	380
1,247	340	371	648	723	383
1,248	328	368	637	715	368
1,248	340	365	632	714	377
1,271	332	362	657	723	375
1,276	340	359	649	733	377
1,279	332	360	656	740	368
1,292	334	367	667	726	377
1,316	344	361	668	756	383
1,324	341	370	668	762	389
1,330	354	371	675	766	401
Totals					
[E] Y	76,096	82,381	143,294	159,607	84,644
No.	350	350	349	350	350
[E] X	266,354	266,354	265,651	266,354	266,354
[E] X2	213,802,454	213,802,454	213,308,245	213,802,454	213,802,454
[E] 1/X	0.4818444	0.4818444	0.4804219	0.4818444	0.4818444
[E] 1/X2	0.000690504	0.000690504	0.000688481	0.000690504	0.000690504
[E] 1/X Y	100.6948914	109.0617962	189.1527185	210.6179901	111.9631376
[E] X Y	60,587,954	65,556,898	114,415,744	127,497,126	67,436,497
[E] Y2	17,194,318	20,135,685	61,414,488	76,071,181	21,299,420

SAMPLE NO. 6
Yellowfin Tuna: Origin, Guatemala

Body length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
510	148	162	280	313	163
512	148	159	279	316	167
545	160	171	303	334	180
555	159	169	307	342	180
555	163	178	306	___	183
555	163	179	311	342	185
560	168	183	310	346	185
563	164	177	307	___	184
563	166	185	311	351	187
566	164	180	309	350	185
566	168	183	316	349	187
567	168	177	314	344	184
567	170	183	307	342	188
567	172	182	318	354	193
569	169	185	317	352	188
569	169	178	316	355	191
570	167	181	313	348	191
572	175	187	320	354	196
576	167	184	317	357	189
576	170	187	314	351	189
576	170	186	326	355	189
578	171	186	319	358	190
580	169	187	318	356	188
580	171	181	318	357	192
582	173	188	323	359	193
583	169	183	322	360	192
583	170	189	319	358	192
583	174	188	326	361	196
584	173	184	324	361	193
587	171	187	326	360	189
588	172	187	323	362	192
588	174	190	318	363	193
588	174	194	328	361	199
589	173	190	327	363	201
591	171	190	325	363	193
592	179	194	327	367	202
593	173	185	319	359	197
593	173	192	326	359	194
594	173	189	324	364	192
594	176	193	325	368	194
595	177	192	332	367	200
596	175	191	329	362	195
597	174	192	327	369	196
597	174	190	327	364	196
597	178	195	331	369	201
597	178	192	330	372	199
598	174	190	332	364	193
599	175	192	325	370	200
599	176	192	330	367	200
601	176	192	334	372	200
601	177	191	332	369	200
602	177	196	332	368	198
602	177	190	331	366	195
603	174	193	333	364	194
603	176	195	335	373	194
603	177	195	333	368	197
603	180	193	328	369	205
603	180	197	335	371	205
606	176	187	330	367	199

SAMPLE NO. 6
Yellowfin Tuna: Origin, Guatemala
(continued)

Body length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
606	178	195	334	372	198
607	179	196	332	372	200
607	180	199	340	374	200
607	181	199	335	371	203
607	181	193	331	371	201
608	177	196	334	369	199
608	179	194	331	371	201
609	180	194	328	373	201
610	178	197	336	380	203
610	181	196	333	381	205
611	179	195	338	375	201
612	179	195	334	364	199
612	183	197	334	371	205
616	184	194	337	374	204
617	181	200	342	378	203
618	186	199	343	388	216
619	181	196	342	376	201
620	178	196	335	378	201
621	179	197	341	376	203
621	181	197	340	384	203
622	178	193	340	377	198
624	183	194	341	378	206
624	184	202	343	381	208
624	186	204	345	382	206
626	181	197	342	383	205
626	182	201	344	386	203
626	188	200	336	378	209
627	183	203	342	381	205
630	182	196	346	381	203
631	186	199	340	386	206
632	187	204	347	390	212
638	189	202	355	387	210
639	188	203	353	390	210
640	186	206	354	394	207
652	188	208	361	401	208
652	191	211	363	400	215
657	189	209	357	401	215
659	198	217	367	415	223
676	196	217	376	419	218
678	195	210	374	406	218
686	195	218	375	416	218
692	198	223	377	419	225
697	203	224	389	428	227
699	201	220	384	425	221
700	204	221	386	429	230
700	207	226	396	434	230
707	206	225	387	435	231
711	207	226	386	434	238
722	206	220	392	435	233
726	207	223	392	440	233
738	211	229	402	443	232
740	213	229	406	450	237
741	210	231	396	445	237
744	212	236	411	453	242
746	215	229	403	449	234
747	211	227	411	451	232

SAMPLE NO. 6

Yellowfin Tuna: Origin, Guatemala (continued)

Body length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
749	212	234	402	449	241
772	226	240	425	473	256
774	220	241	421	465	246
784	223	240	422	472	251
800	231	254	434	485	261
Totals					
[E] Y	21,861	23,805	41,067	45,049	24,520
No.	120	120	120	118	120
[E] X	74,715	74,715	74,715	73,597	74,715
[E] X2	46,929,819	46,929,819	46,929,819	46,304,825	46,929,819
[E] 1/X	0.1942982	0.1942982	0.1942982	0.1907202	0.1942982
[E] 1/X2	0.00031694578	0.00031694578	0.00031694578	0.0003105444	0.00031694578
[E] 1/X Y	35,1387942	38.2602014	65.9796898	72.2613203	39.4126458
[E] X Y	13,719,057	14,940,079	25,785,306	28,329,115	15,387,776
[E] Y2	4,011,557	4,757,787	14,169,369	17,333,699	5,047,454

SAMPLE NO. 7
Yellowfin Tuna: Origin, Cocos Island

Body length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
448	130	142	250	278	143
450	131	148	250	278	146
470	137	151	262	295	148
483	146	154	271	304	160
487	145	158	272	299	161
492	146	160	275	303	161
502	147	156	278	310	162
512	153	167	287	315	167
519	156	172	291	314	169
531	158	173	296	333	174
534	158	172	298	332	176
552	161	178	306	334	176
552	162	179	309	337	179
563	164	183	311	334	177
637	188	202	351	385	201
661	192	212	368	407	211
662	188	205	359	395	208
664	193	207	365	415	216
673	195	208	363	405	211
676	198	213	376	411	214
677	195	213	369	410	215
687	201	218	375	422	219
689	200	212	377	424	220
690	202	215	376	423	219
692	198	223	380	421	217
693	206	224	381	419	227
696	197	221	389	418	212
699	199	213	377	416	217
703	201	219	387	422	221
703	209	224	388	423	230
716	206	220	394	432	228
717	200	218	389	430	229
719	209	230	399	440	233
722	204	226	392	433	227
724	208	221	386	435	230
727	210	225	394	435	227
728	204	219	393	434	223
734	212	224	391	442	234
735	211	227	398	443	231
738	209	228	397	445	228
746	214	230	404	442	235
747	211	231	403	448	233
747	214	236	403	450	237
747	217	231	402	450	242
747	217	237	409	453	238
748	210	233	408	453	232
748	214	229	400	453	237
749	213	228	402	451	233
751	214	236	412	452	243
751	216	230	406	450	246
751	217	241	417	451	233
752	219	237	415	454	242
753	214	233	408	452	239
753	215	234	403	440	231
754	213	231	406	445	234
755	211	232	408	453	234
756	214	231	400	455	235
756	215	234	412	451	238
756	216	241	414	466	238

SAMPLE NO. 7
Yellowfin Tuna: Origin, Cocos Island
(continued)

Body length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
757	219	235	406	456	244
759	215	228	414	460	242
760	216	238	416	458	241
761	216	233	408	448	237
761	217	239	416	459	238
762	215	237	418	456	243
762	219	236	411	457	240
763	223	243	424	462	244
764	215	231	402	450	235
766	216	237	406	452	236
768	221	239	423	469	239
768	223	238	410	464	251
770	219	237	419	462	239
771	220	228	411	456	244
776	218	235	416	465	248
776	220	237	419	470	251
778	223	241	429	467	240
778	224	243	420	463	243
780	220	239	419	462	246
783	224	241	421	473	251
787	222	241	429	474	248
787	223	239	421	470	253
788	225	237	428	475	249
789	220	243	427	468	246
791	224	235	424	475	250
792	222	245	424	474	251
792	229	246	430	481	260
793	222	243	433	471	243
796	227	247	433	481	258
796	230	249	436	480	252
799	225	241	424	474	258
800	228	245	429	475	258
801	226	243	429	476	246
802	226	249	435	474	256
802	226	245	430	479	253
803	228	246	431	484	256
807	234	254	431	482	255
808	227	247	442	491	250
809	225	242	436	483	243
809	230	251	437	488	267
811	227	245	432	485	258
811	232	252	437	486	253
814	225	246	425	485	253
814	230	253	437	486	252
816	226	244	434	482	252
837	228	251	442	489	254
840	237	257	449	498	264
842	230	254	448	506	256
842	235	259	454	503	264
842	237	260	455	507	264
845	240	261	458	510	280
849	234	253	454	498	258
857	240	257	457	510	274
865	242	265	463	520	270
868	245	269	472	518	272
872	243	260	457	520	273

SAMPLE NO. 7

Yellowfin Tuna: Origin, Cocos Island (continued)

Body length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
883	240	266	467	521	272
884	240	263	465	517	265
886	241	264	466	521	277
888	242	262	464	520	260
973	266	285	511	574	300
1,220	328	350	624	699	368
1,277	341	378	661	748	386
1,286	339	377	672	738	375
1,289	348	365	657	751	390
1,316	338	372	675	755	386
1,332	342	383	689	771	395
1,342	347	371	666	758	398
1,353	346	384	694	769	394
1,371	371	401	709	794	426
1,373	365	400	714	798	405
1,376	356	390	697	786	407
1,391	378	402	718	805	425
1,395	362	400	705	787	409
1,396	354	383	693	798	412
1,403	360	382	711	810	405
1,413	365	409	717	808	410
1,417	376	409	720	806	428
1,435	373	400	734	817	418
1,486	389	412	772	872	443
1,505	386	417	755	847	442
1,511	397	432	776	871	444
1,522	396	432	771	861	438
1,526	395	423	766	867	449
Totals					
[E] Y	33,637	36,516	64,362	71,656	37,471
No.	143	143	143	143	143
[E] X	120,712	120,712	120,712	120,712	120,712
[E] X2	111,402,470	111,402,470	111,402,470	111,402,470	111,402,470
[E] 1/X	0.1827093	0.1827093	0.1827093	0.1827093	0.1827093
[E] 1/X2	0.00024889830	0.00024889830	0.00024889830	0.00024889830	0.00024889830
[E] 1/X Y	40.2748938	43.7301970	76.8273084	85.4004657	44.7397043
[E] X Y	30,650,756	33,271,633	58,870,642	65,666,730	34,255,440
[E] Y2	8,450,491	9,958,218	31,142,334	38,733,038	10,547,993

SAMPLE NO. 8
Yellowfin Tuna: Origin, Galapagos Islands

Body length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
504	148	162	276	311	168
504	149	162	276	308	170
506	152	164	279	309	171
507	150	159	279	310	165
509	149	163	279	309	167
513	150	167	285	308	164
514	154	168	285	316	172
522	153	167	290	323	___
524	160	176	293	326	178
525	150	166	290	319	171
525	153	166	290	318	172
527	152	168	289	320	168
527	154	175	294	324	175
528	158	170	291	328	182
528	158	170	294	324	179
529	152	169	296	326	174
529	157	170	294	322	177
529	157	173	294	330	176
530	153	168	288	322	176
530	157	172	290	321	173
530	157	172	289	323	178
530	159	177	297	325	179
531	155	172	296	328	178
531	159	175	292	330	179
533	157	175	295	329	174
534	158	172	296	327	181
535	159	177	297	330	179
535	160	176	296	328	177
537	159	176	296	333	179
540	159	173	297	330	179
540	162	175	295	327	180
541	161	176	300	331	181
542	160	177	299	336	179
542	161	176	300	333	178
543	157	177	298	336	177
543	159	176	298	336	182
543	162	179	295	331	183
546	158	176	300	335	178
546	161	177	302	334	182
547	161	178	304	336	180
547	161	176	305	338	183
547	163	180	302	339	185
548	161	177	300	334	180
550	159	176	301	335	183
550	159	176	303	333	178
550	161	179	303	339	183
550	162	175	302	337	183
551	163	178	311	337	182
551	167	182	306	342	188
552	160	180	306	340	182
552	165	181	306	343	187
553	164	178	307	340	186
554	162	179	303	339	179
554	163	181	306	336	181
555	165	178	306	341	185
556	162	181	308	339	183
556	163	177	306	344	183
556	167	185	307	340	185
557	162	176	306	342	185

SAMPLE NO. 8
Yellowfin Tuna: Origin, Galapagos
Islands (continued)

Body length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
557	162	178	308	338	179
558	165	184	307	344	188
559	161	179	309	342	182
559	162	181	304	339	187
560	158	176	305	339	182
560	169	183	310	349	192
561	163	178	309	339	183
561	165	181	308	343	190
563	165	180	309	346	183
563	166	181	311	351	184
564	163	182	314	347	187
567	163	186	312	351	186
567	165	184	315	350	183
568	162	181	309	343	183
568	163	181	310	342	184
568	165	180	310	342	182
570	166	186	313	349	191
570	168	186	316	345	190
571	163	181	312	349	191
571	167	183	314	351	191
572	165	183	314	354	185
572	168	184	312	352	192
574	165	182	311	341	185
574	166	184	314	348	188
574	167	186	318	355	188
574	169	186	312	350	189
575	170	184	317	353	187
576	166	183	317	354	189
576	168	186	319	354	188
577	167	184	314	353	189
577	168	184	321	356	192
579	168	183	317	353	188
579	173	188	318	355	192
581	169	186	314	351	193
583	169	184	321	356	191
592	169	186	322	358	191
595	172	184	322	362	196
596	175	193	326	366	197
621	182	191	336	377	206
626	180	201	341	379	201
640	184	205	351	383	202
642	188	205	351	397	212
643	185	205	351	387	206
662	195	212	367	406	218
664	192	208	359	403	211
664	194	212	363	406	210
674	199	221	372	413	224
679	194	211	371	414	217
680	197	217	369	411	216
681	194	213	372	407	216
685	197	214	375	419	219
691	199	214	371	406	221
704	206	229	387	428	229
711	207	227	388	433	229
714	208	227	378	426	227
720	204	226	389	426	224

SAMPLE NO. 8
Yellowfin Tuna: Origin, Galapagos
Islands (continued)

Body length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
733	207	228	394	435	228
741	214	239	404	446	239
744	206	230	402	440	228
745	204	232	399	447	227
747	218	235	405	458	243
805	229	253	435	479	251
807	227	247	436	478	253
809	226	250	435	485	250
811	228	247	435	480	254
811	229	246	427	482	251
812	231	255	437	484	256
813	228	254	439	484	246
813	232	250	437	481	258
814	233	248	439	481	254
818	233	255	439	481	256
821	236	258	450	496	265
824	233	255	442	491	255
826	234	256	439	490	260
829	230	256	447	493	252
829	230	252	440	490	253
832	232	254	450	499	264
833	228	260	445	486	251
833	236	259	445	495	259
834	236	258	450	501	262
837	237	262	440	495	262
838	234	258	448	493	259
838	235	252	446	500	264
838	239	253	442	496	265
839	235	256	449	497	260
839	240	260	446	497	266
842	236	262	455	500	266
844	242	272	463	503	267
845	238	263	448	498	258
845	244	261	455	511	272
846	236	263	451	506	263
846	237	257	454	507	266
846	239	260	452	505	259
847	240	262	458	508	269
847	240	265	459	505	265
849	235	255	448	495	259
849	239	267	461	512	267
851	234	258	445	495	264
852	239	263	454	511	265
853	243	264	458	507	266
854	238	265	457	507	265
857	238	266	454	503	266
857	239	260	455	506	266
857	240	261	453	505	266
858	235	261	454	508	262
858	237	254	462	503	273
859	240	266	459	514	262
862	240	265	460	516	263
862	247	276	464	505	275
863	241	274	469	516	269
863	242	272	464	509	263
864	244	270	460	509	268

SAMPLE NO. 8
Yellowfin Tuna: Origin, Galapagos Islands (continued)

Body length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
865	240	263	459	508	269
867	245	263	459	516	275
868	245	276	468	518	281
872	244	276	471	517	273
874	249	273	465	513	268
876	243	274	472	517	268
876	246	268	463	517	271
877	243	274	468	523	270
881	248	277	468	523	275
883	241	272	473	526	271
884	244	270	470	521	274
885	241	262	467	517	271
889	248	268	473	534	279
892	251	279	480	531	282
900	251	278	482	536	275
904	255	279	480	533	285
906	247	277	481	526	273
913	247	282	478	528	273
916	252	280	481	533	272
921	255	287	492	545	286
922	251	278	483	545	284
922	261	283	493	548	287
987	270	302	524	581	308
Totals					
[E] Y	37,959	41,782	71,857	79,801	42,233
No.	194	194	194	194	193
[E] X	132,549	132,549	132,549	132,549	132,027
[E] X2	94,650,761	94,650,761	94,650,761	94,650,761	94,378,277
[E] 1/X	0.2966497	0.2966497	0.2966497	0.2966497	0.2947340
[E] 1/X2	0.00047227410	0.00047227410	0.00047227410	0.00047227410	0.00046860419
[E] 1/X Y	55.8190370	61.4234158	105.4938001	117.1830285	62.1203147
[E] X Y	26,980,827	29,707,721	51,157,908	56,800,721	30,009,038
[E] Y2	7,696,203	9,330,406	27,658,165	34,097,659	9,552,233

SAMPLE NO. 9
Yellowfin Tuna: Origin, Punta Galera, Mexico

Body length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
636	185	201	349	393	210
641	184	203	355	392	206
646	184	201	350	393	209
674	197	212	366	410	216
675	198	210	369	416	221
675	199	220	372	416	222
676	194	211	370	409	219
676	195	211	367	403	213
679	195	211	366	414	219
679	197	215	368	415	223
680	195	209	371	416	222
682	196	215	372	416	220
682	199	223	371	417	223
685	198	219	376	419	224
686	198	219	377	421	221
686	198	223	373	422	223
687	201	215	376	422	224
688	198	214	369	418	219
688	200	219	377	426	220
690	194	213	371	412	217
691	198	220	382	421	220
691	200	220	374	416	225
692	198	219	376	416	221
693	201	219	379	422	224
693	201	220	379	426	224
694	198	222	380	421	219
694	201	223	379	419	222
695	199	215	369	422	222
695	205	222	373	418	225
701	197	217	375	423	219
701	201	224	382	421	222
701	201	220	382	428	226
701	203	223	386	429	225
701	205	223	381	430	227
702	209	230	384	425	230
705	205	228	379	429	226
706	207	229	385	430	229
710	209	223	389	437	232
712	202	221	384	433	226
714	205	228	395	438	228
714	206	229	392	438	230
715	205	230	393	437	230
716	205	220	384	433	231
716	206	223	390	438	227
716	207	227	391	428	234
719	209	226	395	438	234
720	202	224	389	431	226
720	207	229	394	447	227
720	207	229	391	440	235
722	205	221	393	437	232
722	205	226	395	439	233
722	212	227	393	439	236
725	207	225	390	436	229
726	208	226	395	446	235
730	207	230	392	443	233
734	208	233	398	449	236

SAMPLE NO. 9

Yellowfin Tuna: Origin, Punta Galera, Mexico (continued)

Body length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
734	210	233	394	444	236
735	214	240	403	445	241
739	212	233	408	439	231
739	213	231	402	450	236
740	210	227	398	443	233
740	212	234	399	448	237
741	216	233	399	451	241
752	215	238	409	456	243
756	210	231	404	450	238
762	217	229	409	454	241
763	216	234	406	456	245
783	227	246	429	475	249
787	225	248	425	471	251
Totals					
[E] Y	14,053	15,392	26,538	29,655	15,693
No.	69	69	69	69	69
[E] X	48,811	48,811	48,811	48,811	48,811
[E] X2	34,589,005	34,589,005	34,589,005	34,589,005	34,589,005
[E] 1/X	0.0977073	0.0977073	0.0977073	0.0977073	0.0977073
[E] 1/X2	0.00013859523	0.00013859523	0.00013859523	0.00013859523	0.00013859523
[E] 1/X Y	19,8687623	21.7619439	37.5190442	41.9281208	22.1879847
[E] X Y	9,956,728	10,905,344	18,803,359	21,010,671	11,118,473
[E] Y2	2,866,599	3,439,330	10,222,874	12,763,993	3,574,617

SAMPLE NO. 10
Yellowfin Tuna: Origin, Panama

Body length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
513	154	167	285	320	171
538	161	177	298	330	182
541	164	177	298	330	183
542	163	171	304	332	180
544	160	179	307	332	181
544	161	174	300	329	180
544	163	176	299	333	180
551	163	170	303	338	177
551	167	186	311	338	188
552	163	179	298	336	179
552	164	181	309	340	182
553	162	178	306	343	181
554	162	176	304	343	186
554	168	185	311	342	191
554	168	185	311	331	182
557	160	177	310	338	181
560	162	179	310	340	179
561	173	184	317	350	192
563	168	180	314	351	189
565	165	183	316	347	186
566	166	186	313	347	188
566	169	184	314	351	189
566	169	182	314	352	186
566	169	178	316	345	187
568	169	179	315	344	185
568	170	184	311	344	189
569	167	180	317	351	188
569	169	182	311	346	190
570	170	182	315	349	194
571	170	184	313	345	189
573	171	187	318	353	188
574	168	184	317	353	187
574	170	182	320	353	192
574	174	186	322	354	198
579	169	187	320	351	193
579	170	186	312	352	188
580	170	187	322	357	189
580	173	184	315	356	190
582	167	186	322	355	185
582	174	187	321	364	198
586	170	189	323	356	189
586	178	190	330	363	196
587	172	191	323	352	190
587	173	189	319	355	189
589	173	191	323	368	188
589	174	187	328	367	197
592	173	188	325	356	193
593	175	192	331	367	194
596	177	187	327	371	198
598	177	193	328	367	197
600	179	192	326	363	202
601	174	189	326	362	193
603	180	194	334	372	200
603	181	191	333	360	197
605	180	192	333	374	200
606	180	198	340	372	201

SAMPLE NO. 10
Yellowfin Tuna: Origin, Panama
(continued)

Body length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
607	177	194	332	375	196
608	175	194	332	372	196
609	178	196	333	371	195
609	181	197	339	378	206
610	177	198	334	377	204
611	183	198	335	373	201
612	177	194	337	377	199
612	181	202	340	370	201
614	181	192	339	379	201
615	180	196	337	376	205
615	182	201	344	381	201
616	182	204	343	377	203
617	184	197	338	379	199
622	185	196	346	382	200
623	181	198	345	374	199
624	186	204	345	384	203
626	183	201	348	386	208
627	183	198	342	382	201
628	184	198	340	384	205
628	184	197	343	378	203
630	184	201	344	389	208
631	184	196	345	387	206
632	182	196	353	388	203
633	182	201	345	387	211
636	187	197	346	386	207
638	183	203	354	387	205
639	185	203	350	391	209
641	189	206	351	390	210
642	189	207	352	398	208
642	194	210	354	395	217
643	187	198	349	388	210
645	192	209	359	395	216
647	186	201	351	390	209
647	188	207	356	398	210
650	186	200	355	395	204
651	188	204	357	397	214
653	194	213	363	406	220
654	188	208	351	394	209
656	194	214	361	405	214
656	195	208	364	403	214
659	194	206	365	406	217
662	193	210	366	402	202
663	195	210	365	412	218
664	196	211	368	407	225
668	193	210	361	402	215
672	196	213	368	409	220
674	196	212	372	410	218
683	201	216	375	418	222
690	202	218	375	427	230
692	200	220	381	422	223
693	199	224	377	422	221
694	201	214	376	427	231
695	201	216	375	421	227
699	202	223	379	428	224
699	205	217	384	431	234
701	202	223	380	422	230
703	203	220	385	428	227
711	204	217	386	432	232
713	205	225	384	436	229
727	208	229	396	435	231

SAMPLE NO. 10
Yellowfin Tuna: Origin, Panama (continued)

Body length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
728	210	230	398	442	238
731	215	234	403	449	234
737	210	232	406	446	235
737	216	230	401	445	240
745	215	233	400	449	236
752	217	231	407	454	243
788	222	241	420	466	249
Totals					
[E Y]	22,363	24,296	41,893	46,562	24,948
No.	123	123	123	123	123
[E] X	76,149	76,149	76,149	76,149	76,149
[E] X2	47,526,799	47,526,799	47,526,799	47,526,799	47,526,799
[E] 1/X	0.2002296	0.2002296	0.2002296	0.2002296	0.2002296
[E] 1/X2	0.00032838867	0.00032838867	0.00032838867	0.00032838867	0.00032838867
[E] 1/X Y	36.1539812	39.2813132	67.7070347	75.2328928	40.3296425
[E] X Y	13,944,549	15,148,930	26,130,807	29,050,750	15,557,907
[E] Y2	4,092,471	4,830,420	14,369,035	17,759,428	5,094,982

SAMPLE NO. 11
Yellowfin Tuna: Origin, Clipperton Island

Body Length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
585	174	188	322	357	191
627	184	202	342	376	203
631	184	200	343	383	209
634	187	208	348	384	208
644	190	205	348	384	___
649	191	211	357	393	208
655	192	209	356	398	212
655	195	212	361	390	213
656	189	210	359	402	210
656	194	209	361	400	220
657	186	208	357	396	210
657	193	214	364	402	216
659	192	210	354	394	212
660	189	204	365	403	209
662	194	210	356	397	209
666	192	206	354	397	220
670	196	213	363	401	216
670	198	215	371	405	217
671	193	210	367	406	219
677	194	215	372	411	219
681	195	210	367	405	217
682	200	216	377	406	218
705	197	222	383	424	220
710	204	226	382	424	227
720	206	224	390	432	232
724	206	225	384	434	224
730	211	234	401	443	237
756	217	239	409	451	241
781	223	242	422	470	251
804	229	251	431	478	244
842	234	262	455	492	263
871	245	271	469	519	271
886	244	268	468	518	279
911	256	281	485	539	289
935	256	283	490	548	292
1,064	290	318	570	617	321
1,101	302	324	576	645	342
1,135	298	331	584	655	333
Totals					
[E] Y	8,020	8,786	15,163	16,779	8,722
No.	38	38	38	38	37
[E] X	28,079	28,079	28,079	28,079	27,435
[E] X2	21,434,147	21,434,147	21,434,147	21,434,147	21,019,411
[E] 1/X	0.0528130	0.0528130	0.0528130	0.0528130	0.0512602
[E] 1/X2	0.00007497370	0.00007497370	0.00007497370	0.00007497370	0.000072562508
[E] 1/X Y	10.9019004	11.9390594	20.5686421	22.7573333	11.8069947
[E] X Y	6,089,484	6,673,241	11,541,699	12,774,521	6,652,317
[E] Y2	1,731,818	2,079,574	6,217,215	7,615,589	2,107,300

SAMPLE NO. 12

Yellowfin Tuna: Origin, Costa Rica

Body length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
549	160	176	304	337	180
555	164	177	305	342	182
558	162	178	310	350	186
566	164	183	313	354	184
571	167	181	313	355	188
588	173	187	322	361	199
601	174	194	333	364	195
603	173	193	335	372	195
605	177	195	334	371	197
609	186	199	343	385	211
614	181	201	339	389	213
615	180	198	337	382	201
617	178	192	336	380	203
617	181	200	343	383	203
620	180	199	344	384	203
620	182	202	343	379	198
624	179	201	338	380	201
628	187	199	344	390	214
631	186	201	343	389	207
633	183	199	346	389	204
634	187	208	354	398	208
637	181	197	340	385	204
637	184	204	355	392	204
645	189	205	355	399	214
647	188	207	352	392	214
648	190	206	349	395	212
654	187	208	357	393	208
Totals					
[E] Y	4,823	5,290	9,087	10,190	5,428
No.	27	27	27	27	27
[E] X	16,526	16,526	16,526	16,526	16,526
[E] X2	10,138,404	10,138,404	10,138,404	10,138,404	10,138,404
[E] 1/X	0.04420819819	0.04420819819	0.04420819819	0.04420819819	0.04420819819
[E] 1/X2	0.000072596920	0.000072596920	0.000072596920	0.000072596920	0.000072596920
[E] 1/X Y	7.8804718	8.643407927	14.84909767	16.65185858	8.869891176
[E] X Y	2,958,549	3,245,052	5,573,642	6,250,045	3,329,334
[E] Y2	863,529	1,038,860	3,064,567	3,853,646	1,093,860

SAMPLE NO. 13
Yellowfin Tuna: Origin, White Friars, Mexico

Body length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
641	188	207	354	393	208
646	192	205	357	392	219
653	189	205	362	397	211
658	191	212	363	407	210
660	184	204	362	403	208
660	188	207	357	397	212
663	195	215	372	411	222
665	193	209	365	409	218
666	191	207	359	396	212
666	191	212	364	402	214
669	194	210	366	411	218
670	194	211	363	410	219
671	189	213	360	406	215
673	198	216	372	409	218
677	192	206	368	409	218
682	196	218	373	419	224
683	195	215	367	406	220
684	196	214	376	416	216
686	200	219	371	415	224
690	198	217	375	415	221
691	203	226	380	423	227
694	203	223	381	421	228
695	198	216	376	421	221
696	202	225	384	425	226
700	199	219	380	426	224
704	200	220	379	424	229
704	203	220	382	423	225
707	200	221	379	435	228
707	204	226	387	427	228
708	201	224	384	429	226
709	203	221	381	428	233
710	206	229	384	431	229
711	201	222	389	428	228
711	201	220	386	424	226
712	201	222	387	432	226
713	203	218	381	426	226
713	209	225	385	422	225
715	206	230	393	435	231
716	203	221	391	436	225
716	203	221	387	430	229
716	205	220	390	431	232
716	208	232	397	443	234
716	209	227	390	434	236
717	203	222	382	432	227
719	204	225	389	435	224
721	209	233	399	442	233
723	211	237	397	441	234
725	208	234	396	432	230
726	205	226	395	438	229
726	206	225	391	438	226
727	210	230	396	442	234
728	209	234	401	441	236
729	205	226	397	442	236
729	213	231	396	442	240
731	206	224	394	437	230
732	211	232	400	450	238

SAMPLE NO. 13
Yellowfin Tuna: Origin, White Friars, Mexico
(continued)

Body length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
733	209	228	399	442	237
733	215	228	402	449	236
734	213	233	401	448	238
734	213	234	399	448	241
736	210	229	396	441	234
736	217	231	397	449	240
737	208	229	399	447	235
737	209	231	399	444	235
739	213	232	407	448	242
739	215	232	402	443	238
740	208	233	404	441	237
741	210	228	402	446	233
742	212	233	405	451	235
743	209	227	397	448	234
745	206	229	402	441	233
749	212	240	410	452	238
750	213	235	412	450	239
750	214	234	403	450	237
752	212	233	407	454	235
752	216	234	404	455	236
754	211	223	407	458	239
754	216	238	407	453	240
755	214	238	407	451	237
756	212	232	407	455	238
756	215	236	413	460	238
757	214	232	411	459	245
757	219	244	413	457	241
758	220	239	416	458	244
761	223	241	415	461	253
766	223	246	415	463	250
769	221	244	417	466	247
770	217	234	415	461	240
771	224	242	420	472	254
776	223	239	418	467	245
776	225	247	410	472	254
781	222	242	424	471	250
789	223	247	423	472	247
796	222	245	425	475	244
796	229	250	435	493	256
798	224	250	432	478	253
798	226	249	433	481	252
801	228	246	432	484	258
814	229	253	434	493	261
824	233	259	447	500	261
Totals					
[E] Y	20,772	22,778	39,415	43,896	23,266
No.	100	100	100	100	100
[E] X	72,531	72,531	72,531	72,531	72,531
[E] X2	52,763,147	52,763,147	52,763,147	52,763,147	52,763,147
[E] 1/X	0.1382815944	0.1382815944	0.1382815944	0.1382815944	0.1382815944
[E] 1/X2	0.00019178740	0.00019178740	0.00019178740	0.00019178740	0.00019178740
[E] 1/X Y	28.64664748	31.41311152	54.35465748	60.52814016	32.08798767
[E] X Y	15,106,616	16,565,511	28,666,260	31,928,520	16,919,476
[E] Y2	4,326,094	5,202,504	15,575,945	19,322,616	5,427,136

JAPANESE SAMPLE
Yellowfin Tuna: Origin, Western Pacific

Body length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
1,197	308	339	621	694	346
1,200	300	338	606	687	337
1,048	270	302	544	608	310
1,037	269	298	543	593	299
970	248	278	506	571	288
Totals					
[E] Y	1,395	1,555	2,820	3,153	1,580
No.	5	5	5	5	5
[E] X	5,452	5,452	5,452	5,452	5,452
[E] X2	5,987,382	5,987,382	5,987,382	5,987,382	5,987,382
[E] 1/X	0.0046181	0.0046181	0.0046181	0.0046181	0.0046181
[E] 1/X2	0.0000042954	0.0000042954	0.0000042954	0.0000042954	0.0000042954
[E] 1/X Y	1.2799871	1.4269760	2.5880983	2.8928721	1.4508974
[E] X Y	1,531,149	1,706,565	3,094,560	3,461,113	1,732,865
[E] Y2	391,629	486,457	1,599,698	2,000,959	501,730

HAWAIIAN SAMPLE
Yellowfin Tuna: Origin, Vicinity of Honolulu

Body length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
558	162	175	306	341	181
569	163	182	316	353	182
548	158	177	306	330	175
557	160	177	308	334	177
569	163	180	316	350	184
573	163	181	313	349	182
573	163	184	321	348	181
541	155	180	305	326	171
556	159	180	306	337	177
537	153	173	294	323	175
566	169	186	319	346	183
542	156	172	300	331	174
Totals					
[E] Y	1,924	2,147	3,710	4,068	2,142
No.	12	12	12	12	12
[E] X	6,689	6,689	6,689	6,689	6,689
[E] X2	3,730,403	3,730,403	3,730,403	3,730,403	3,730,403
[E] 1/X	0.0215386	0.0215386	0.0215386	0.0215386	0.0215386
[E] 1/X2	0.00003867862	0.00003867862	0.00003867862	0.00003867862	0.00003867862
[E] 1/X Y	3.4515720	3.8521736	6.6556502	7.2970522	3.8428988
[E] X Y	1,073,018	1,197,219	2,069,055	2,268,971	1,194,524
[E] Y2	308,696	384,333	1,147,716	1,380,202	382,540

PERUVIAN SAMPLE
Yellowfin Tuna: Origin, Coast of Peru

Body length	*Head length*	*1st dorsal insertion*	*2d dorsal insertion*	*Anal insertion*	*Ventral insertion*
901	245	274	479	542	276
881	242	269	473	525	271
818	233	257	453	512	258
863	246	272	465	524	281
896	249	281	491	531	279
878	248	272	469	542	278
Totals					
[E] Y	1,463	1,625	2,830	3,176	1,643
No.	6	6	6	6	6
[E] X	5,237	5,237	5,237	5,237	5,237
[E] X2	4,575,555	4,575,555	4,575,555	4,575,555	4,575,555
[E] 1/X	0.0068813	0.0068813	0.0068813	0.0068813	0.0068813
[E] 1/X2	0.0000079004	0.0000079004	0.0000079004	0.0000079004	0.0000079004
[E] 1/X Y	1.6768833	1.8622355	3.2433285	3.6405592	1.8829781
[E] X Y	1,277,687	1,419,417	2,471,859	2,773,547	1,435,042
[E] Y2	356,899	440,415	1,335,646	1,681,834	450,267

APPENDIX C—ALBACORE
Tabulation of original measurements by sample. All measurements are in millimeters

APPENDIX C—ALBACORE
Tabulation of original measurements by sample. All measurements are in millimeters

ALBACORE: 1941 LOCAL SAMPLE, ORIGIN, COAST OF CALIFORNIA, OREGON AND WASHINGTON

Body length	Head length	Second dorsal insertion	Anal insertion	Ventral insertion	Body depth	Dorsal-ventral distance	Dorsal-anal distance	First dorsal base	Pectoral length	Height of first dorsal	Second dorsal base	Anal base	Diameter of iris	Length of body cavity
673	206	400	442	232	174	165	269	186	----------	75	76	58	35	255
714	209	422	453	238	187	172	280	197	315	79	69	57	37	263
602	175	358	400	210	161	149	250	169	226	65	59	48	29	235
674	201	407	440	228	183	170	276	190	276	----------	62	60	35	260
646	196	385	425	227	169	159	260	170	264	74	71	54	35	239
623	183	373	409	212	168	160	253	175	237	69	69	53	33	235
586	175	353	381	200	149	142	229	160	218	56	58	46	32	224
697	208	419	452	237	177	171	273	183	297	----------	58	60	39	265
595	175	354	387	198	153	142	240	166	235	66	61	51	32	225
540	163	323	357	184	142	131	221	151	180	----------	65	50	30	206
844	244	494	537	287	216	203	331	230	344	95	96	74	39	313
815	234	480	518	268	209	196	319	224	323	85	88	69	38	----------
823	240	473	526	291	210	193	319	220	333	94	86	68	40	----------
804	233	477	521	274	197	188	316	218	321	84	87	65	38	----------
794	226	465	509	279	205	193	311	216	335	79	82	70	37	----------
694	200	407	451	249	176	167	272	191	269	77	74	59	34	----------
764	228	447	495	265	204	190	303	203	313	89	85	65	38	----------
808	236	465	508	273	208	193	312	213	318	82	97	76	37	----------
805	232	470	512	265	209	197	313	212	310	82	85	69	38	----------
764	227	446	490	275	193	184	291	201	331	90	85	67	37	----------
812	228	466	508	271	199	186	308	214	350	90	99	71	37	----------
762	226	444	491	----------	192	185	290	199	331	88	71	63	38	----------
767	236	446	510	----------	187	182	295	201	324	82	85	69	37	----------
900	262	514	562	297	226	207	344	234	379	101	104	78	40	----------
841	242	498	537	286	210	188	330	237	340	90	97	72	37	----------
768	225	456	496	274	190	178	296	210	321	85	90	69	39	----------
840	237	481	529	281	206	197	324	227	347	93	100	73	38	----------
769	226	448	492	268	198	184	296	201	314	85	87	67	36	----------
770	226	451	490	260	193	184	297	202	333	85	88	66	37	----------
764	223	448	492	262	195	182	298	200	333	82	78	60	37	----------
533	157	317	348	185	131	126	209	147	183	53	48	46	29	----------
750	229	441	483	263	193	178	296	201	315	82	85	65	38	----------
808	236	468	515	275	202	190	312	212	335	87	90	70	39	----------
821	239	473	518	280	210	197	318	218	344	87	91	72	39	----------
812	238	463	517	286	212	198	314	203	359	95	84	68	37	----------
794	228	455	497	268	201	185	304	212	321	89	86	68	37	----------
553	163	327	359	191	141	134	220	150	179	60	65	49	29	----------
862	251	500	546	299	225	211	339	234	371	91	103	79	40	300
875	256	511	559	307	226	210	343	232	354	101	93	71	39	310
852	243	491	538	285	220	202	336	230	374	94	100	78	40	299
873	251	504	560	318	229	214	338	232	363	98	101	77	40	303
885	251	516	568	309	227	211	344	239	366	100	93	73	40	313

ALBACORE: 1942 LOCAL SAMPLE, ORIGIN, SOUTHERN CALIFORNIA

Body length	Head length	Second dorsal insertion	Anal insertion	Ventral insertion	Body depth	Dorsal-ventral distance	Dorsal-anal distance	First dorsal base	Pectoral length	Height of first dorsal	Second dorsal base	Anal base	Diameter of iris
782	229	458	505	261	203	187	310	213	355	80	74	62	38
675	197	399	434	228	178	166	264	179	269	76	74	57	35
672	202	393	433	235	171	165	255	172	255	73	82	57	33
759	220	446	485	250	200	186	301	204	302		86	65	36
660	192	378	420	223	168	158	253	167	262	72	75	56	34
784	225	456	493	257	196	185	307	213	326	88	99	70	36
848	240	487	536	276	208	196	326	223	355	90	82	78	39
768	218	447	487	251	201	184	302	207	305	83	87	64	35
632	188	382	415	217	160	155	247	169	269	72	70	51	33
692	205	414	448	241	177	172	270	188	258	76	78	58	34
639	190	377	413	217	173	163	258	173	251	72	72	54	34
621	187	373	395	209	158	147	241	167	242	70	69	51	32
767	226	446	489	258	193	184	300	207	310	84	85	62	37
637	186	370	413	217	160	152	246	167	230	72	69	58	33
638	188	369	420	220	164	153	251	164	263	70	60	56	33
683	203	399	440	237	180	167	264	179	269	76	74	55	34
613	179	364	393	206	158	151	241	168	214	68	70	49	31
623	184	371	396	208	166	157	236	157	251		60	56	34
616	184	376	386	207	158	153	236	168	246	69	71	50	33
577	171	343	372	195	147	139	230	159	199	63	64	47	30
651	188	385	418	217	166	156	253	174	256	64	73	55	33
641	190	377	412	212	166	149	253	168	242	67	73	54	32
661	193	393	425	223	174	162	257	181	255	76	77	58	32
655	194	388	424	221	171	162	255	171	256	73	74	53	33
589	173	343	388	199	146	141	234	156	212	62	70	49	31
591	173	345	379	198	154	146	230	154	201	61	68	53	31
573	168	344	370	191	147	145	227	155	203	66	67	45	30
562	164	332	364	188	140	138	218	151	201	66	60	46	30
567	165	337	368	193	140	137	221	152	207	60	61	45	30
821	235	482	522	269	217	199	323	221	345	97	87	66	38
795	232	460	517	268	199	188	306	202	347	89	87	67	38
831	239	486	539	278	219	202	325	225	339	87	96	71	39
806	230	470	526	263	204	190	320	219	322	88	93	71	36
844	243	494	531	277	221	205	326	224	351	88	96	70	40
792	229	462	507	261	201	190	310	212	281	81	87	66	38
810	237	476	521	274	212	201	323	222	360	94	86	67	40
797	237	464	512	276	200	190	303	206	353	84	88	67	39
805	234	468	514	274	205	198	312	213	364	92	85	65	36
807	233	470	520	269	218	201	320	214	315	96	80	64	37
856	243	496	538	282	211	203	328	227	358	90	98	70	39
763	219	448	490	255	192	183	300	207	300	91	81	59	35
766	218	446	482	251	197	183	299	206	311	85	88	67	37

777	226	465	499	259	196	188	299	213	329	87	73	55	38
600	173	353	388	197	146	141	232	159	198	69	71	49	30
606	178	362	400	201	158	147	240	162	241	70	68	50	31
601	174	354	386	200	149	140	230	159	209	66	70	50	29
605	178	357	392	204	147	137	233	161	227	68	68	55	31
606	175	355	391	201	156	149	236	158	231	64	72	51	31
870	245	504	549	284	221	207	333	231	355	98	103	71	38
871	250	515	560	291	225	216	345	237	347	93	99	74	41
744	217	443	481	261	200	191	291	201	294	90	86	64	37
823	238	484	527	271	211	201	320	217	341	92	96	69	39
747	216	439	476	250	189	179	291	201	295	83	88	64	37
717	211	421	460	243	185	177	281	193	301	80	83	59	35
728	215	428	469	254	193	182	285	189	286	79	83	63	35
709	202	418	462	237	183	175	278	191	287	77	73	59	35
886	251	510	564	298	230	209	350	238	400	93	100	72	40
903	251	511	566	295	222	211	353	245	375	104	106	83	41
855	243	499	537	279	224	211	338	229	338	93	107	73	38
831	239	486	534	287	222	207	325	217	333	95	102	75	38
933	268	536	589	309	235	218	361	247	362	99	110	78	41
873	243	500	548	299	217	205	337	232	373	96	110	79	38
833	242	483	532	280	206	192	321	220	354	90	91	70	39
851	240	489	526	279	217	203	333	230	362	89	97	------	38
891	252	518	562	293	230	214	344	240	374	101	98	76	39
854	239	497	535	276	226	207	337	228	359	91	100	75	38

JAPANESE AND HAWAIIAN ALBACORE

I. JAPANESE SAMPLE: Origin, Western Pacific:

Body length	Head length	Second dorsal insertion	Anal insertion	Ventral insertion	Body depth	Dorsal-ventral distance	Dorsal-anal distance	First dorsal base	Pectoral length	Height of first dorsal	Second dorsal base	Anal base	Diameter of iris	Length of body cavity
848	241	497	550	281	224	201	336	232	393	93	95	72	40	325
825	241	501	540	274	224	207	332	226	375	92	92	72	40	320
839	236	489	543	281	221	205	339	230	351	99	93	70	40	318
798	234	487	523	267	221	202	324	226	363	88	83	69	40	314
820	233	499	533	273	222	214	339	234	337	95	74	59	40	348
882	------------	------------	------------	------------	235	221	356	236	398	102	78	75	------------	347
906	250	516	580	288	239	220	359	237	391	104	87	76	42	357
872	247	511	552	284	238	218	348	236	379	102	92	70	41	328
831	230	496	537	270	195	188	318	226	349	97	------------	70	42	329

II. HAWAIIAN SAMPLE: Origin, Vicinity of Honolulu:

Body length	Head length	Second dorsal insertion	Anal insertion	Ventral insertion	Body depth	Dorsal-ventral distance	Dorsal-anal distance	First dorsal base	Pectoral length	Height of first dorsal	Second dorsal base	Anal base	Diameter of iris	Length of body cavity
987	280	574	623	320	260	234	379	255	444	------------	116	83	45	370
1,006	285	588	645	321	270	243	399	270	439	------------	114	87	47	387
1,002	288	586	639	333	265	244	391	262	452	------------	110	81	46	382

APPENDIX D

APPENDIX D

Albacore: Tabulation by Sample of the Sums and Products of Variates Used in the Calculation of the Several Regressions

Regression (BL = Body Length) (Lg = Length) (Ht = Height)	ΣY	ΣY^2	ΣXY	$\Sigma \frac{1}{X} Y$	ΣX	ΣX^2	$\Sigma \frac{1}{X}$	$\Sigma \left(\frac{1}{X}\right)^2$	N
Head Lg on BL—									
1. Local 1941	9,264	2,073,752	7,096,963	12.3006632	31,676	24,298,288	.0567916	.00007851870788	42
2. Local 1942	14,017	3,027,305	10,464,209	19.1543569	48,383	36,183,213	.0919152	.0001307078730	66
3. Japan	1,912	457,312	1,612,003	2.2709522	6,739	5,684,635	.0095098	.00001131946076	8
2d Dor. Ins. on BL—									
1. Local 1941	18,536	8,300,518	14,200,171	24.6134961	31,676	24,298,288	.0567916	.00007851870788	42
2. Local 1942	28,341	12,388,869	21,170,479	38.7056436	48,383	36,183,213	.0919152	.0001307078730	66
3. Japan	3,996	1,996,694	3,368,122	4.7474158	6,739	5,684,635	.0095098	.00001131946076	8
Anal Ins. on BL—									
1. Local 1941	20,328	9,982,316	15,572,307	26.9945587	31,676	24,298,288	.0567916	.00007851870788	42
2. Local 1942	30,973	14,799,499	23,138,638	42.2960463	48,383	36,183,213	.0919152	.0001307078730	66
3. Japan	4,358	2,376,040	3,674,962	5.1751239	6,739	5,684,635	.0095098	.00001131946076	8
Ventral Ins. on BL—									
1. Local 1941	10,357	2,731,201	7,945,329	13.7431188	30,147	23,129,355	.0541755	.00007509668215	40
2. Local 1942	16,200	4,050,358	12,103,602	22.1189124	48,383	36,183,213	.0919152	.0001307078730	66
3. Japan	2,218	615,316	1,869,969	2.6343993	6,739	5,684,635	.0095098	.00001131946076	8
Body Depth on BL—									
1. Local 1941	8,103	1,588,835	6,211,513	10.7520946	31,676	24,298,288	.0567916	.00007851870788	42
2. Local 1942	12,407	2,381,137	9,279,061	16.9213182	48,383	36,183,213	.0919152	.0001307078730	66
3. Japan	2,019	454,333	1,711,954	2.3845778	7,621	6,462,559	.0106436	.00001260496320	9
Dor-vent. Dist. on BL—									
1. Local 1941	7,594	1,393,954	5,818,010	10.0826323	31,676	24,298,288	.0567916	.00007851870788	42
2. Local 1942	11,696	2,112,108	8,739,375	15.9674209	48,383	36,183,213	.0919152	.0001307078730	66
3. Japan	1,876	391,984	1,590,460	2.2160100	7,621	6,462,559	.0106436	.00001260496320	9
Dor-anal Dist. on BL—									
1. Local 1941	12,389	3,707,573	9,489,853	16.4546535	31,676	24,298,288	.0567916	.00007851870788	42
2. Local 1942	18,874	5,506,734	14,114,515	25.7469261	48,383	36,183,213	.0919152	.0001307078730	66
3. Japan	3,051	1,035,783	2,586,741	3.6037620	7,621	6,462,559	.0106436	.00001260496320	9
1st Dor. Base on BL—									
1. Local 1941	8,510	1,750,210	6,519,157	11.3020561	31,676	24,298,288	.0567916	.00007851870788	42
2. Local 1942	12,902	2,575,604	9,651,995	17.5940387	48,383	36,183,213	.0919152	.0001307078730	66
3. Japan	2,083	482,269	1,764,856	2.4620002	7,621	6,462,559	.0106436	.00001260496320	9
Pectoral on BL—									
1. Local 1941	12,681	4,037,533	9,797,410	16.6717142	31,003	23,845,359	.0553057	.00007631080907	41
2. Local 1942	19,381	5,900,087	14,580,311	26.2656070	48,383	36,183,213	.0919152	.0001307078730	66
3. Japan	3,336	1,240,340	2,828,931	3.9396288	7,621	6,462,559	.0106436	.00001260496320	9
Ht 1st Dor. on BL—									
1. Local 1941	3,259	277,657	2,528,327	4.2641634	29,765	23,066,603	.0520213	.00007082944449	39
2. Local 1942	5,178	427,670	3,877,643	7.0547887	47,001	35,219,003	.0889926	.0001263957207	64
3. Japan	872	84,716	739,688	1.0294484	7,621	6,462,559	.0106436	.00001260496320	9

Lg 2d Dor. Base on BL—									
1. Local 1941	3,451	292,031	2,656,275	4.5591761	31,676	24,298,288	.0567916	.00007851870788	42
2. Local 1942	5,430	458,436	4,064,517	7.4017455	48,383	36,183,213	.0919152	.0001307078730	66
3. Japan	694	60,620	589,243	0.8186068	6,790	5,771,998	.0094402	.00001115679164	8
Lg Anal Base on BL—									
1. Local 1941	2,723	180,049	2,089,912	3.6086477	31,676	24,298,288	.0567916	.00007851870788	42
2. Local 1942	3,998	251,828	2,985,052	5.4627400	47,532	35,459,012	.0907401	.0001293270130	65
3. Japan	633	44,711	536,844	0.7474588	7,621	6,462,559	.0106436	.00001260496320	9
Iris on Head Lg—									
1. Local 1941	1,536	56,580	342,082	7.0040427	9,264	2,073,752	.1937093	.0009110883544	42
2. Local 1942	2,335	83,335	501,740	11.0534853	14,017	3,027,305	.3162755	.001543110469	66
3. Japan	325	13,209	77,687	1.3606562	1,912	457,312	.0334978	.0001403666283	8
Body Cavity on BL—									
1. Local 1941	4,245	1,146,075	3,128,284	5.9175066	11,541	8,551,943	.0227951	.00003334985993	16
2. Local 1942									
3. Japan	2,986	992,532	2,531,245	3.5275498	7,621	6,462,559	.0106436	.00001260496320	9

APPENDIX E

APPENDIX E

Estimates of the Parameters of the Population of Local Albacore

Regression	"a"	"b"	"c"	Mean square
Head length on body length	170.491	.161	—53,950.150	11.8198
Second dorsal insertion on body length	152.393	.461	—43,794.407	21.5534
Anal insertion on body length	162.061	.509	—46,772.867	29.7501
Ventral insertion on body length	118.776	.252	—39,761.766	42.7586
Body depth on body length	101.151	.184	—34,752.312	22.9942
Dorsal-ventral distance on body length	119.466	.151	—38,554.627	18.2014
Dorsal-anal distance on body length	—23.277	.401	11,344.813	18.6863
Length first dorsal base on body length	—67.852	.313	25,024.628	19.1635
Length of pectoral on body length	474.153	.132	—198,008.727	187.7281
Height of first dorsal fin on body length	53.820	.073	—19,048.868	12.4647
Length second dorsal base on body length	—133.406	.208	44,374.753	32.2773
Length of anal base on body length	—37.081	.113	12,044.907	8.1936
Diameter of iris on head length	40.366	.044	—2,966.946	0.9365
Length of body cavity on body length	331.116	.102	—97,663.112	27.2403