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RELATIONSHIP BETWEEN LENGTH AND WEIGHT OF YELLOWFIN AND BIGEYE TUNA FROM THE EASTERN ATLANTIC OCEAN

by

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SUMMARY

Yellowfin tuna and bigeye tuna are the major species of the Korean Atlantic longline catch. When the fishermen are asked to report catch and biological data on both species, they tend to report GG-weight (gilled and gutted) catch and curved length along the fish body surface. The reason is that they weigh the fish after GG treatment on board, and measure the length with a folding ruler. Therefore, any proper conversion factors are necessary in all cases to make round weight and straight length data. The paper provides these kind of conversion factors as well as relation equations between weight and length.

RESUME

L'albacore et le thon obèse sont les principales espèces pêchées par les palangres coréennes dans l'Atlantique. Lorsque les pêcheurs sont priés de fournir des données de capture et des données biologiques sur ces deux espèces, ils le font de préférence en termes de poids éviscéré (GG) pour la prise et de longueur courbe (en suivant la surface du corps) pour le poisson. La raison en est qu'ils présentent le poisson à bord une fois traité (GG), et prennent les mensurations avec un mètre pliant. Des facteurs de conversion adéquats sont donc nécessaire dans tous les cas pour établir des données en poids vif et en longueur projetée. Le présent document traite de ces facteurs, ainsi que des équations sur la relation poids-longueur.

RESUMEN

El rabil y el patudo son las principales especies capturadas por la pesca de palangre coreana en el Atlántico. Cuando se pide información a los pescadores sobre la captura y datos biológicos de ambas especies, suelen informar sobre el peso del pescado sin visceras ni agallas (GG), y sobre la talla, siguiendo la curva de la superficie del cuerpo del pez. Esto de debe a que pesan el pescado después de su manipulación (GG) a bordo, y lo miden con una regla plegable. Por lo tanto, se necesitan factores adecuados de conversión para establecer datos de peso en vivo y de longitud proyectada. El documento proporciona esta clase de factores de conversión, así como ecuaciones de relación peso-talla.

Korean tuna fishery is carried out mainly by longliners. Their main catch in the tropical area is yellowfin tuna and occasionally bigeye tuna, too. Due to the peculiar characteristcs of longline gear, they catch large, but a few fish in a set which lasts a day. Consequently, longline fishermen have enough time to handle their catch by means of gilled, gutted and fin-off (so-called GG) treatment before storage. They can get more profit in a cruise through this treatment because they can keep better quality, and stock as many fish as possible in the fish-hold. After GG treatment and cleaning with sea water, each fish is weighed, and the weight is recorded in their "fishing logbook" by species. The weight figures are summed up to give the total catch amount which is reported without conversion to the fishery administrative office via their company. Therefore, it is indispensable to find a proper conversion factor which can correct the submitted GG weight figures into the live weight statistics.

On the other hand, biological data is also necessary for fishery study. There are two methods which are popularly used for the fish measurement; one is fork length and another predorsal length measurement. It may be needless to say that the straight distance between two points should be obtained rather than the curved distance, whatever the chosen length may be. However, it is not practical to ask fishermen to measure a straight length without giving them a proper tool.

ICCAT (1972) suggests two kinds of tools for fish measurement: a measuring board and calipers. But both tools have several disadvantages as regards handling, as will be pointed out in the Discussion section. In this case, it is sometimes inevitable to ask fishermen to measure fish with a folding ruler, which gives curved length data. This paper gives conversion formulae to correct from curved length to straight one.

Materials and methods

The data analized in this paper were measured from a Korean tuna longliner, St. Maarten No. 28, during the period from 21 to 27 May, 1975 in the fishing area of 02°N, 007°W near Abidjan, Ivory Coast. Among the catch, 79 (Range of fork length : 104.5-163.0 cm) fish of yellowfin tuna and 39 (Range of fork length : 86.2-179.2 cm) fish of bigeye tuna were selected randomly to measure weights and lengths without checking their sex and maturing stages. For the measurement of weight a beam balance was used, which has 1 kg unit, so that the weight is measured to the nearest kilogramme. It must be noted that both live and GG weights are measured on a fresh fish condition; in other words, right after the fish is hauled up on the deck. Fish may reduce their weight after being frozen, as fishermen suggest.

It is necessary to illustrate how to prepare GG fish. After both sides of the gill cover are opened, the gill content is removed without harming the gill cover. The gut is removed through a knife-dissected abdominal opening. In case of fin-off, pectoral and anal fins are cut off from the insertion with a knife, 2nd dorsal fin and both lobes of caudal fin are removed with a chopper. The residual fins, however, remain because the 1st dorsal fin always slips into the back when the fish is on the deck, and the ventral fins are too small to handle. The body of the fish is then cleaned. The insides of the gill and body cavity, as well as body surface, should be well washed with sea water in order to remove all the blood and small particles which may remain. GG weight is measured at this stage. Both fork and predorsal lengths were measured respectively with two kind of tools : calipers and a wood-made folding ruler, both tools are graduated in millimetres. Calipers measure a straight distance. However, the ruler gives a curved length because it goes along the curved body surface of the fish. Consequently, the later length is always longer than the former. Fig. 1 shows the cut-off parts of fish for GG treatment and length measurement positions. Six items were measured for each sampled fish, tabulating each item with its symbol and definition as follows:

Weight (W) ... Fish weight in the nearest kilogrammes.

Wl ... Round live weight in fresh condition

Wg ... Weight after gilled, gutted and fin-off; so-called GG weight

Fork length (Lf) ... Distance from the tip of the upper jaw to the posterior end of the shortest caudal ray, read to millimetres

sLf ... Straight fork length measured by calipers

cLf ... Curved fork length measured by a folding ruler

Predorsal length (Ld) ... Distance from the tip of the upper jaw to the anterior base of the first dorsal fin, read to mm.

sLd ... Straight predorsal length measured by calipers

cLd ... Curved predorsal length measured by a folding ruler

Results

1. GG weight (Wg) - live weight (Wl) relationship

A linear regression equation is employed to show the relationship between GG weight and live weight. The resultant regression equation and correlation coefficient (r) are computed as follows:

Yellowfin : $Wl = 1.4827 + 1.0837\ Wg$ $(r = 0.99737)$

Bigeye : $Wl = 1.0352 + 1.1097\ Wg$ $(r = 0.99672)$

Some GG weights and their corresponding calculated values are given.

GG weight in kg (Wg)		10	30	50	70	90	110	130	150
Calculated live weight in kg (Wl)	Yellowfin	12.3	34.0	55.7	77.3	99.0	120.7	142.4	164.0
	Bigeye	12.1	34.3	56.5	78.7	100.9	123.1	145.3	167.5

Practically, it is very necessary to give the ratio of GG weight to live weight particularly for converting GG weight catch to live weight catch statistics. The resultant ratio is calculated as follows:

Yellowfin : $Wl = 1.128\ Wg$

Bigeye : $Wl = 1.130\ Wg$

2. Relationship between curved fork length (cLf) and straight fork length (sLf)

The straight regression equation and corresponding correlation coefficient of each species is computed as follows:

Yellowfin : sLf = 1.1483 + 0.9491 cLf (r = 0.99631)

Bigeye : sLf = 2.5293 + 0.9344 cLf (r = 0.99707)

Curved fork length in cm (cLf)		70	85	100	115	130	145	160
Calculated straight fork length in cm (sLf)	Yellowfin	67.6	81.8	96.1	110.3	124.5	138.8	153.0
	Bigeye	67.9	82.0	96.0	110.0	124.0	138.0	152.0

3. Relationship between curved predorsal length (cLd) and straight predorsal length (sLd)

Yellowfin : sLd = 0.1280 + 0.9589 cLd (r = 0.99035)

Bigeye : sLd = 0.1353 + 0.9638 cLd (r = 0.99696)

Curved predorsal length in cm (cLd)		20	24	28	32	36	40	44	48
Calculated straight predorsal length in cm (sLd)	Yellowfin	19.3	23.1	27.0	30.8	34.6	38.5	42.3	46.2
	Bigeye	19.4	23.3	27.1	31.0	34.8	38.7	42.5	46.4

4. Fork length (sLf) - live weight (Wl) relationship

Allometric formula, $Wl = a\ (sLf)^b$, is employed to show the relationship between fork length and live weight. The formula is then transformed into log-log form, $\log Wl = \log a + b \log sLf$, to make a regression line.

Yellowfin : log Wl = -5.45428 + 3.34320 log sLf (r = 0.99123)

Bigeye : log Wl = -5.35125 + 3.31768 log sLf (r = 0.98933)

Fork length in cm (sLf)		70	85	100	115	130	145	160	175
Calculated live weight in kg (Wl)	Yellowfin	5.2	9.9	17.1	27.2	41.0	59.1	82.1	110.8
	Bigeye	5.9	11.2	19.2	30.6	45.9	66.0	91.5	123.2

5. Predorsal length (sLd) - live weight (Wl) relationship

Transformed allometric formula is employed, and the results are given by following equations:

Yellowfin : log Wl = -4.44830 + 3.92307 log sLd (r = 0.98251)

Bigeye : log Wl = -3.97157 + 3.57607 log sLd (r = 0.97800)

Predorsal length in cm (sLd)		20	24	28	32	36	40	44	48
Calculated live weight in kg (Wl)	Yellowfin	4.5	9.3	16.9	28.6	45.4	68.7	99.8	140.4
	Bigeye	4.8	9.2	16.0	25.8	39.3	57.2	80.4	109.8

6. Predorsal length (sLd) - fork length (sLf) relationship

Two formulae, transformed allometry and linear regression line are employed for each of two fish species, respectively.

Yellowfin : $\log sLf = 0.31834 + 1.16485 \log sLd$ $(r = 0.98394)$

$sLf = -21.2026 + 4.3155\ sLd$ $(r = 0.98493)$

Bigeye : $\log sLf = 0.42772 + 1.07043 \log sLd$ $(r = 0.98171)$

$sLf = -11.6934 + 3.7686\ sLd$ $(r = 0.98103)$

Predorsal length in cm (sLd)			20	24	28	32	36	40	44	48
Calculated fork length in cm (sLf)	Y.F.	Allometric curve	68.2	84.3	100.9	117.9	135.3	152.9	170.9	189.1
		Linear regression	65.1	82.4	99.6	116.9	134.2	151.4	168.7	185.9
	B.E.	Allometric curve	66.1	80.4	94.8	109.4	124.1	138.9	153.8	168.8
		Linear regression	63.7	78.8	93.8	108.9	124.0	139.1	154.1	169.2

Discussion

Morita (1973) found the fact that the conversion factor of GG weight to live weight by size of fish becomes lower as size in length gets larger, giving the following equation which is derived from the data of the Pacific and Atlantic Oceans combined.

Yellowfin : $\log r = 0.5707 - 0.2445 \log L$

Bigeye : $\log r = 0.0741 - 0.0050 \log L$

where r = Conversion factor of GG weight to live weight at the fork length L cm.

L = Fork length in cm.

This phenomenon became evident from the present data, even though the value shows some discrepancy. However, in case of converting GG-weight catch amount to live-weight statistics of a particular year, only a single conversion factor can be used, which is calculated with mean length of the year under study. Here, the author calculates a typical conversion factor which can be applied for longline catch statistics regardless year of which is considered.

Lenarz and Sakagawa (1973) give yearly mean fork lengths of the Atlantic yellowfin tuna caught by longline for the years 1965 to 1970, from which overall mean fork length is calculated to be more or less

130 cm. Honma (1974) gives the data of Japanese Atlantic yellowfin catch in number and weight caught by longline for the years 1957 to 1971, from which the overall mean weight is calculated approximately 42 kg, which is equivalent to about 130 cm in fork length. The conversion factor of fork length 130 cm of yellowfin tuna is 1.13 from the above equation.

On the other hand, the mean fork length of Atlantic bigeye tuna caught by longline can be derived from Kume's (1974) data. The data show yearly total catch in number and weight of Japanese longline catch in the Atlantic Ocean for the years 1957 to 1971. The overall mean weight is about 47 kg, which is equivalent to about 130 cm of fork length. Therefore, the conversion factor is calculated to be 1.16. When comparing the above with this paper's result, yellowfin tuna has the same conversion factor (1.13). But for bigeye tuna, Morita's conversion factor (1.16) is larger than the value presented in this paper (1.13). Disagreement is also found in other relations. Various authors have published equations illustrating relations between length and weight. Table 1 summarizes those equations expressed by symbols adopted in the present report.

Table 1. Length-weight relations presented by various authors.

Relation	Species	Regression equation	Source
GG weight-live w.	Y.F.	$Wl = 1.13\ Wg$ *	Morita (1973)
	B.E.	$Wl = 1.16\ Wg$ *	"
Fork l.-live w.	Y.F.	$Wl = 0.0000214\ sLf^{2.9736}$	Lenarz (1971)
	"	$\log Wl = -4.77958 + 3.02655 \log sLf$	Morita (1973)
	B.E.	$\log Wl = -4.60106 + 2.97324 \log sLf$	"
Predorsal-live w.	Y.F.	$Wl = 0.0003272\ sLd^{3.276762}$	Fonteneau & Caveriviere (1973)
Predorsal-fork l.	Y.F.	$\sqrt{sLf} = 3.6378 + 0.2118\ sLd$	Poinsard (1969)
	"	$\log sLf = 0.273 + 1.175 \log sLd$	Lenarz (1971)

* Morita's equation of GG weight - live weight is simplified by the author to give a single conversion factor.

There appear some discrepancies between above equations and the results of this paper. It might be attributed to the fact that the raw data used in this paper are collected from a limited area and time, as well as the limitation of the number of samples. Further careful reexamination with large data collected from expanded time and area might be necessary. It is also important that all the items of measurement on weights and lengths should be measured simultaneously from the same sampled specimens.

Korea is located far from the Atlantic Ocean. Furthermore, as the landing bases are so scattered geographically (Indeed, Korea has 9 bases along the Atlantic Ocean in 1975), so we have to ask fishermen to collect biological data for us. ICCAT's Field Manual (1972) presents two kinds of tools for the fish measurement: a measuring board and calipers. But several disadvantages are found in using a measuring board especially for tuna longliners. As pointed out earlier, because they often catch large fish, the measuring board should be large, at least 2 m in length. This makes it difficult to handle and to store safely. Another disadvantage is that the data will be biased because large fish are not measured. In fact, if the fish is over 70 kg in weight, it is very difficult to haul; hence, difficult to put the fish on the measuring board. Therefore, fishermen may try to skip weighing the large fish, which gives some biased data since small ones may be over-represented.

In case of using calipers, even though the tool is much better than a measuring board for longliners, there still exists some problems. Because calipers are made of wood, after using for several hours, the water swells the wood, and so it is very difficult to move up and down the sliding part of the calipers. If you plane the stick part, the sliding part is too loose. Furthermore, a 2m-long stick hampers the fishermen's activity who work in a very limited area. Also it is easily broken. To overcome these difficulties, and for convenience as well as quick measurement, the fishermen tend to use a folding ruler when they are asked to measure length of fish. Except discrepancy due to measuring a curved length, the ruler might be the most convenient measuring tool.

References

Fonteneau, A. et A. Caveriviere (1973) Application des modeles de Schaefer et derives aux populations d'albacore (Thunnus albacares) de l'Atlantique. Doc. pres. ICCAT meeting, Paris, 1973.

Honma, M. (1974) Overall fishing intensity and catch by length class of yellowfin tuna in Japanese Atlantic longline fishery, 1956-1971. ICCAT Coll. Vol. of Sci. Pap. Vol. II. p. 1-9.

Kume, S. (1974) Overall fishing intensity of Japanese Atlantic longline fishery for bigeye tuna, 1956-1971. ICCAT Coll. Vol. of Sci. Pap. Vol. II. p. 145-149.

Le Guen, J. C. and G. T. Sakagawa (1973) Apparent growth of yellowfin tuna from the eastern Atlantic Ocean. Fishery Bulletin, Vol. 71, No. 1. p. 175-187.

Lenarz, W. H. (1971) Length-weight relations for five Atlantic scombrids. SCRS/71/20. 9p. ICCAT.

Lenarz, W. H. and G. T. Sakagawa (1973) A review of the yellowfin tuna fishery of the Atlantic Ocean. ICCAT Coll. Vol. of Sci. Pap. Vol. I. p. 1-58.

Morita, Y. (1973) Conversion factors for estimating live weight from gilled-and-gutted weight of bigeye and yellowfin tunas. Far Seas Fish. Res. Lab. Bulletin 9, p. 109-121.

Poinsard, F. (1969) Relations entre longueur prédorsale, longueur à la fourche et poids des albacores Thunnus albacares (Bonnaterre) pêchés dans le sud du Golfe du Guinée. Cah. O.R.S.T.O.M. Sér. Oceanogr. 7(2):89-94.

ICCAT (1972) Field manual for statistics and sampling of Atlantic tunas and tuna-like fishes.

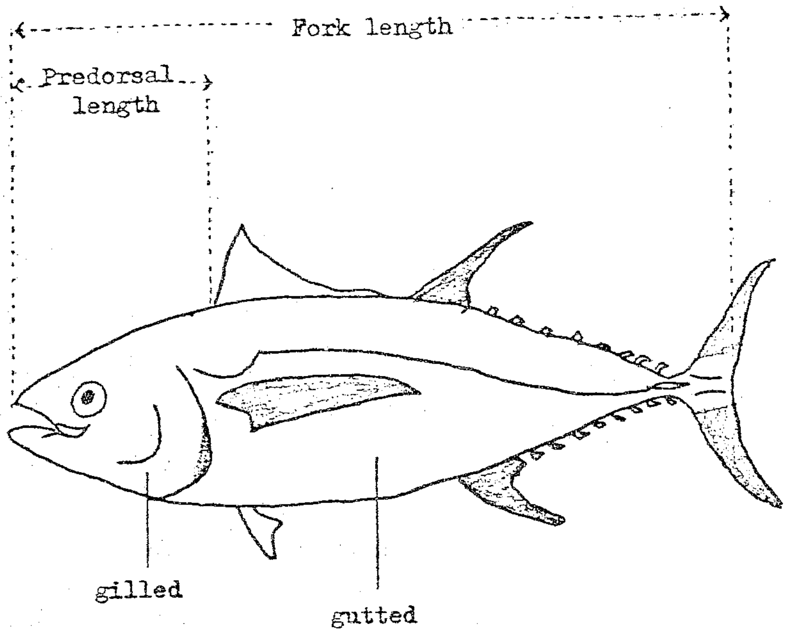

Fig. 1. Cut-off parts of GG treatment for yellowfin and bigeye tunas are illustrated in black areas. Position of length measurement is also indicated.