Col.Vol.Sci.Pap. ICCAT, 40 (2) : 371-374 (1993)

APPROPRIATE WEIGHT-LENGTH RELATIONS FOR CONVERTING CATCHES IN WEIGHT TO CATCHES IN NUMBERS FOR NORTH ATLANTIC ALBACORE STOCKS

Parrack, N. C.
U.S. Department of Commerce, NOAA, NMFS, 75 Virginia Beach Drive, Miami, Florida, USA

SUMMARY

Conversion formulae necessary for converting length to weight for north Atlantic albacore exist and the merits of most have been discussed. This paper summarizes the historical formulae available to estimate weight from length. This transformation is important in the estimation of total numbers caught from reported landings data. The adequacy of certain equations for accurately transforming catches in weight to catches in numbers is discussed and specific concerns raised by the 1989 Albacore Workshop as to the introduction of biases into catch estimations from continuing the use of the Beardsley (1971) weight-length curve are reviewed. The adequacy of recommending a single length-weight relation or multiple equations is judged. Selection is based on the temporal coverage of the sample data, the fishery/gear coverage, geographical coverage of the data, life history stage sampled with regards to sizes of males and females, sample size, estimation methods, and the likely amount of bias produced from using a specific curve. Possible changes to the historical estimates of the catch in numbers from the use of a different conversion formulae are discussed. Improvement to the historical catch data base and possible trade-offs of accuracy in other areas are also discussed.

RESUME

La conversion de la formule nécessaire pour convertir la longueur en poids du germon de l'Atlantique nord existe et une grande partie des valeurs ont été discutées. Ce document récapitule la formule historique disponible pour estimer le poids à partir de la longueur. Cette transformation est importante dans l'estimation du nombre total capturé provenant des déclarations des données de débarquements. L'acceptabilité de certaines équations pour transformer de façon précise les prises en poids en prises en nombre est discutée et les inquiétudes spécifiques soulevées lors des Journées d'étude de 1989 sur le germon, à savoir l'introduction de biais dans les estimations de prises en continuant à utiliser la courbe de poids-longueur de Beardsley (1971) sont examinées. L'acceptabilité de recommander une relation simple longueur-poids ou des équations multiples est jugée. La sélection est basée sur la couverture temporelle des données des échantillons, la couverture pêcherie/engin, la couverture géographique des données, le stade du cycle vital échantillonné en ce qui concerne les tailles des mâles et des femelles, la taille de l'échantillon, les méthodes d'estimation, et le montant éventuel de biais produits en utilisant une courbe spécifique. Les changements éventuels des estimations historiques de la prise en nombre en utilisant une formule de conversion différente sont discutés. L'amélioration de la base de données des prises historiques et les éventuels échanges de précision dans d'autres zones sont également discutés.

RESUMEN

Existen fórmulas de conversión necesarias para convertir la talla a peso del atún blanco del Atlántico norte, y se han discutido las ventajas de la mayor parte de ellas. Este documento resume las fórmulas históricas disponibles para estimar el peso a partir de la talla. Esta transformación es importante en la estimación del total de individuos capturados, a partir de datos de desembarques comunicados. Se discute la idoneidad de ciertas ecuaciones para transformar con precisión las capturas en peso en capturas en números, y se examinan, asimismo, las preocupaciones específicas señaladas en las Jornadas de Trabajo sobre el Atún Blanco, 1989, en cuanto a la introducción de sesgos en las estimaciones de captura, de continuar la aplicación de la curva peso-talla de Beardsley (1971). Se juzga la oportunidad de recomendar una única relación talla-peso o múltiples ecuaciones. La selección se basa en la cobertura temporal de los datos de muestreo, la cobertura de la pesquería/arte, cobertura geográfica de los datos, fases del ciclo vital muestreadas con vistas a obtener tallas de machos y hembras, tamaño de la muestra, métodos de estimación y la probable importancia del sesgo producido a partir de la aplicación de una curva específica. Se discuten posibles cambios en las estimaciones históricas de la captura en números, a partir de la aplicación de una fórmula de conversión diferente. También se discute la mejora de la base de datos histórica y posibles opciones de precisión en otras áreas.

Introduction

Many weight-length conversion formulae for North Atlantic albacore exist. These formulae are used transform weight of individual fish to length. The transformation is a primary calculation required to compute the numbers caught from yield (weight caught) and a length sample. The latter is used as basic information in many of the traditional fisheries stock assessment models (e.g., virtual population analyses). The procedure computes numbers at length as follows. First, the length frequency sample is transformed to a weight freuency with a weight-length conversion. Then the sample average weight is computed and divided into the yield (catch in weight) to estimate the numbers caught. The estimated total numbers caught is then proportioned over the length frequency to give the estimated numbers at length. One may decompose the estimates of numbers at length into numbers caught at age and incorporate into age based virtual population analyses (Fry 1949) or use the numbers at length estimates directly to investigate stock condition (Jones 1974, 1981, Pauly et al 1987, Fournier and Doonan 1987, Sullivan 1989, Parrack 1990, Sullivan et al. 1990, and Parrack 1992). The purpose of this report is to addresses the adequacy of the weight-length formula used to transform catches in weight to catches in numbers adopted by the ICCAT.

An Overview of Albacore Weight-length Biometrics

The entity with responsibility for assessing the status of albacore tuna stocks in the North Atlantic is the International Commission for the Conservation Atlantic Tunas (ICCAT). The 1989 ICCAT Albacore Workshop (ANON., 1990) reviewed four studies that dealt with the weight-length relations of Atlantic Albacore. These four studies were considered comparable in terms of most major sampling attributes (e.g., geographical and fishery coverage and sizes sampled, reasonable sample sizes, and timespan). Other studies exist on this topic however, since they were concerned with albacore resources in the North Pacific and Indian Ocean, they were excluded from selection. The four studies considered were Beardsley (1971), Bard (1981), Mejuto and Gonzalez-Garces 1985, and the Albacore working group (ANON 1990). These authors described weight-length relations from albacore samples taken in the North Atlantic from surface and longline fisheries. Although, these studies were not identical in terms of fishery coverage, sizes sampled, months samples they were though as being most relevant for describing North Atlantic Albacore weight-length biometrics (Table 1).

Beardsley's (1971) fuction was adopted by the Workshop, but the Beardsley function did not consider sex, the estimation procedure was not described, the total sample size was not given (although at least 350 fish were from longline samples), and the amount of variation explained by the fitted model (r^2) was not given. The Workshop felt that universal application of the Beardsley function might introduce biases into weight estimates for larger fish (>90 cm). The group compared weight estimates from the Beardsley function with that from relations developed for North Pacific and Indian Ocean fish (Anon 1990) and found that the estimated values for fish 90 cm and larger were different for the two conversions. It was not possible to determine which model was unbiase but only that there were differences between weight estimates at larger sizes. These differences might be a result of sampling larger sized fish only during months of spawning. Fish would be fattier and heavier and have higher allometric factors (the b parameter in the weight-length function) than during other seasons.

The Beardsley sample size was larger than most studies to date. The overall coverage in size was most representative of all (approximately 60-120 cm) studies. The data series extended from 1966-1970 and captured year to year changes in the weight-length relation. The geographical coverage included the entire Atlantic covering the major fisheries and all months of the year were sampled; Beardsley included longline caught fish sampled at Puerto Rico and fish from the Bay of Biscay surface fishery (1967-1970). In general the Beardsley data set was reasonably comprehensive.

The existence of sexual dimorphism was identified by the Workshop as important in future research for North Atlantic albacore. This concern was not great though and support for this appears evident from several studies conducted in the North Atlantic. Bard's 1981 study also showed no major differences in the weight-length relation between sexes for fish sampled from 85-120 cm and only minor differences in the estimates were apparent beyond the sample data. De Jaeger's (1963) also study did not find the weight-length relation to differ by sex. The recent study by Santiago (unpublished 1992) further addressed sexual dimorphism in the weight-length relation. This study is the most recent study garmane to this topic. Fish were sampled (n=714) from 1990 between July and December in the Bay of Biscay and the Azores from surface fisheries. This study used systematic sampling and provided detailed explanation of the analyses. The importance of sex and within year variation of weight in length (quarter of the year) was investigated using a general linear model. 95% confidence interval estimates of weight at length were compared to the precicted weight calculated from the model adopted by the ICCAT (the Beardsley function). These results provide the basis to further judge the adequacy of the Beardsley weight-length function for computing weight from length.

Summary

The 1989 albacore Workshop conducted a broad review of all weight-length formula relevant for North Atlantic albacore for use in transforming catches in weight to catches in numbers. The Beardsley weight-length function was adopted as best reflecting weight at length from the available North Atlantic relations. Analyses of the Workshop also showed that the curves are similar up to until about 90-95 cm (Anon 1990, Table 8,9 & Figure 10) and suggest extremely small differences from about 95-105 cm. Although the curves diverged after size 90 cm however, analyses of the 1989 Workshop showed that Beardsley curve fell about mid-way of the remaining six curves considered. Weight at length estimates for some curves were higher than the Beardsley and others lower. These results clarify the disparity between the Beardsley curve and others and show that major differences occurr at about 105 cm. The group advised that continued sampling to investigate sexual dimorphism especially in the larger fish (>120 cm) should ensue.

Santiago (1992) in his sampling of fish from the Azores and Bay of Biscay in 1990 considered the problem of sexual dimorphism. Those results support the finding by Bard that sexual dimorphism is not strong factor in the weight-length relation for the size range covered in the study (up to 117 cm). Santiago's regression parameter estimates do differ slightly from the equation parameters of Beardsley 1971 study but the statistical significance of the difference had not been determined yet. The 0.95 % confidence intervals of weight at length from the Santiago study do however include Beardsley's weight estimates up until about 100 cm. This suggests that the overall differences are indeed slight when comparisons are made on similar size ranges.

The 1989 Albacore Workshop adopted the Beardsley weight-length relation as predicting weight at length with reasonable accuracy. Deficiences of the study were noted and important analyses to be conducted in the near future were recommended and carried out soon after the Workshop. The results from that study (Santiago 1992) described above suggest that sexual dimorphism can be eliminated from the list of elements that are of concern in the length weight relation. The concern of bias from application of the Beardsley function for fish of larger sizes (90 cm +) does not seem significant. Santiago's study results support this for fish up to about 100 cm. Use of the Beardsley function for historical catch estimations (pre 1990) is justified based upon analysis findings presented by the 1989 Workshop. These are, the robustness of the Beardsley study in terms of overall geographical coverage, large sample size as compared to earlier existing studies, fisheries covered, and the within year sampling intensity. That workshop also showed that upto about 90 cm all historical curves behaved very similarly. After 90 cm estimates from the Beardsley curve were generally mid way of the other curves. This finding suggests that of the six curves evaluated by the Workshop the Beardsley curve was most conservative of all historical curves. Comparisons of curves generated from Indian Ocean and North Pacific fish, although of academic interest, have no real support scientifically for North Atlantic albacore.

Reccommendations

Rather extensive studies of the weight-length relation in North Atlantic albacore have resulted in as many as 10-15 conversion formulae (ANON 1990, Santiago 1992). The results of these studies indicate that up to 100 cm, any single equation will predict weight at length with reasonable confidence. This finding alone indicates that use of a different conversion by ICCAT for converting length to weight will not drastically alter estimates of the historical data base up through size 100 cm and is not recommended. In addition, for fish caught before 1990 the Beardsley relation remains appropriate since that study remains the most comprehensive as regards spatial and temporal coverage. Beardsley used fish sampled from surface and from longline fisheries and sampled year round. An interesting observation from all of these studies when compared together, is the overall robustness of the albacore weight-length relation through time and area. In general, multiple studies conducted over a span of over 30 years (1951-1990) yield strikingly similar results suggesting the weight-length relation has not altered significantly over time. The Beardsly fuction though developed from fish sampled in the 1960's still reflects the albacore allometric relation of fish sampled in 1990 reasonably accurately.

The results from Bard's study and those of Santiago suggest sexual dimorphism also is no longer a concern in the relation. For fish up to 100 cm the Beardsley weight-length function is recommended. Concern of bias in weight estimates generated, from Beardsley's function, for fish larger from 90-100 cm is insignificant based on the 0.95 % confidence interval estimates from Santiago's study. The current North Atlantic albacore catch is composed of few fish greater than 100 cm. The amount of bias introduced to the estimates of catch numbers in the catch for these sizes is insignificant in comparison to other probable errors associated with sampling the larger and more rare size groups. Errors in estimates of total catch asociated with biases in catch reporting and low sampling rates are much more of a concern than these possible systematic biases associated with the use of one weight-length over another.

Of the studies conducted to date the Beardsley remains the most comprehensive study as regards major sampling attributes. The use by ICCAT of another conversion for converting length to weight will not likely produce large differences in the historical estimates of numbers at length in the catch and is not recommended.

References

ANON., 1990. Report of the First ICCAT Albacore Workshop. ICCAT Collect. Vol. Sci. Pap., 31: 73-243.

Bard, F.X., 1981. Le thon germon (*Thunnun alalunga*) de l'ocean Atlantique. These Doc. Sc. Paris. 336p.

Beardsley, G.L. 1971 Contribution to the population dynamics of Atlantic albacore with commentos on potential yields. Fish. Bull., 69(4): 845-857.

De Jaeger, B. 1963 Synopsis of biological data on bluefin tuna *Thunnus thynnus orientalis* (Temminck and Schlegel) 1842, longfin tuna *Thunnus alalunga* (Bonnaterre) 1788, yellowfin tuna *Thunnus albacares* (Bonnaterre) 1788, and bigeye tuna *Thunnus obesus* (Lowe) 1839 (South Africa). *In* H. Rosa, Jr. (editor), Proceedings of the world scientific meeting on the biology of tunas and related species, p. 588-607. FAO Fish. Rep. 6.

Fournier, D.A., and I.J. Doonan. A length-based assessment method utilizing a generalized delay-difference model. Can. J. Fish. Aquat. Sci. 44:422-437.

Fry, F.E. 1949. Statistics of a lake trout fishery. Biometrics 5(1):27-67.

Jones, R. 1974. Assessing the long term effects of changes in fishing effort and mesh size from length composition data. Int. Counc. Explor. Sea Doc. CM 1974/F:33, 13p.

Jones, R. 1981. The use of length composition data in fish stock assessments (with notes on VPA and cohort analysis). FAO Fish. Circ. 734:59p.

Mejuto, J. & A. Gonzalez-Garces. 1985 Relacion talla-peso de atun blanco juvenil del Atlantico norte. ICCAT. Vol. Sci. Pap., 23(2): 278-281.

Parrack, M.L. 1990. Estimating stock abundance from size data. Ph. D. Diss., School Fish., Univ. Wash., Seattle, Wash. 157p.

Parrack, M. L. 1992. Estimating stock abundance from size data. Fish. Bull. 90:302-325.

Pauly, D. , M.L. Palomares, and F.C. Gayanilo. 1987. VPA estimates of monthly population length composition, recruitment, mortality, biomass and related statistics of Peruvian anchoveta, 1953 to 1981. *In* Pauly, D., and I. Tsukayama (eds.), The Peruvian anchoveta and its upwelling ecosystem: Three decades of change, p. 142-166. ICLARM (Int. Cent. Living Aquat. Resour. Manage.) Stud. Rev. 15, Manila.

Santiago, J. 1992. A new length-weight relationship for the North Atlantic Albacore. [Draft manuscript 6p., included in correspondence to the ICCAT Working Group from ICCAT Assistant Executive Secretary dated 18 June 1992].

Sullivan, P.J. 1989. kalman filter approach to catch at length analysis. Ph. D. diss., Univ. Wash., Seattle, 160p.

Sullivan, P.J., H.L. Lai, and V.F. Gallucci. 1990. A catch-at-length analysis that incorporates a stochastic model of growth. Can. J. Fish. Aquat. Sci. 47:184-198.

Table 1. Length Weight Studies for North Atlantic Albacore.

Study	Temporal Coverage: Years	Temporal Coverage: Months	Size Range	Fishery	Area	Sample Size	Comments
Beardsley (1971)	1967-1970	1-12 summer	60-115 cm	Longline, Surface	Canneries (Puerto Rico), Bay of Biscay	>350	- Longline fish (i.e., fish >90cm), frozen & thawed, - surface fish < 90 cm from fresh samples
Bard (1981)	1952	6-9	46-90 cm			381	
	1952	8	90-110			92	
	1961,1969	6-9	50-75 cm			357	
	1970	1-12	85-115			350	
	1977	9	50-103			230	
Mejuto (1985)	1984	7-8	49-92	Troll	North Atlantic	1203	
Santiago (1992)	1990	7-12	42-117	Surface	Bay of Biscay, Azores	714	