SCRS/1993/054

Col.Vol.Sci.Pap. ICCAT, 42 (1) : 100-103 (1994)

REVIEW OF SWORDFISH AGE AND GROWTH DATA AND METHODOLOGIES

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SUMMARY

This paper reviews swordfish age and growth data and methodologies for use in the workshop discussions. The following topics are considered: basic characteristics of life history, the data sets available on size and growth, methodologies used (and attempted) for ageing, and the development procedures used currently to convert size to age.

RESUME

Le présent document passe en revue les données sur l'âge et la croissance de l'espadon, ainsi que les méthodologies employées dans les délibérations du groupe de travail. Les domaines suivants sont examinés: charactéristiques fondamentales du cycle vital, jeux de données disponibles sur la taille et la croissance, méthodologies employées (ou qui ont fait l'objet de tentatives) pour la détermination de l'âge, et les méthodes suivies à l'heure actuelle pour convertir la taille en âge.

RESUMEN

Este documento examina los datos de edad y crecimiento del pez espada y las metodologías a usar en las discusiones de las Jornadas de Trabajo. Se consideran los siguientes temas: características básicas del ciclo vital, los conjuntos de datos disponibles sobre talla y crecimiento, las metodologías aplicadas (y las intentadas) en la determinación de la edad y el desarrollo de los procedimientos usados actualmente para convertir la talla en edad.

INTRODUCTION

The purpose of this paper is to review the swordfish age and growth data and methodologies, in order to provide the background for making informed decisions on alternate methods of ageing the catch during the ICCAT Workshop on the Technical Aspects of Methodologies Which Account for Individual Growth Variability by Age. No new information is presented, rather a review of basic data, current ageing practices, as well as deficiencies in our data and analyses.

REVIEW

Swordfish are distributed widely in the tropical and temperate waters of the Atlantic Ocean and Mediterranean Sea. They are believed to spawn in the warm waters of the Atlantic and Mediterranean. Stock structure of swordfish is uncertain and, for a combination of biological and logistic reasons, there are considered to be North Atlantic, South Atlantic and Mediterranean stocks.

Growth

Swordfish are considered to be fast-growing, although our knowledge of growth is somewhat meagre and contradictory. Adult swordfish do not have scales and the otoliths are minute, so conventional ageing methods are difficult to apply. Further, in many fisheries, swordfish are dressed at sea, making it difficult to obtain hardparts.

Examination of external features of otoliths using electron microscopy have been applied (Radtke and Hurley 1983; Wilson and Dean 1983; Megalofonu et al. 1990a). Anal fin ray sections have also been used (Berkeley and Houde 1983; Tsimendes and Tserpes 1989; Megalofonou et al. 1990b; Ehrhardt 1991).

Evidence indicates that females grow faster and live longer than males (Kume and Joseph 1969; Berkeley and Houde 1983; Ehrhardt 1991; Lee and Anocha 1993; reviews by Lee 1989, Porter and Smith 1991), and males mature at an earlier age (Taylor and Murphy 1992; Anocha and Lee 1993). Berkeley and Houde (1983) estimated ages for a set of anal fin spines collected off the Florida coast. They estimated sex-specific von Bertalanffy growth parameters based on the estimates of back-calculated lengths at age. The growth parameters suggested a high degree of dimorphic growth, particularly for older age classes (Table 1). Ehrhardt (1991) reanalyzed this data set and developed a different method to back-calculate lengths at age. His results indicated less divergence in the mean lengths at age between the sexes (Table 1). At the present time, there is not sufficient sampling by area to estimate sex-specific catch at size. In order to reduce the variance on the length at age, sex-specific growth patterns should be quantified (Haist and Porter 1993).

Ageing with the use of hardparts has not been validated. An alternate growth curve based on fitting a Gompertz function to mark-recapture data (Anon. 1987, 1989; revised version: Restrepo 1990; Table 1; Fig. 1) has been adopted by the SCRS for use in the age-structured assessment models. Haist and Porter (1993) estimated lengths at age from a MULTIFAN analysis of the Spanish longline data. Results (Table 1) were not very different from Berkeley and Houde (1983) fin spine data for sexes combined. The range in estimates of mean lengths at age (Table 1) indicate that there is uncertainty regarding these growth parameters for Atlantic swordfish.

Age composition

Age-structured VPA analyses have been conducted since 1988 and the catch-at-age matrix has been developed based on the "age-slicing" technique (Anon. 1989, 1990, 1991, 1992, 1993). Though modal/age type analyses were evaluated at that time, due to lack of adequate size-frequency information in time strata, this method was abandoned. During the 1991 and 1992 assessment workshops (Anon. 1992, 1993) considerable attention was directed at alternatives for ageing the catch and both times the Committee considered it essential to evaluate the degree of overlap between adjacent cohorts prior to ageing the catch and developing abundance indices using modal/age or age-length-key methods. These alternative methods would also allow the possibility of incorporating sexual dimorphism into the process of estimating catch at age.

The age-slicing technique has come under much criticism. It assumes that for each age there is a characteristic length range and that the length ranges do not overlap. It is very unlikely that there is no overlap in the length range for adjacent ages. The technique has been applied because it is easy to implement, and because we have been unable to evaluate the degree of overlap between adjacent cohorts. The age-slicing method may average out the strength of the cohort by distributing fish of a strong year-class to neighboring cohorts. On the other hand, modal analysis may increase the variability between cohorts by giving excess weight to the strong cohort. Analysis by Haist and Porter (1993) showed that the length-sliding method is extremely sensitive to accurate knowledge of the true mean and the variance of the lengths at age.

The Kimura-Chikuni (1987) method solves the catch at age when a length-at-age key with overlapping ranges applicable, given the catch at length. The slicing method is simply a special use of the Kimura-Chikuni method for the extreme case when the length ranges of age groups do not overlap. In 1991 and 1992, the Kimura-Chikuni method was applied to swordfish and simulated data (Anon. 1992, 1993; Haist and Porter 1993; Restrepo 1993). This method worked very well when the true distribution of size at age was known with relatively high accuracy. However, the performance of this method deteriorated when the true means and standard deviations of lengths at age deviated by more than a few cm from those assumed in the analysis.

Similarly in 1992, modal analysis using the Schnute-Fournier (1980) method and MULTIFAN Fournier et al. (1990) extension of that method was attempted on the swordfish data (Haist and Porter 1993). This approach showed promising results because the approach is relatively insensitive to simulated variances of the lengths. When using actual swordfish data, the performance may deteriorate; the Schnute-Fournier model assumes that the number of age classes represented in the data is known and that fish lengths at age are normally distributed, assmuptions which may not be appropriate for swordfish.

CONCLUSIONS

Given the uncertainty associated with the mean lengths at age for swordfish, priority must be placed on establishing a direct method to age the catch using a validated method for ageing based on hardpart analysis. Differential growth by sex must be incorporated into the models. Presently, that isolates the Berkeley and Houde (1983) data collected 15 yr ago (1977-80) as the best data set, at least for the western Atlantic. Not only are these ages not validated, but also there is no way to evaluate if growth rates have changed since that time; catches in 1987 (the peak) were 70% higher than 10 yr earlier when the samples were taken.

Further, it is obvious that better knowledge about the distribution of size at age is required, hence extensive sampling must be conducted. In addition, attempts should be made to reduce the variance on the length at age by obtaining actual fish lengths for the western Atlantic catches (rather than dressed weights converted to LJFL), and by quantifying sex-specific growth patterns.

That said, in the interim, every attempt must be made to make the best use of the data at hand. It has been suggested that age-slicing may not be appropriate and the task of the present workshop is to evaluate alternate methods and to test their performance on swordfish data.

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Table 1. Estimates of mean length-at-age (LJFL) for males (M), females (F), and sexes combined (C) from various sources. Sample sizes are shown in brackets.

	Anal fin spines					Mark-recapture		MULTIFAN
	Berkeley & Houde (1983)			Ehrhardt (1991)		Anon. (1989)	Restrepo (1990)	Haist & Porter (1993)
Age	M(275)	F(164)	C(439)	M(263)	F(162)	C(85)	C(105)	C
0	-	-	-	-	-	-	-	84.0
1	97.2	98.0	99.5	89.7	89.8	87.1	85.0	100.3
2	118.5	119.8	119.2	117.0	118.9	113.2	114.9	119.9
3	136.0	139.7	137.0	137.3	142.9	137.4	142.2	137.3
4	150.4	157.8	153.0	153.4	161.3	158.4	165.4	152.6
5	162.3	174.3	167.4	168.9	177.2	176.0	184.0	166.2
6	172.0	189.2	180.4	181.8	189.6	190.1	198.5	178.1
7	180.0	202.9	192.1	195.3	204.4	201.2	209.4	188.7
8	186.6	215.3	202.4	206.1	214.7	209.8	217.4	198.1
9	-	-	-	234.1	241.6	-	-	-
10	-	-	-	235.1	274.1	-	-	-

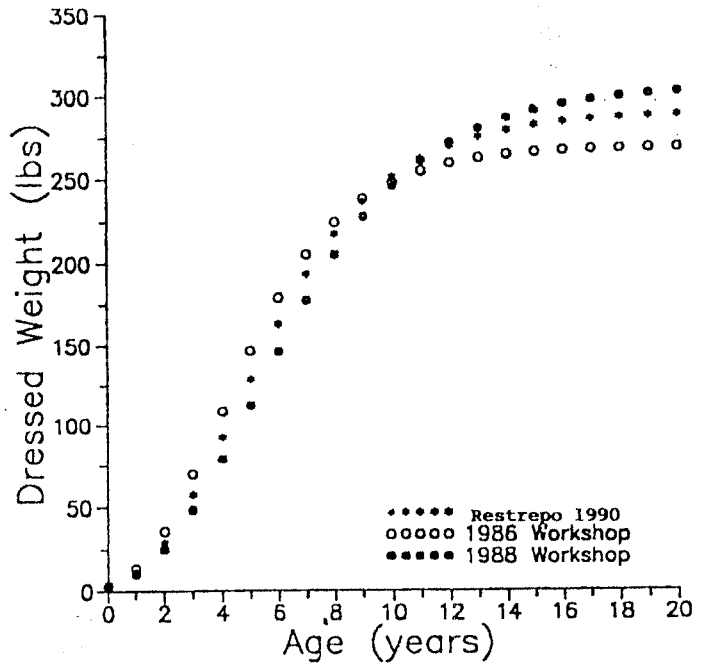

Fig. 1. Gompertz growth curves for swordfish estimated in 1986 and 1988 Workshops and Restrepo (1990). From Restrepo (1990).