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DEVELOPMENT OF A SWORDFISH SEX-RATIO-AT-SIZE RELATIONSHIP FOR CATCHES FROM THE CANADIAN FISHERY

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SUMMARY

Swordfish sex-ratio at size was estimated using data collected from the Canadian fishing zone during six years of sampling by Canadian research and observer programs. Analyses based on 2,020 female (77-220 cm LJFL) and 865 male (68-250 cm LJFL) swordfish, indicated that the proportion of females is 50% at lengths < 115 cm, 100% at length > 230 cm and increases linearly from 115 to 230 cm LJFL (Proportion Female=0.097413 + 0.003779 (LJFL)). This relationship is used in an example to partition the 1995 catch at size by sex.

RÉSUMÉ

Le sex-ratio par taille de l'espadon a été estimé d'après des données recueillies dans la zone de pêche canadienne pendant six ans d'échantillonnage par des programmes canadiens de recherche et d'observateurs. Des analyses fondées sur 2.020 espadons femelles (77-220 cm de LJF) et 865 mâles (68-250 cm de LJF) ont montré que les femelles sont présentes à 50% à une taille de < 115 cm, et à 100% à une taille de > 230 cm, et que cette proportion augmente de façon linéaire de 115 à 230 cm de LJFL (proportion de femelles = 0.097413 + 0.003779(LJFL)). Ce rapport est utilisé pour illustrer la ventilation par sexe de la prise par taille de 1995.

RESUMEN

Se estimó la proporción por sexos por talla del pez espada, usando datos recogidos de la zona de pesca canadiense en el curso de seis años de muestreo llevado a cabo en programas canadienses de investigación y observación. Análisis basados en 2.020 peces espada hembras (77-220 cm LJFL) y 865 machos (68-250 cm LJFL), indicaban que la proporción de hembras es del 50% en tallas de < 115 cm, 100% en tallas < 230 cm, e incrementos lineales de 115 a 230 cm LJFL (Proporción hembras = 0.097413 + 0.003779 [LJFL]). Esta relación se usa en un ejemplo para desglosar la captura de 1995 por talla según el sexo.

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Introduction

Male and female swordfish exhibit growth dimorphism, with females reaching a larger size than males (Ehrhardt et al., 1996). In order to incorporate more biological realism in the stock assessment, the ICCAT Swordfish Species Group will conduct a sex-specific VPA for north Atlantic swordfish in 1996. To this end, "all nations should provide swordfish catch-at-size-by-sex back to 1986" for use in the sex specific VPA (Anon., 1996). A comparison of the total catch-at-age estimated with sex-specific growth curves versus a single (sexes combined) growth curve revealed a shift in the age composition to older ages and a more even distribution of catches across ages when sex-specific growth equations were used (Turner et al., 1996).

In this paper we examine sex ratio and size data for swordfish collected by Canadian Scientists and Observers during six, non-consecutive years of sampling between 1980 and 1995. The purpose of this analysis is to develop an appropriate sex-ratio-at-size relationship for swordfish captured in the Canadian fishing zone to develop sex-specific catch-at-size data for Canadian longline and harpoon fisheries.

Materials and Methods

Swordfish sex and lower jaw fork length (LJFL, to the nearest cm) data were obtained from 369 pelagic longline sets conducted from June through October off Nova Scotia and Newfoundland along the edge of the continental shelf and Gulf Stream (Fig. 1). The data were collected at sea by Canadian Scientists aboard research vessels (1990, 1991) and commercial fishing vessels (1980, 1990, 1991, 1993), and by Observers involved in monitoring the Canadian swordfish fishery for management purposes (1994, 1995) (Table 1). Observations for 2020 female (77-290 cm) and 865 male (68-250 cm) swordfish were avialable for the sex-ratio-at-size analyses. Although observer data have also been collected from Japanese vessels fishing in Canadian waters, they were excluded from the analyses because the Japanese fleet fishes further offshore and during a different season (Oct.-Feb.) than the Canadian fleet.

The proportion of female swordfish by 5 cm intervals was examined for combined collections, as well as by season and geographical area. Seasons were defined as summer (June-August) and autumn (September-October). Two geographical areas were used for classification, defined as ICCAT Areas 2 and 14, falling west and east of the 60 ° W line of longitude, respectively (Fig. 1). The proportion of females was assumed to be 100% at sizes greater than 230 cm. For sizes < 115 cm, where the proportion of females was generally quite variable and sample sizes small, a 1:1 sex ratio was assumed. Regression analysis was used to determine the proportion of female swordfish by 5 cm size groups for fish ranging from 115 to 230 cm LJFL. The sex ratio algorithm was then applied to the 1995 catch-at-size data for a comparison of the numbers-at-size-by-sex with the numbers-at-size for the entire catch.

Results and Discussion

Female swordfish generally averaged larger in size than males for all years, areas and seasons (Table 1). Overall, females outnumbered males 2.3:1, although the sex ratio varied among samples from 1.9:1 (1995) to 5.9:1 (1991). In the combined sample collections, size frequencies for both sexes were similar up to about 120 cm, with female swordfish becoming increasingly more abundant than males at sizes greater than 120 cm (Fig. 2a). The proportion of female swordfish in the combined collections was variable at sizes less than 115 cm, then increased steadily from 50% at 115 cm to 100% at 230 cm, above which all were mostly female (Fig. 2b). These results are similar to those described by Turner et al. (1996) for swordfish sampled north of 35° N (temperate region). However, it should be noted that the Canadian swordfish sex-ratio-at-size is substantially different from the 1:1 sex ratio currently assumed in ICCAT swordfish assessments (Anon., 1995).

An analysis of the proportion of female swordfish at size by season indicated similar trends for the summer and autumn collection periods (Fig 3a). Each showed a relationship comparable to that for all collections combined (Fig. 2b). The proportion of female swordfish in collections from ICCAT Areas 2 and 14 (Fig. 3b) was also consistent with observations for all samples combined (Fig. 2b). Since the trends in sex-ratio-at-size by quarter and area were very similar, all collections were pooled to increase sample sizes for regression analysis. It was assumed that year effects contributed little to the observed sex-ratio-at-size, as was the case in Turner et al. (1996), but this assumption could not be examined with the limited Canadian data.

Regression analysis, based on the proportion of female swordfish in 5 cm intervals ranging from 115 to 230 cm provided the following relationship:

$$\text{Proportion female} = 0.097413 + 0.003779(\text{LJFL})$$

This relationship explained over 90% (multiple r^2 =0.903, n=24) of the variability in proportion of female swordfish with size (Fig. 4).

Using this relationship, and assuming a 1:1 sex ratio at sizes < 115 cm and 100% females at sizes > 230 cm, the 1995 catch-at-size data was partitioned by sex as shown in Figure 5. This relationship will be used to develop sex-specific catch-at-size data for Canadian longline and harpoon fisheries from 1986 to 1995, for use in the 1996 sex-specific VPA.

Literature cited

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Ehrhardt, N.M., R.J. Robbins, and F. Arocha. 1996. Age validation and growth of swordfish, *Xiphias gladius*, in the northwestern Atlantic. Int. Comm. Conserv. Atl. Tunas, Coll. Vol. Sci. Pap. 45(?): 000-000.

Turner, S.C., F. Arocha, and G.P. Scott. 1996. U.S. swordfish catch at age by sex. Int. Comm. Conserv. Atl. Tunas, Coll. Vol. Sci. Pap. 45(?): 000-000.

Table 1. Sample size and length statistics (LJFL cm) used for Canadian swordfish sex ratio analysis for males and females by year, season and ICCAT Area from Research (r) and Observer (o) program collections, 1980-1995.

Year Season Area	No. of sets	Males n	Males LJFL ± S.D.		Males min	Males max	Females n	Females LJFL ± S.D.		Females min	Females max	Months sampled	Sex Ratio (F:M)
1980(r)	22	62	161.4	26.21	92	217	160	176.3	32.83	83	280	August-October	2.6:1
1990(r)	22	44	140.1	27.19	98	198	123	167.7	31.72	100	285	August-September	2.8:1
1991(r)	21	24	149.0	23.46	108	198	141	172.4	28.48	105	255	July, Sept-Oct	5.9:1
1993(r)	14	38	167.1	24.92	120	217	87	159.5	32.06	95	270	September-October	2.3:1
1994(o)	176	508	147.4	28.92	68	250	1157	166.3	31.52	77	290	July-October	2.3:1
1995(o)	114	189	143.3	18.30	108	210	352	165.0	32.71	103	281	June-September	1.9:1
Summer	196	483	148.2	26.02	68	250	913	168.0	31.75	85	290	June-August	2.1:1
Autumn	173	427	148.0	27.90	79	222	1107	166.3	31.89	77	285	September-October	2.6:1
Area 2	250	529	146.7	29.75	68	247	1129	165.0	32.10	77	290	June-October	2.1:1
Area 14	119	336	150.2	25.18	86	250	891	169.7	31.30	107	285	July-September	2.7:1
All	369	865	148.1	26.95	68	250	2020	167.1	31.83	77	290	June-October	2.3:1

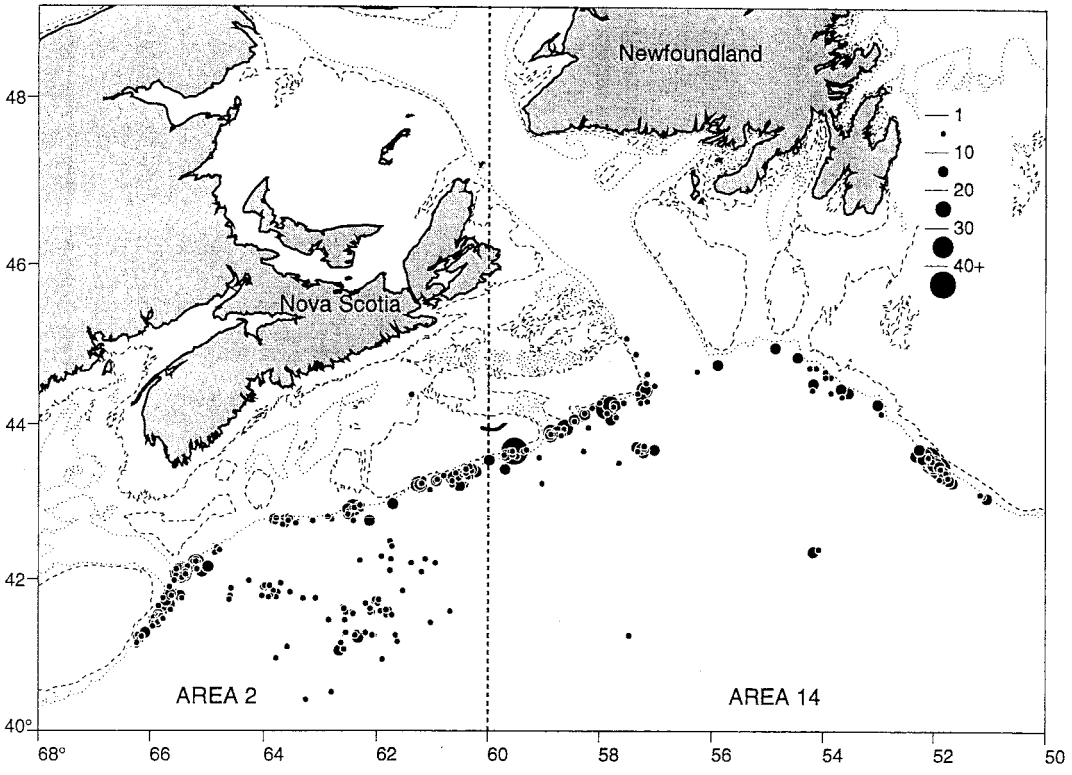

Figure 1. Set locations and relative number of swordfish sampled per set from Canadian research and observer program sample collections, 1980-1995.

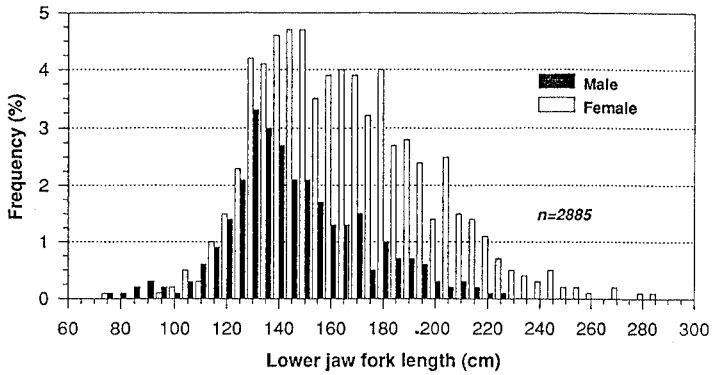

Figure 2a. Swordfish size frequencies by sex (5 cm intervals) from Canadian research and observer program sample collections, 1980-1995.

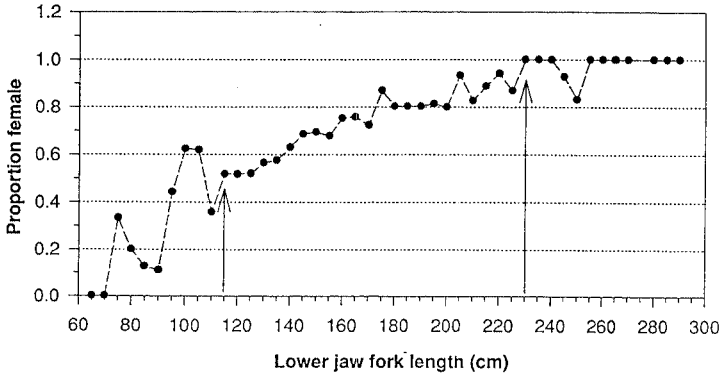

Figure 2b. Porportion of female swordfish in Canadian research and observer program sample collections, 1980-1995. Arrows indicate beginning (115cm) and end (230cm) of length range used for regression analysis.

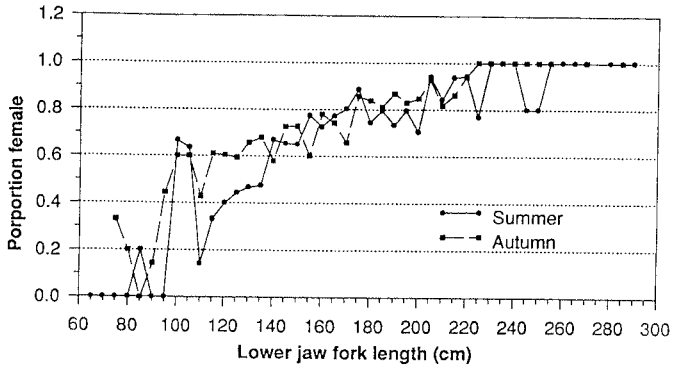

Figure 3a. Proportion of female swordfish in Canadian research and observer program samples by season (summer: June-August; autumn: Sept.-Oct.), 1980-1995.

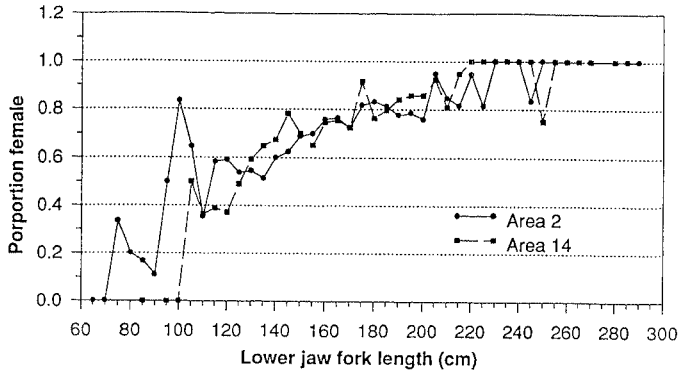

Figure 3b. Proportion of female swordfish in Canadian research and observer program samples, by ICCAT Area, 1980-1995.

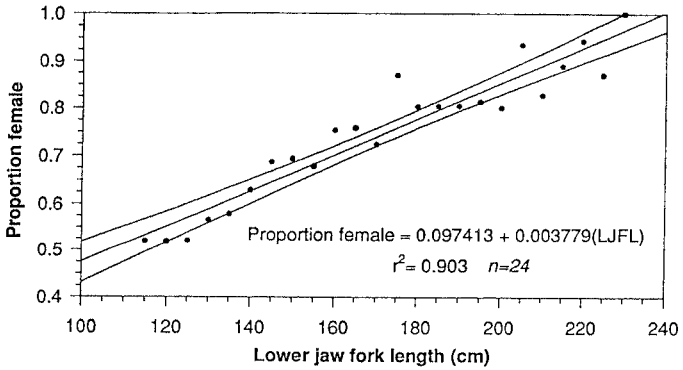

Figure 4. Regression relationship for lower jaw fork length (5 cm intervals) and proportion of female swordfish for Canadian research and observer program sample collections, 1980-1995. 95% CI is indicated by curved bands. *n* = number of 5cm intervals.

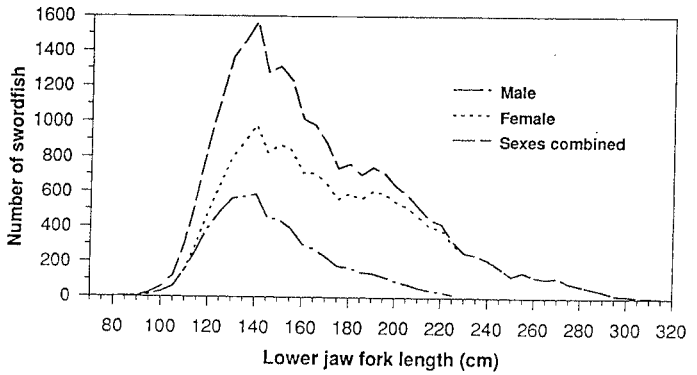

Figure 5. Length frequencies (LJFL cm) of swordfish for combined sexes and individual sexes determined from sex ratio analyses using the 1995 Canadian catch at size data.