LENGTH-LENGTH AND LENGTH-WEIGHT RELATIONSHIPS OF SWORDFISH, *XIPHIAS GLADIUS*, CAUGHT BY LONGLINERS IN THE SOUTHWESTERN ATLANTIC OCEAN

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SUMMARY

*This study reports size and weight relationships for swordfish (*Xiphias gladius*) in the southwestern Atlantic Ocean. Relationships presented are length-length between Lower Jaw Fork length (LJFL) and Dorsal Caudal Length (DCL), and length-weight between LJFL and Dressed weight (DWT). Data used in this document were gathered by the Uruguay National Observer Program on board the Uruguayan pelagic longline fleet between 1998 and 2012, on board Japanese tuna longline fleet operating in Uruguayan jurisdictional waters in the period 2009-2011 and 2013, and on board DINARA´s R/V. The relationships provided in this contribution cover at least an extended portion of the reported full size spectrum of swordfish.*

RÉSUMÉ

*La présente étude fait état des relations taille-poids de l'espadon (*Xiphias gladius*) dans le sud-ouest de l'océan Atlantique. Les relations présentées sont la relation taille-taille entre la longueur maxillaire inférieur-fourche (LJFL) et la longueur caudale-dorsale (DCL), et la relation taille-poids entre la longueur LJFL et le poids manipulé (DWT). Les données utilisées dans ce document ont été recueillies par le programme national d'observateurs d'Uruguay embarqués à bord de la flottille palangrière pélagique uruguayenne entre 1998 et 2012, à bord de la flottille palangrière japonaise opérant dans les eaux sous la juridiction uruguayenne au cours de la période 2009-2011 et en 2013 et à bord du navire de recherche de la DINARA. Les relations décrites dans ce document couvrent au moins une grande part de toute la gamme de tailles déclarées d'espadon.*

RESUMEN

Este estudio informa sobre las relaciones talla-peso del pez espada (Xiphias gladius) *en el Atlántico sudoccidental. Las relaciones presentadas son talla-talla entre longitud mandíbula inferior a la horquilla (LJFL) y longitud dorsal caudal (DCL) y una relación talla peso entre LJFL y peso canal (DWT). Los datos utilizados en este documento fueron recogidos por el Programa Nacional de Observadores de Uruguay a bordo de la flota de palangre pelágico uruguaya entre 1998 y 2012, a bordo de la flota atunera de palangre japonés que operaba en aguas jurisdiccionales uruguayas en el periodo 2009-2011 y 2013 y a bordo del R/V de la DINARA. Las relaciones presentadas en este documento cubren al menos una amplia parte del espectro de tallas completo declarado del pez espada.*

KEYWORDS

Swordfish; Length-length, Length-weight, Southwestern Atlantic

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1. Background

Basic data such as average, minimum and maximum sizes, as well as length-length and length-weight relationships are often not available or reported, but are important for understanding population structure (Francis, 2006). Adopting conversion factors is important for the recovery of incomplete information and also to compare between studies.

In this study we present length-length and length-weight relationships for swordfish (*Xiphias gladius*) for the Southwestern Atlantic Ocean.

2. Methods

Data presented in this study were obtained by scientific observers from the National Observer Program on board the Uruguayan longline fleet between 1998 and 2013. Two longline fleets were considered, the Uruguayan longline fleet targeting mainly swordfish (*Xiphias gladius*) and blue shark (*Prionace glauca*) and the Japanese longline fleet targeting bigeye tuna (*Thunnus obesus*). Also, information from swordfish caught by DINARA´s R/V Aldebarán was included.

Data from the Uruguayan fleet correspond to the period 1998 – 2012 when the fleet operated in Uruguayan jurisdictional waters (UEEZ) and international waters of the Southwestern Atlantic Ocean. Japanese fleet operated almost exclusively within the Uruguayan EEZ with an experimental fishing license during austral autumn and winter of 2009-2011 and under a leasing agreement in 2013.

Length data correspond to both fleets and the R/V, but weight data correspond only to Japanese fleet, as individuals are not weighted by the Uruguayan fleet. Length data; lower jaw fork length (LJFL) and dorsal caudal length (measured from the first dorsal fin to the caudal peduncle length, DCL) were measured to the nearest centimeter with a metal measuring tape. Dressed weight (DWT; gilled, gutted, part of head off, fins off) was measured with a steelyard balance to the nearest kilogram. When possible, individuals were also sexed.

The relationships between LJFL and DCL, and between LJFL and DWT, were fitted using linear and nonlinear regression models respectively, applying robust methods to reduce the influence of possible outliers. Analysis were done for sexes combined and for males and females separately.

3. Results

3.1 Length-length relationship

LJFL and DCL data were available for 1,494 males (68-261 cm), 3.460 females (71-319 cm) and 1.819 unsexed individuals (67-287 cm). **Figure 1** presents the size distribution (LJFL and DCL) of all swordfish used for the analysis. Differences in LJFL-DCL relationship were found between sexes, however, as the sex of the specimens may not always be available, we present a both sex-specific relationships as well as one for both sexes combined (**Table 1a**, **Figure 2)**.

3.2 Length-weight relationship

Length and dressed weight data were available for 66 males (110-203 cm), 124 females (105-198 cm) and 11 unsexed individuals. Dressed weight range was 5 to 67 kg. **Figure 3** presents the size and weight distributions of all swordfish. Differences in LJFL-DWT relationship were also found between sexes. As in the previous analysis, we present the relationship for each sex separately as well as one for both sexes combined (**Table 1b**, **Figure 4**).

Figure 5 and **Table 2** shows the present LJFL-DWT relationship for sexes combined as well as other published equations from the Atlantic Ocean for comparison.

The results indicated differences in the length and weight relationships by sex for southern swordfish, this is in agreement with the observed differences in growth for this species for the north and south Atlantic stocks (Arocha et al., 2003). Where females attain larger sizes while males tend to smaller size but their growth rates are higher than the females.

Acknowledgments

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Table 1. a) Swordfish LJFL-DCL relationship for combined sexes as well as for each sex. LJFL: lower jaw fork length; DCL: dorsal caudal length (measured from the first dorsal fin to the caudal peduncle length). **b)** Swordfish LJFL-DWT relationship for combined sexes as well as for each sex. DWT: dressed weight (gilled, gutted, part of head off, fins off).

a **Regresion**	**alpha**	**Std Error**	**beta**	**Std Error**	**N**	**LJFL Range (cm)**	**DCL Range (cm)**
LJFL–DCL Combined	14.8075	0.337	1.4086	0.003	6,773	67 - 319	42 - 221
LJFL–DCL Males	13.4247	0.694	1.4190	0.007	1,494	68 - 261	43 - 178
LJFL–DCL Females	17.1196	0.514	1.3915	0.005	3,460	71 - 319	43 - 221
b **Regresion**	**alpha**	**Std Error**	**beta**	**Std Error**	**N**	**LJFL Range (cm)**	**DWT Range (kg)**
LJFL–DWT Combined	2.4916E-06	9.62E-07	3.2340	0.075	201	105 - 203	5 - 67
LJFL–DWT Males	4.6075E-06	2.97E-06	3.1188	0.125	66	110 - 203	7 - 66
LJFL–DWT Females	1.6854E-06	8.74E-07	3.3170	0.101	124	105 - 198	5 - 67

Table 2. Summary of the current weight-length relationships for Atlantic swordfish, *Xiphias gladius*.

Region	**alpha**	**beta**	**Weight (kg)**	**Size (cm)**	**Size Range (cm)**	**Reference**
N-ATL	4.45E-06	3.204	RWT	LJFL	80-253	ICCAT. 2006-2016
S-ATL	2.46E-06	3.314	RWT	LJFL	89-266	ICCAT. 2006-2016
NW-ATL	4.59E-06	3.137	DWT	LJFL	NA	Turner 1987
SW Equatorial-ATL	8.00E-07	3.497	DWT	LJFL	75 - 255	Hazin et al. 2002
SW-ATL	2.49E-06	3.24	DWT	LJFL	105 - 203	Present study

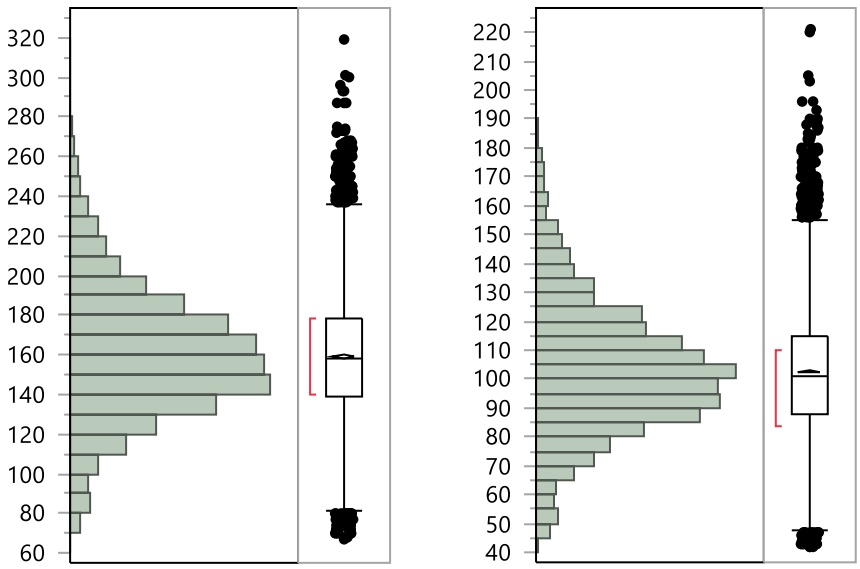

Figure 1. Size distribution (LJFL left panel and DCL right panel) for the total swordfish used for the relationship.

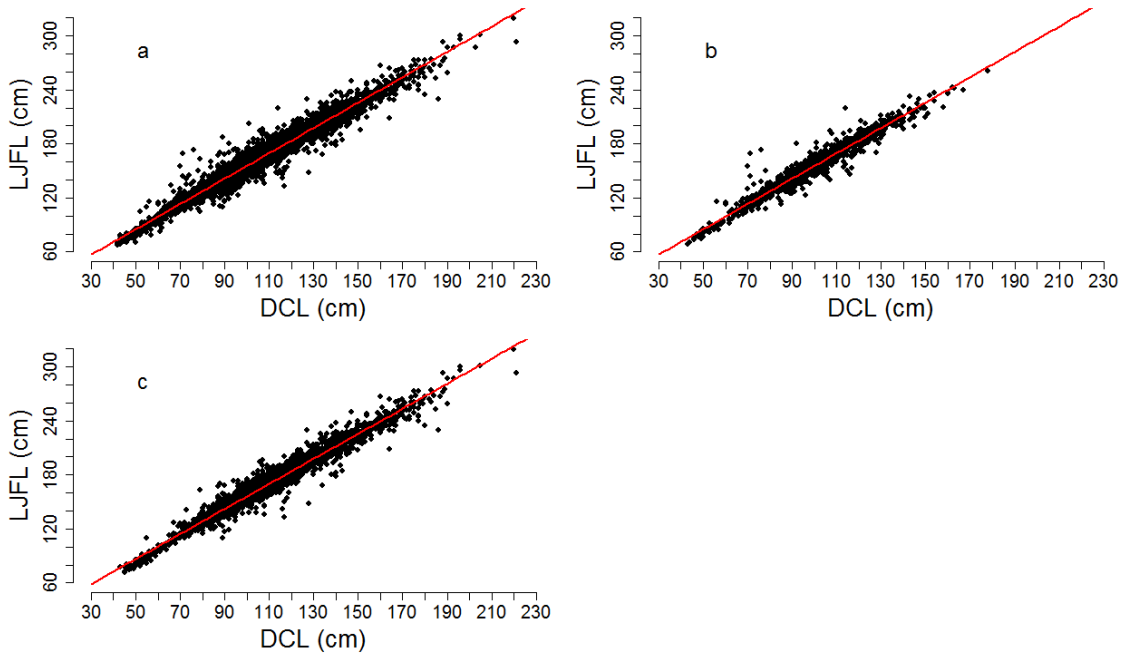

Figure 2. Lower jaw fork length (LJFL) and first dorsal to caudal peduncle length (DCL) relationship for swordfish, *Xiphias gladius*. Relationships are given for sex combined (a), males (b) and females (c).

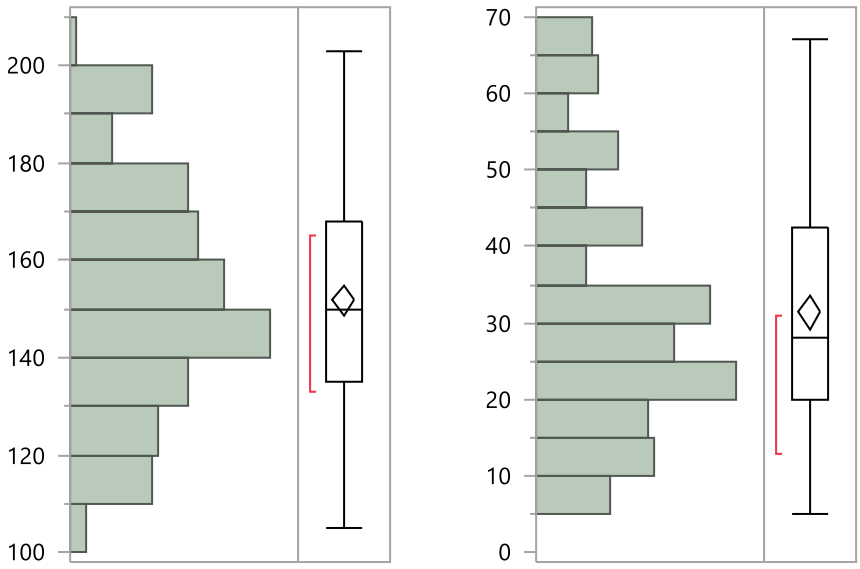

Figure 3. Size (LJFL left panel) and weight (DWT right panel) distributions of swordfish used for the relationship.

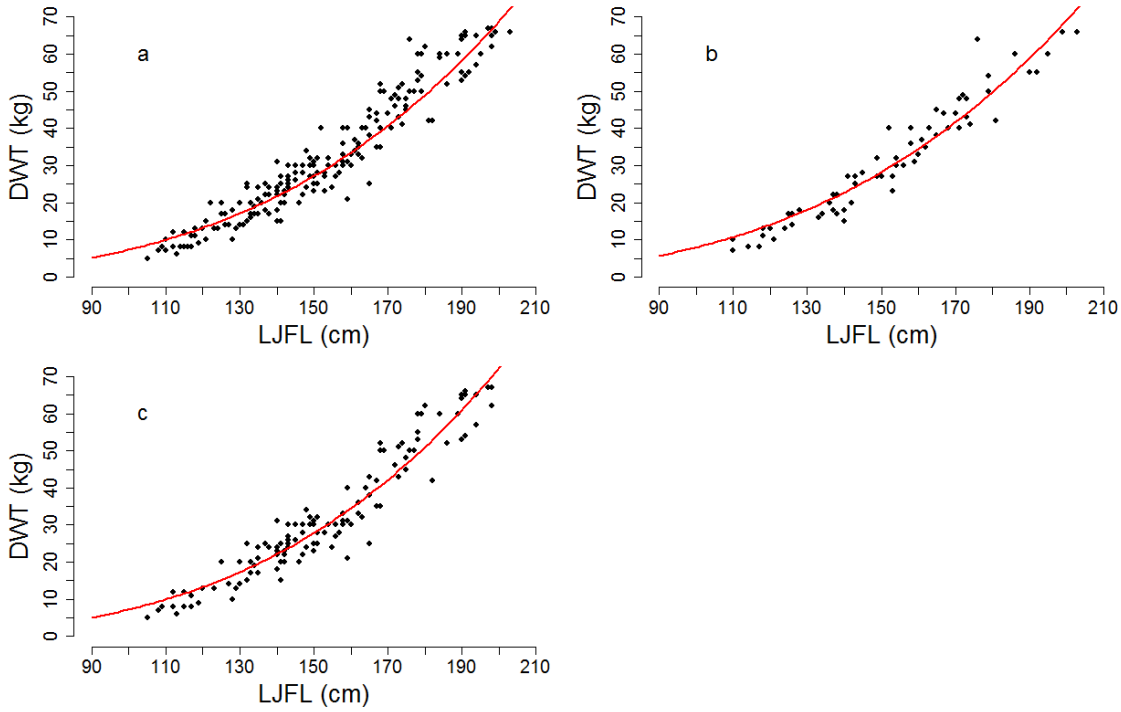

Figure 4. Lower jaw fork length (LJFL) – dressed weight (DWT) relationship for swordfish, *Xiphias gladius*, caught by the Japanese longline fishery in the Uruguayan Exclusive Economic Zone. Relationships are given for sex combined (a), males (b) and females (c).

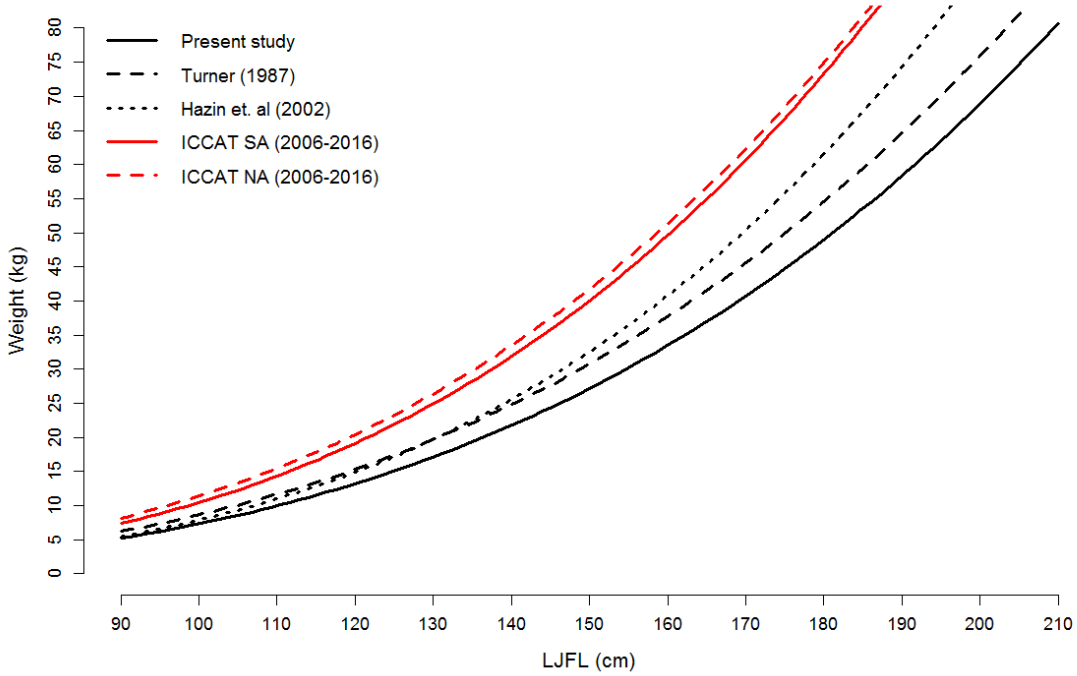

Figure 5. Lower jaw fork length (LJFL) – weight relationships for swordfish, *Xiphias gladius*, (sex combined) caught by longliners in the Atlantic Ocean. Regressions in black are length – weight relationships based on dressed weight (DWT); Regressions in red are length – weight relationships based on round weight (RWT). For additional information of each relationship see **Table 2**.