

A First Look at Age, Growth, and Reproduction in Gulf of Mexico Swordfish

Una Primera Mirada a la Edad, el Crecimiento y la Reproducción en el Pez Espada del Golfo de México

Un premier Regard sur L'âge, la Croissance et la Reproduction de L'espadon du Golfe du Mexique

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EXTENDED ABSTRACT

Swordfish, *Xiphias gladius*, is a highly migratory, circumglobal pelagic species that is categorized into three genetically distinct stocks in the Atlantic Ocean (North Atlantic, which includes the Gulf of Mexico (GOM) and Caribbean, South Atlantic, and Mediterranean). In the GOM, Swordfish are a prized sport fish that also support a commercial fishery, yet there is limited data on the species from this region. Age, growth, and reproduction studies have been conducted in the Mediterranean and Aegean Seas and the South Atlantic (Taylor and Murphy 1992, Tserpes and Tsimendes 1995, Arocha 2007, Aykol and Ceyhan 2013, Quelle et al. 2014), and sexual maturity is reported to occur at 4-5 years with maximum age estimated at 16 years. The objective of this study was to characterize the life history of Swordfish from the northcentral GOM by assessing age, generating and comparing growth models, and investigating the reproductive biology.

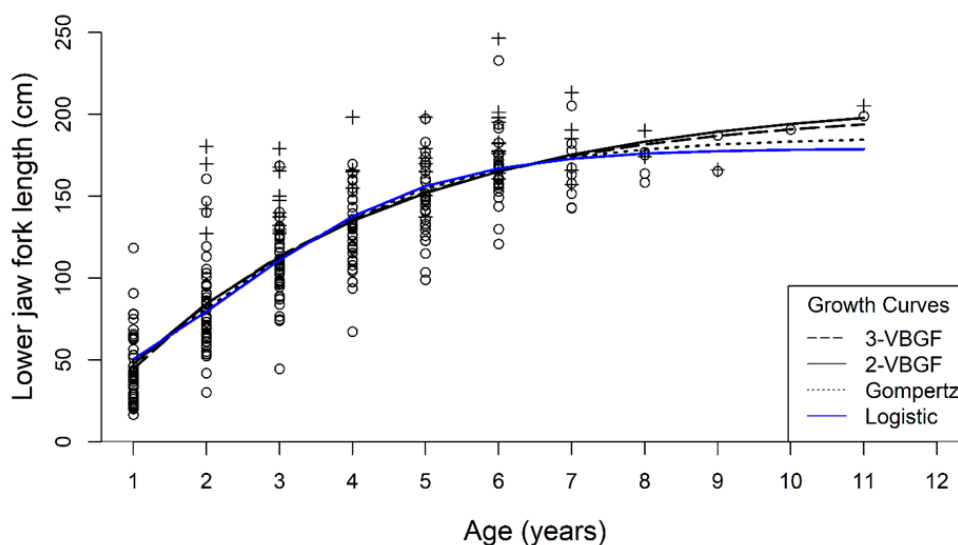
Swordfish (n = 51) were collected opportunistically from the tournament and recreational charter fisheries off the Mississippi and Louisiana coasts from March through July of 2017-2019, with the majority of the fish captured in June (n = 36). Lower jaw fork length (LJFL, cm) and total weight (W, kg) were measured for each fish upon capture. Whole anal fins were removed and the second spine was extracted and prepared for age analysis. Three to five transverse cross sections (0.45 mm thick) were cut with an Isomet low speed saw (Buehler; Lake Bluff, Illinois), digitally imaged, and growth bands were digitally marked and counted by two independent readers. Average percent error (APE) between readers was calculated. Due to recreational size regulations, retention of smaller fish was not possible in this study. However, to overcome this challenge we conducted a Dahl-Lee back calculation of observed length-at-age to provide estimates for missing size classes. Four growth models (three-parameter von Bertalanffy (VBGF), two-parameter VBGF, Gompertz, and logistic) were fitted to the observed and back calculated data and were compared using the Akaike Information Criterion (AIC). Model parameters were used to estimate theoretical longevity.

In order to examine reproductive biology, a thin mid-section of each gonad was extracted and placed in 10% neutral buffered formalin for histological processing. Fixed gonadal tissue was rinsed overnight in running tap water, dehydrated, embedded in paraffin, sectioned at 4 μ m, and stained with hematoxylin and eosin following standard histological procedures. Stained tissue was histologically classified into one of six reproductive phases. Physiological sexual maturity was defined as the presence of cortical alveolar oocytes or evidence of previous reproductive development in ovarian tissue and primary spermatocytes or residual spermatozoa in testicular tissue.

Females (n = 40) ranged in size from 127-246 cm LJFL and were 2-11 years old. Males (n = 11) ranged in size from 142-198 cm LJFL and were 2-7 years old, with an overall APE of 6.41%. Both the two- and three-parameter VBGF models provided an adequate fit to the observed and back calculated data for combined sexes (Δ AIC 0 and 0.96, respectively), with the Gompertz and logistic models providing a poorer fit (Δ AIC 3.74 and 9.24, respectively; Figure 1). The 3-parameter VBGF L_{∞} was estimated at 202 cm LJFL and theoretical longevity was estimated to be 12 years. Both these values are less than previous estimates of 238 cm LJFL and 18 years in the Mediterranean Sea (Tserpes and Tsimendes 1995), 283 cm LJFL and 23 years in the Aegean Sea (Aykol and Ceyhan 2013) and 358 cm LJFL and 37 years in the South Atlantic (Quelle et al. 2014). While previous studies included smaller fish, it appears that GOM Swordfish grow to a smaller maximum size and have a shorter lifespan.

Table 1. Percentages and length (mean \pm SE) of male and female Swordfish in various reproductive phases. Specimens captured from the Gulf of Mexico 2017-2019.

Month/length	N	Early Developing	Developing	Spawning Capable	Regenerating
Males					
April	2		100%		
June	8		12%	88%	
July	1			100%	
Length (cm LJFL)			164.0 \pm 17.5	171.8 \pm 4.6	
Females					
March	6	17%			83%
April	6	17%			83%
June	26	61%	23%	2%	2%
Length (cm LJFL)		180.6 \pm 5.05	167.8 \pm 5.3	183.5 \pm 17.5	149.6 \pm 8.4

**Figure 1.** Growth curves for Swordfish captured from the Gulf of Mexico 2017-2019. Models based on combined sexes using collected specimens (+) and back-calculated lengths (o). 3-VBGF, 3-parameter von Bertalanffy; 2-VBGF, 2-parameter von Bertalanffy.

All Swordfish examined histologically (37 females, 11 males) were sexually mature, and reproductively active females are batch spawners with asynchronous oocyte development, in contrast to previous reports of group synchronous oocyte development (Taylor and Murphy 1992). The majority of male Swordfish captured were spawning capable, although in April all males were in the developing phase (Table 1), suggesting the spawning season had not yet begun.

The only reproductively active females (developing and spawning capable) examined were captured in June, although the majority of June females were still in the early developing sub-phase (Table 1). Regenerating females were most common in March and April, but the presence of some females in the early developing sub-phase during these months suggests gonadal recrudescence had initiated.

The spawning capable females were ages 6 and 7 and had the largest mean length (Table 1). Female Swordfish were sexually mature at a younger age (2) and smaller size (155 cm LJFL) than previous estimates of 5 years (Arocha 2007) and 170 cm LJFL (Taylor and Murphy 1992) for Atlantic Basin Swordfish. Histological analysis suggests Swordfish spawn in the GOM during June, but more data are needed during spring and summer months to adequately describe their reproductive seasonality. Previous reports of Swordfish spawning in sub-tropical areas off Florida suggest an extended spawning season from February through December (Taylor and Murphy 1994), while spawning in the more climatologically-similar Mediterranean Sea is reported from June-August (Arocha 2007).

This preliminary study adds important information to the life history of Swordfish in a previously unstudied region. Swordfish in the GOM appear to have a shorter lifespan, smaller maximum size, and earlier size at maturity than conspecifics in the Mediterranean Sea, South Atlantic, or the Florida Straits. Additional year-round collections from the GOM are needed to adequately describe the reproductive seasonality and age- and length-at-maturity.

KEYWORDS: *Xiphias gladius*, life history, longevity

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