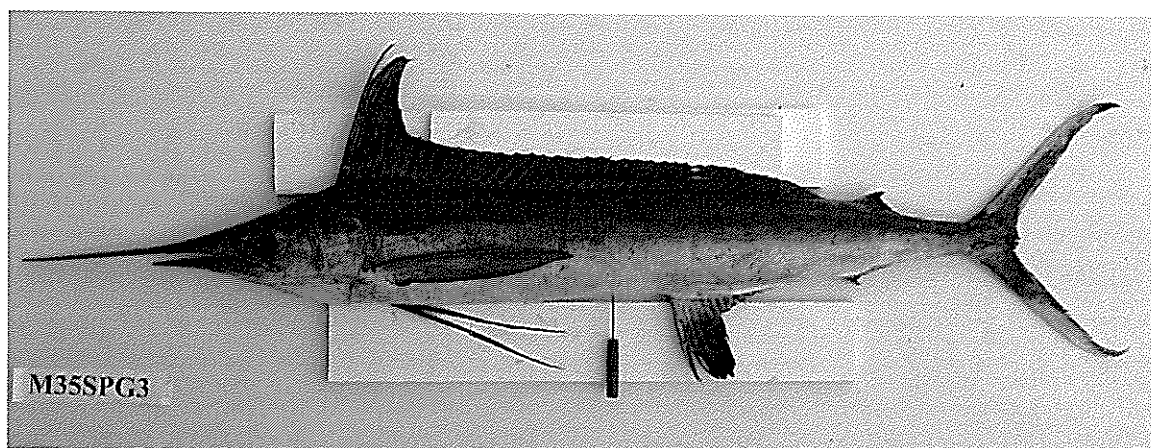




ROUNDSCALE SPEARFISH *Tetrapturus georgii* (Lowe, 1840); UPDATED  
MORPHOLOGY, DISTRIBUTION, AND RELATIVE ABUNDANCE IN THE  
WESTERN NORTH ATLANTIC

BY

LAWRENCE BEERKIRCHER, DENNIS LEE, AND GEORG HINTEREGGER



U.S. DEPARTMENT OF COMMERCE  
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National Marine Fisheries Service  
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July 2008



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U.S. DEPARTMENT OF COMMERCE  
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July, 2008

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## Introduction

In the western North Atlantic, fishes in the family Istiophoridae (billfishes) are highly sought after gamefishes that are often taken incidentally in commercial fishing operations (Hoey, 1995). Stock assessments suggesting severe declines in the populations of some species have led to increased regulation and intense public debate about management of these fishes (Anonymous, 2002). Rational management regimes require accurate stock assessments which in turn rely on data collection of catch and effort. Since these data are often self-reported by recreational and commercial fishermen, accurate species identification is of critical importance. At this time, there are four species of Istiophoridae commonly accepted as occurring in the western North Atlantic (Schulze-Haugen et al., 2003): blue marlin *Makaira nigricans*, white marlin *Tetrapturus albidus*, longbill spearfish *T. pfluegeri*, and Atlantic sailfish *Istiophorus albicans*.

Robins (1974a) examined a variety of Istiophoridae from the eastern Atlantic Ocean. While the significant majority of these billfishes were identified by that author as either the Mediterranean spearfish *Tetrapturus belone* or *T. albidus*, 4 specimens had distinctive characteristics. Robins reviewed the literature and proposed that these specimens were possibly the same species described briefly by Lowe (1840) as *Tetrapturus georgii*, and, in any event, applied the name *T. georgei* to the four specimens he examined and provided a more detailed description. Robins (1974a) noted the anteriorly rounded scales with two or three posterior projections, unspotted rounded dorsal and anal fins, and the distance of the anal opening from the anal fin origin about half the height of the first anal fin. Subsequent to this description, no more original research was done until recently, when Shivji et al. (2006) conducted a preliminary genetic analysis on 16 samples from western North Atlantic billfish having characteristics closely matching the fish described by Robins (1974a). These authors found reciprocal monophyly between these billfish (presumably *T. georgii*) and all the other species of Istiophoridae known to occur in the western North Atlantic. In addition, Collette et al. (2006) discussed the relationship of *T. georgii* to other billfish as part of a comprehensive review of Istiophoridae.

Because Shivji et al. (2006) based their analysis upon tissue samples and limited measurements taken by fisheries observers at sea before the fish were discarded, detailed laboratory examination of multiple western North Atlantic specimens of *T. georgii* have been lacking up to this point. In this paper, we present data on 16 complete specimens of *T. georgii* collected in the western North Atlantic. These data are combined with available observer data to present updated identification characteristics for *T. georgii* and to highlight the morphological differences and similarities between this species and some other co-occurring billfish. In addition, we provide information on this species' distribution in the western North Atlantic and numerical relationship to other Istiophoridae in this area. We also briefly discuss the evidence supporting the existence of a possible fourth species of *Tetrapturus* in the western North Atlantic, sometimes referred to as the "hatchet marlin".

## Methods

Sixteen specimens of *T. georgii* were collected by one of the authors (GH) while deployed as a fishery observer on pelagic longline vessels operating off the northeastern coast of the United States and the Sargasso Sea in summer 2005 and winter 2006, respectively. Specimens were given a cursory examination on board the vessel, photographed, and then frozen before being thawed and examined in the laboratory. Detailed external measurements and counts were taken following the methods Robins (1974a) employed on his four specimens; many of these measurements are more fully described in Rivas (1956). Scale samples were taken at random from about 5 cm above and below the lateral line, at a position about midway under the pectoral fin. Ranges of the data for the 16 specimens we collected were then compared to the data presented by Robins (1974a) for *T. georgii*, as well as to data presented by Robins and de Sylva (1963) for *T. pfluegeri* and Mather et al. (1975) for *T. albidus*. Three specimens were retained in a whole condition for other research institutions; the remainder were given a rudimentary dissection. Counts were made of precaudal and caudal vertebrae, otoliths were extracted and examined, and gut contents (if any) were saved. In addition, for female fish the gonads were blotted dry and weighed; gonosomatic indices (GI) for these eight fish were calculated based on the method described in Arocha and Lee (1992). ANOVA tests were used to compare the GI from the specimens collected off the northeastern United States to those from the Sargasso Sea. ANOVA was also used to attempt to elucidate any sexual dimorphism in the characters we examined.

On the basis of the examination of the 16 specimens, we reexamined observer records from the United States pelagic longline fleet operating in the western North Atlantic, Gulf of Mexico, and Caribbean Sea during June 1992 through December 2007 (see Beerkircher et al., 2004 for a description of observer program data collection protocols, spatial distribution, and coverage levels) for billfish specimens where (1) the distance between the anal opening and first anal fin (AFA) divided by the height of the first anal fin (AFH) (hereafter referred to as the AFA/AFH relationship), either through actual measurements or clear photographic evidence, fell between the mean AFA/AFH relationship for *T. albidus* (0.32; Robins, 1974b) and *T. pfluegeri* (0.99; Robins, 1974c), and (2) lateral scale samples matched the sixteen fish in this present study and the description of Robins (1974a). Photographic evidence was considered sufficient if the photograph was taken as a lateral profile over the specimen, with the first anal fin pulled to a fully erect position and the position of the anus clearly marked. Image processing software was then used to estimate the AFA/AFH relationship from these photos. While the literature descriptions of the position of the anus are generally given as AFA expressed as a percentage of body length, body length in these cases is almost always taken as a straight line with calipers. Observers were not equipped with calipers; instead they took body length, also referred to as lower jaw fork length (Rivas, 1956), as a curved measurement midline along the contour of the body with a metric tape measure. For these reasons, comparisons of the positions of the anus relative to body length from animals measured by observers with data from the literature and our laboratory specimens are difficult; thus we used AFA/AFH relationship as an identification criterion. ANOVA was used to examine if there were significant differences between AFA/AFH measurement methods (laboratory measurement, vessel measurement, and image analysis).

Distribution of both the whole specimens examined and specimens identified as *T. georgii* following the above criteria were plotted. Average sea surface temperature for sets that captured *T. georgii* was calculated by taking the mean of begin set, end set, begin haul, and end haul temperature data. Bottom depth for each individual was taken by averaging minimum and maximum depths throughout the gear deployment.

Because highly varied amounts of training and awareness of the existence of *T. georgii* were suspected in the fisheries observers, determining relative abundance by the common method of calculating nominal catch per unit of effort (CPUE) was considered inappropriate for application to the entire observer data set. Instead, data personally gathered by one of the present authors (GH) as a fisheries observer during 23 longline trips, encompassing 14 years and 166 observed sets, were used to create a table of Istiophoridae species ratios and nominal *T. georgii* CPUE expressed as catch per set for various spatial (geographical areas defined by NMFS; Figure 1) and temporal (winter, spring, summer, and fall) strata. In addition, we also examined observer data to elucidate any trends that might be caused by increasingly rigorous identification protocols used by observers in recent years. Correct identification criteria were not widely distributed to observers until 1998, was not stressed during trainings and debriefings until 2001, and it was not until January 2006 that observers were required to collect skin patches and take measurements of AFA/AFH relationships. Further, in January 2007 a new identification code, WHX, was added to account for live billfish in the water that could not be conclusively identified to species level, but were either *T. georgii* or *T. albidus*. Therefore, we compared *T. georgii*, *T. albidus*, and WHX (2007 only) CPUE expressed as catch per 1000 hooks for the time periods of 1992-1997, 1998-2000, 2001-2005, 2006, and 2007.

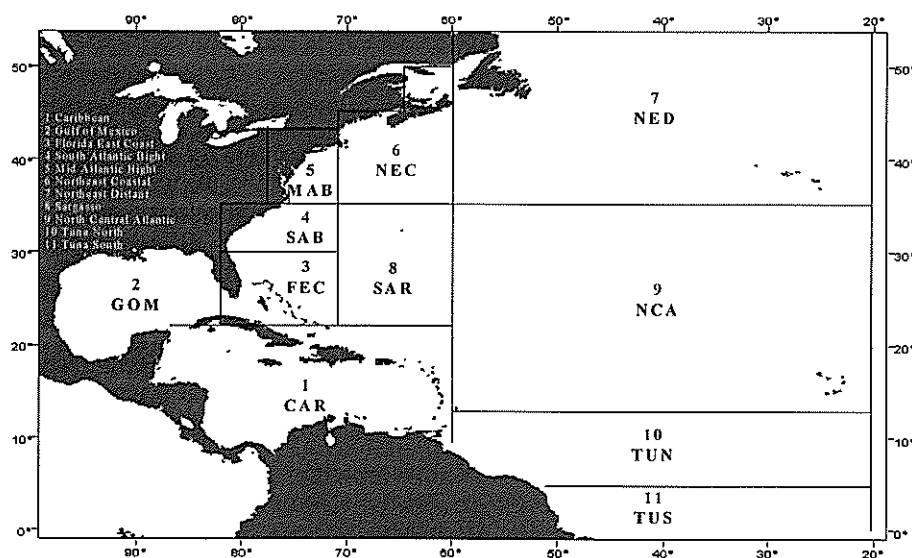


Figure 1. Geographic areas of the western North Atlantic defined by the National Marine Fisheries Service, and used in this study.

Photographs of specimens of *T. albidus*, *T. georgii*, and *T. pfluegeri* captured in the western North Atlantic were examined for characteristics described for “hatchet marlin”: truncated lobes of the anterior first dorsal and first anal fins. Available morphometric data and scale samples from specimens exhibiting this morphology were examined to see if this characteristic seemed to be consistent with only one of the western North Atlantic *Tetrapturus*, or were more indicative of a trait that was shared interspecifically.

## Results

### *External morphology*

Morphometric data for 15 specimens are presented in Table 1; body length in one specimen (M36SPG3) was considered unreliable due to a malformed lower mandible and data from this specimen were not included. The body lengths ranged from 1385 mm to 1709 mm ( $\bar{x}$  = 1551 mm). All the following characteristics are given as percent of body length, except where noted, and terminology follows Rivas (1956); D1 first dorsal fin, D2 second dorsal fin, P1 pectoral fin, P2 pelvic fin, A1 first anal fin, and A2 second anal fin. Body shape of *T. georgii* is moderately fusiform and slender (depth at origin D1: 12-14, depth at origin A1: 10-13, origin of D2 to origin A2: 8.0-9.3, greatest body depth 13-15). The body is moderately compressed laterally in the anterior portion (width at P1 base: 6.6-8.3) but less so proceeding posteriorly through the body (width at A1 origin: 6.5-8.3, width at A2 origin: 5.3-6.7, width of caudal peduncle in front of keels: 2.4-3.1). The bill is relatively short (bill length: 22-27) and rounded (Depth of bill: 0.7-1.3, width of bill: 1.1-1.5). The dorsal profile of the head slopes gently from the base of the bill up to the origin of the first dorsal fin (Origin of P2 to nape: 13-15). The mouth is large (maxillary length: 14-16) and the eye is moderately large (orbit diameter: 2.7-3.0). The retractable first dorsal fin is moderately high anteriorly (height D1: 15-19) but slopes down rapidly to a much lower height (length of 25<sup>th</sup> D1 spine: 2.8-5.7). The lobes of the first dorsal and first anal were often ragged in the whole specimens we examined, probably due to handling and freezing (Figures 2, 3); however the field photographs of these animals in their fresh dead condition indicate that a rather flattened or blunt shape to the anterior lobe is the most common profile (Figure 4). There are 42 - 47 first dorsal elements, most commonly 45 (Table 2). The second dorsal fin is small (height D2: 3.8-4.3) and pointed with a slightly longer trailing last ray (length last D2 ray: 5.7-7.5).

The pectoral fin is long (length P1: 19-25) and gently pointed at the distal end, and is made up of 16 - 19 (most commonly 19) rays. The pelvic fins were similar in length to the pectoral fins (length P2: 19-24) and fit into ventral grooves in the body. The first anal fin was moderately high (height A1: 9.7-12) and in profile was generally flattened or blunt rather than rounded. The first anal fin was made up of 12 to 17 (most commonly 16) elements. The second anal fin was short and shaped similarly to the second dorsal (height A2: 3.5-4.2, length last A2 ray: 5.3-6.1). The anal opening was located moderately far forward of the origin of the first anal fin (anus to origin A1: 5.4-7.8) and this distance was generally more than half the height of the first anal fin (AFA/AFH: 0.48-0.81). The lateral scales were invariably broad based and rounded anteriorly; most commonly there were 2 to 3 points; however some scales only had single points (Figure 5).

Table 1. Morphometric information for 15 specimens of *Tetrapturus georgii* from the western North Atlantic. All measurements are given as percent of body length except for Body length (1), which is given as the actual body length of the specimen in mm, and AFA/AFH, which is given as the relationship of the anus to anterior anal fin measurement divided by the anal fin height measurement. Numbers in parentheses in the measurement descriptions are from Rivas (1956); the other measurements are described in Robins (1974a). Dashes indicate a measurement that could not be taken due to storage and shipping damage.

| Specimen Number              | M34SPG1 | M34SPG2 | M35SPG1 | M35SPG3 | M36SPG17 | M36SPG6 | M35SPG2 | M36SPG12 | M36SPG1 | M36SPG19 | M36SPG11 | M36SPG13 | M36SPG8 | M36SPG7 | M36SPG18 |
|------------------------------|---------|---------|---------|---------|----------|---------|---------|----------|---------|----------|----------|----------|---------|---------|----------|
| Sex                          | F       | F       | F       | U       | M        | M       | F       | F        | M       | U        | M        | F        | F       | M       | U        |
| Body length (1)              | 1709    | 1610    | 1696    | 1523    | 1522     | 1385    | 1656    | 1661     | 1458    | 1520     | 1480     | 1491     | 1596    | 1441    | 1479     |
| Body girth (2)               | 33.8    | 35.2    | 33.6    | 34.1    | 30.2     | 31.6    | 32.9    | 32.5     | 32.6    | 30.9     | 28.6     | 31.3     | 31.3    | 31.4    | 31.6     |
| First predorsal length (3)   | 21.8    | 20.5    | 22.0    | 22.4    | 22.2     | 23.3    | 21.0    | 22.3     | 20.8    | 22.0     | 21.2     | 21.9     | 22.9    | 21.2    | 21.8     |
| Second predorsal length (4)  | 81.0    | 80.7    | 80.3    | 80.2    | 78.1     | 79.8    | 79.9    | 80.0     | 80.0    | 79.1     | 79.7     | 80.1     | 79.9    | 79.3    | 78.8     |
| Prepectoral length (5)       | 25.0    | 23.2    | 24.4    | 25.3    | 25.2     | 26.3    | 23.3    | 25.5     | 24.1    | 25.3     | 24.2     | 24.4     | 24.6    | 24.2    | 24.9     |
| Prepelvic length (6)         | 26.5    | 25.2    | 25.9    | 26.8    | 26.3     | 27.0    | 25.2    | 27.1     | 25.7    | 26.8     | 25.3     | 26.0     | 25.8    | 26.0    | 26.5     |
| First preanal length (7)     | 59.2    | 58.0    | 58.6    | 58.8    | 58.6     | 59.4    | 58.0    | 58.6     | 57.8    | 59.1     | 59.7     | 59.8     | 60.1    | 56.4    | 57.5     |
| Second preanal length (8)    | 78.5    | 78.1    | 78.5    | 77.3    | 78.6     | 78.4    | 78.4    | 79.3     | 79.1    | 78.3     | 78.2     | 78.7     | 79.3    | 77.5    | 78.5     |
| Orig. D1 to orig. P1 (9)     | 11.1    | 10.6    | 10.9    | 10.2    | 10.4     | 10.6    | 10.2    | 10.8     | 10.8    | 10.5     | 10.1     | 11.0     | 10.3    | 10.8    | 11.1     |
| Orig. D1 to orig. P2 (10)    | 14.2    | 14.5    | 14.3    | 14.1    | 13.8     | 13.9    | 13.9    | 14.5     | 14.2    | 13.6     | 13.0     | 14.2     | 13.5    | 13.9    | 14.1     |
| Orig. D2 to orig. A2 (11)    | 9.2     | 9.3     | 9.1     | 9.2     | 8.3      | 8.4     | 8.6     | 8.5      | 8.6     | 8.0      | 8.0      | 8.3      | 8.1     | 8.3     | 8.2      |
| Tip mandible to anus         | 51.5    | 49.4    | 51.5    | 51.9    | 51.0     | 51.7    | 50.8    | 51.1     | 50.1    | 51.5     | 51.1     | 51.8     | 50.9    | 49.4    | 50.8     |
| Orig. P2 to nape (13)        | 14.5    | 14.7    | 14.5    | 14.9    | 14.8     | 14.6    | 14.3    | 14.8     | 13.7    | 14.2     | 13.2     | 14.4     | 14.0    | 14.1    | 14.1     |
| Greatest body depth (14)     | 14.1    | 15.0    | 14.4    | 14.3    | 13.4     | 13.7    | 14.0    | 14.2     | 13.9    | 13.2     | 12.6     | 13.7     | 13.3    | 13.5    | 13.6     |
| Depth at orig. D1 (15)       | 13.2    | 13.4    | 13.7    | 13.1    | 12.7     | 13.4    | 12.7    | 14.0     | 12.6    | 12.6     | 12.3     | 13.5     | 12.5    | 13.0    | 12.9     |
| Depth at orig. A1 (16)       | 12.9    | 12.7    | 12.8    | 12.0    | 11.3     | 11.0    | 11.2    | 11.1     | 11.0    | 10.3     | 9.6      | 10.9     | 10.5    | 11.0    | 11.0     |
| Least depth cp (17)          | 3.9     | 3.9     | 3.7     | 3.8     | 3.4      | 3.3     | 3.6     | 3.5      | 3.4     | 3.3      | 3.3      | 3.4      | 3.4     | 3.4     | 3.4      |
| Width at P1 base (18)        | 7.5     | 8.3     | 7.8     | 6.9     | 6.7      | 7.2     | 7.7     | 7.3      | 7.3     | 7.2      | 6.6      | 7.1      | 7.1     | 7.2     | 6.9      |
| Width at A1 orig. (19)       | 8.0     | 8.3     | 8.0     | 7.6     | 7.0      | 6.8     | 7.2     | 7.2      | 7.1     | 6.8      | 6.5      | 6.6      | 6.7     | 6.7     | 7.0      |
| Width at A2 orig. (20)       | 6.7     | 6.7     | 6.5     | 6.4     | 5.7      | 5.8     | 5.9     | 5.6      | 5.6     | 5.5      | 5.4      | 5.3      | 5.3     | 5.6     | 5.7      |
| Width cp (in front of keels) | 2.9     | 3.0     | 3.1     | 2.7     | 2.7      | 2.5     | 2.7     | 3.1      | 2.7     | 2.4      | 2.4      | 2.5      | 2.6     | 2.6     | 2.6      |
| Length of upper keel (22)    | 3.2     | 2.5     | 3.4     | 3.3     | 3.2      | 3.3     | 3.1     | 3.9      | 3.2     | 3.4      | 3.4      | 3.6      | 3.8     | 3.5     | 3.7      |
| Length of lower keel (23)    | 3.1     | 2.9     | 2.4     | 3.2     | 2.6      | 3.0     | 3.3     | 3.5      | 3.2     | 2.8      | 2.9      | 3.2      | 3.1     | 3.3     | 3.4      |
| Head length (24)             | 24.0    | 23.2    | 23.5    | 24.6    | 24.0     | 25.4    | 23.4    | 24.6     | 23.5    | 24.5     | 23.2     | 23.9     | 24.2    | 24.2    | 24.0     |
| Snout length (25)            | 12.2    | 10.9    | 11.3    | 11.8    | 11.7     | 12.7    | 11.5    | 12.4     | 11.5    | 12.2     | 11.8     | 11.8     | 12.0    | 11.5    | 11.7     |
| Bill length (26)             | 25.7    | 22.4    | 23.2    | 27.0    | 26.5     | -       | 23.3    | 26.7     | 26.7    | 27.4     | -        | -        | -       | 24.0    | -        |
| Maxillary length (28)        | 15.3    | 14.1    | 14.5    | 15.2    | 14.7     | 16.2    | 14.7    | 15.7     | 14.7    | 15.4     | 14.9     | 15.0     | 15.4    | 14.9    | 15.0     |
| Orbit diameter (29)          | 2.7     | 2.7     | 2.8     | 3.0     | 2.9      | 3.0     | 2.8     | 2.9      | 3.0     | 2.8      | 2.9      | 2.8      | 2.9     | 3.0     | 2.9      |
| Depth of bill (33)           | 0.8     | 0.9     | 0.8     | 0.9     | 0.9      | 0.9     | 1.1     | 0.8      | 1.0     | 0.7      | 0.8      | 0.7      | 0.8     | 0.8     | 1.3      |
| Width of bill (34)           | 1.3     | 1.5     | 1.3     | 1.4     | 1.4      | 1.5     | 1.1     | 1.4      | 1.4     | 1.4      | 1.4      | 1.3      | 1.3     | 1.4     | 1.5      |
| Height D1 (39)               | 16.9    | 15.4    | 15.6    | 17.1    | 18.1     | 18.6    | 16.4    | 16.6     | 17.1    | 18.2     | 16.1     | 16.2     | 15.4    | 18.0    | 16.8     |
| Length 25th D1 spine (40)    | 4.0     | 3.5     | 4.8     | 2.8     | 3.9      | 5.7     | 3.7     | 3.9      | 4.9     | 3.9      | 4.1      | 4.0      | 4.4     | 5.0     | 3.2      |
| Height D2 (41)               | 3.8     | -       | 4.3     | 3.9     | -        | 4.0     | -       | 3.9      | -       | 3.8      | 4.0      | 3.8      | 4.0     | 3.8     | 4.1      |
| Height A1 (42)               | 11.5    | 10.3    | 10.4    | 11.6    | 11.5     | 11.8    | 9.8     | 11.0     | 11.1    | 10.1     | 10.6     | 11.1     | 9.7     | 11.1    | 11.2     |
| Height A2 (43)               | 3.7     | 3.5     | 3.7     | 3.7     | 3.7      | 4.1     | 3.6     | 4.2      | 3.7     | 3.7      | 3.6      | 3.8      | 3.7     | 4.0     | 3.5      |
| Length P1 (44)               | 21.4    | 20.7    | 19.6    | 20.2    | 21.5     | 25.3    | 19.4    | 21.8     | 22.2    | 21.9     | 20.7     | 21.1     | 23.9    | 22.8    | 21.8     |
| Length P2 (45)               | 19.4    | 20.4    | 19.8    | 21.8    | 22.5     | 23.6    | 19.3    | -        | 23.9    | 20.1     | 23.6     | 22.3     | 19.5    | -       | 21.3     |
| Length last D2 ray           | 6.4     | 5.7     | 6.8     | 6.9     | 6.2      | 6.2     | 5.9     | 6.1      | 6.8     | 6.0      | 6.2      | 5.7      | 7.5     | 6.4     | 5.8      |
| Length last A2 ray           | 6.0     | 5.6     | 5.9     | 6.1     | 5.7      | 5.4     | 5.3     | 5.8      | 5.8     | 5.6      | 5.5      | 5.8      | 5.6     | 5.8     | 5.9      |
| Orig. D1 to Orig. D2         | 59.9    | 60.8    | 58.5    | 57.9    | 57.7     | 57.2    | 61.2    | 59.1     | 60.3    | 58.0     | 59.4     | 59.6     | 58.7    | 58.9    | 58.8     |
| Anus to orig. A1             | 6.8     | 6.6     | 6.4     | 6.2     | 6.8      | 6.1     | 5.8     | 6.3      | 6.9     | 6.5      | 6.9      | 6.3      | 7.8     | 6.1     | 5.4      |
| AFA/AFH                      | 0.60    | 0.64    | 0.61    | 0.54    | 0.59     | 0.52    | 0.59    | 0.58     | 0.62    | 0.64     | 0.65     | 0.57     | 0.81    | 0.55    | 0.48     |



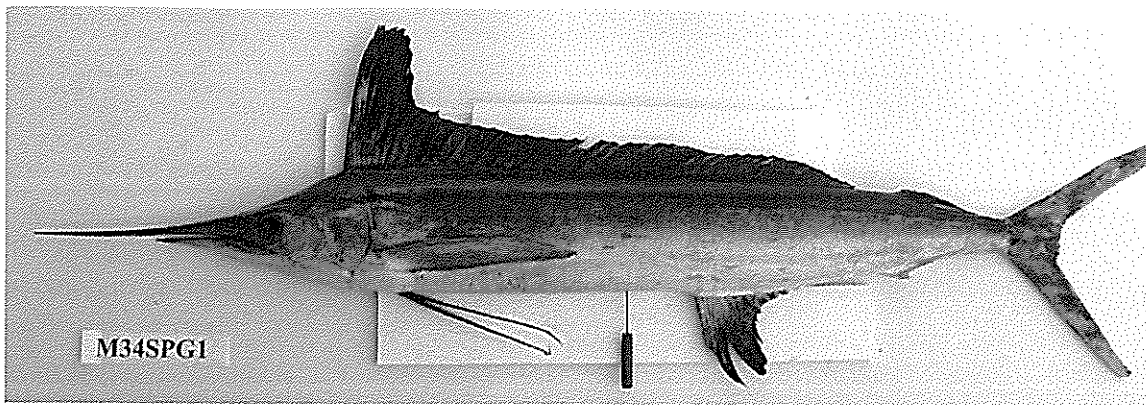


Figure 2. Laboratory photograph of *Tetrapturus georgii*, specimen number M34SPG1, captured approximately 160 km south of Cape Cod in the western North Atlantic. Probe marks position of anal opening.

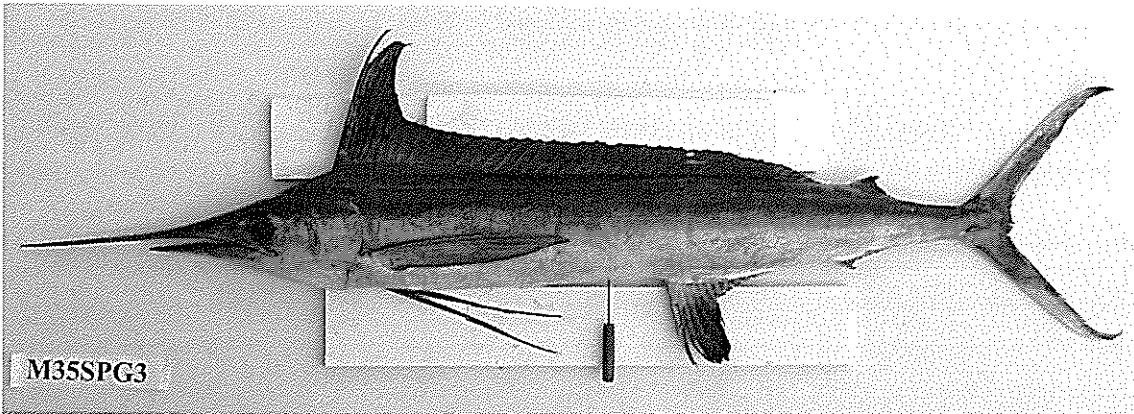


Figure 3. Laboratory photograph of *Tetrapturus georgii*, specimen number M35SPG3, captured off of George's Bank in the western North Atlantic. Probe marks position of anal opening.



Figure 4. Field photograph of *Tetrapturus georgii*, specimen number M34SPG1. Probe marks position of anal opening.

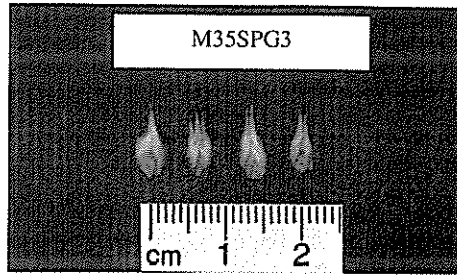


Figure 5. Examples of lateral scales from *Tetrapturus georgii*, specimen number M35SPG3.

Table 3. Comparative morphometrics, expressed as percentage of body length\* ranges, for *Tetrapturus georgii* (western North Atlantic; this study), *T. georgii* (eastern North Atlantic; Robins 1974a), *T. albidus* (western North Atlantic; Mather et al. 1975), and *T. pfluegeri* (western North Atlantic; Robins and de Sylva 1963). Numbers in parentheses are descriptions from Rivas (1956); all others from Robins (1974a). Dashes indicate unavailable data.

| Measurement                  | <i>T. georgii</i><br>(This study) | <i>T. georgii</i><br>(Robins, 1974a) | <i>T. albidus</i><br>(Mather et al., 1975) | <i>T. pfluegeri</i><br>(Robins and DeSylva, 1963) |
|------------------------------|-----------------------------------|--------------------------------------|--|---|
| First predorsal length (3)   | 21-23                             | 22-23                                | 22-25                                      | 19-21   |
| Second predorsal length (4)  | 78-81                             | 81-81                                | 77-83                                      | 81-85   |
| Prepectoral length (5)       | 23-26                             | 24-27                                | 25-27                                      | 23-26   |
| Prepelvic length (6)         | 25-27                             | 26-29                                | 26-29                                      | 24-27   |
| First preanal length (7)     | 56-60                             | 59-60                                | 57-62                                      | 60-64   |
| Second preanal length (8)    | 77-79                             | 79-80                                | 75-81                                      | 80-83   |
| Orig. D1 to orig. P1 (9)     | 10-11                             | 10-14                                | 12-14                                      | 7.6-9.9   |
| Orig. D1 to orig. P2 (10)    | 13-15                             | 15-18                                | -  | 11-13   |
| Orig. D2 to orig. A2 (11)    | 8.0-9.3                           | 9.2-9.9                              | -  | 5.4-7.8   |
| Tip mandible to anus         | 49-52                             | 52-56                                | -  | 49-53   |
| Orig. P2 to nape (13)        | 13-15                             | 15-17                                | -  | 11-15   |
| Greatest body depth (14)     | 13-15                             | 15-18                                | 14-19                                      | 8.7-13  |
| Depth at orig. D1 (15)       | 12-14                             | 14-17                                | -  | 7.6-13  |
| Depth at orig. A1 (16)       | 10-13                             | 13-14                                | 12-16                                      | 6.8-11  |
| Least depth cp (17)          | 3.3-3.9                           | 3.4-4.3                              | 3.5-4.2                                    | 2.4-3.3   |
| Width at P1 base (18)        | 6.6-8.3                           | 6.1-7.5                              | 5.2-9.4                                    | 3.3-5.5   |
| Width at A1 orig. (19)       | 6.5-8.3                           | 7.2-8.1                              | -  | 3.3-6.5   |
| Width at A2 orig. (20)       | 5.3-6.7                           | 5.7-6.0                              | -  | 2.5-5.2   |
| Width cp (in front of keels) | 2.4-3.1                           | 2.5-3.5                              | 2.7-3.8                                    | 1.5-2.3   |
| Length of upper keel (22)    | 2.5-3.9                           | 2.6-3.8                              | 2.7-4.7                                    | 2.2-3.8   |
| Length of lower keel (23)    | 2.4-3.5                           | 3.1-3.4                              | 2.7-4.7                                    | 1.7-3.1   |
| Head length (24)             | 23-25                             | 24-27                                | 24-27                                      | 22-26   |
| Snout length (25)            | 11-13                             | 12-14                                | -  | 10-13   |
| Bill length (26)             | 22-27                             | 31                                   | 25-35                                      | 19-31   |
| Maxillary length (28)        | 14-16                             | 15-17                                | 15-17                                      | 12-17   |
| Orbit diameter (29)          | 2.7-3.0                           | 2.9-2.9                              | 2.8-3.2                                    | 2.4-4.1   |
| Depth of bill (33)           | 0.7-1.3                           | 0.8-1.0                              | .81-1.3                                    | .7-1.1  |
| Width of bill (34)           | 1.1-1.5                           | 1.4-1.4                              | 1.2-2                                      | 1-1.2   |
| Height D1 (39)               | 15-19                             | 18-24                                | 14-23                                      | 13-19   |
| Length 25th D1 spine (40)    | 2.8-5.7                           | 5.0-9.2                              | 4-6.2                                      | 11-26   |
| Height D2 (41)               | 3.8-4.3                           | 3.8-4.4                              | 3.1-4.7                                    | 3.2-4.7   |
| Height A1 (42)               | 9.7-11.8                          | 12-15                                | 12-16                                      | 6.5-11  |
| Height A2 (43)               | 3.5-4.2                           | 3.0-3.3                              | 2.8-3.9                                    | 2.2-3.9   |
| Length P1 (44)               | 19-25                             | 21-26                                | 19-27                                      | 7.3-23  |
| Length P2 (45)               | 19-24                             | 21-22                                | 14-22                                      | 18-25   |
| Length last D2 ray           | 5.7-7.5                           | 6.7-6.9                              | 4.2-7.2                                    | 3.3-6.7   |
| Length last A2 ray           | 5.3-6.1                           | 5.1-6.2                              | 4.8-6.7                                    | 3.8-6.5   |
| Orig. D1 to Orig. D2         | 57-61                             | 58-60                                | -  | 61-64   |
| Anus to orig. A1             | 5.4-7.8                           | 4.8-7.6                              | 3.7-5.2                                    | 6.3-10  |
| AFA/AFH                      | 0.48-0.81                         | 0.31-0.63                            | 0.24-0.39                                  | 0.60-1.58   |

\*except for AFA/AFH which is not a percent of body length, and for *T. albidus* comes from Robins (1974b).

Comparison of these morphometric data with data collected by Robins (1974a) from *T. georgii* in the eastern Atlantic (Table 3) indicated that the majority of morphometrics were either consistent or showed a substantial amount of overlap. For approximately 25% of the morphometrics, however, Robins' specimens from the eastern Atlantic had values greater than those in the present study (including morphometrics where the minimum value of Robins' equaled the maximum value in the present study). Six of those measurements (Origin D1 to Origin P2, Origin D2 to Origin A2, Origin P2 to Nape, Greatest body depth, Depth at origin D1, and Depth at origin A1) indicate that the eastern Atlantic specimens were more robust in profile than those in the present study. Bill length appears to be shorter in the present study (22-27 in the present study compared to 31 in Robins, 1974a) although Robins was only able to examine one specimen with an intact bill. The eastern Atlantic specimens appear to have a much deeper first anal fin; which would contribute to the AFA/AFH relationship being lower for the eastern Atlantic specimens. Counts (first dorsal, first anal, and pectoral fin elements) were similar, and the scale samples from the 16 fish we examined matched the description for *T. georgii* given in Robins (1974a). Compared to the "most diagnostic characters" given for *T. georgii* by Robins (1974a), the fish in the present study match 6 of the 7 characters.

Of the dissected specimens, 8 were female and 5 were male. Significant differences were found between the sexes for actual body length ( $F=21.69$ ;  $df=1,11$ ;  $P < 0.001$ ) and percent-of-body length values for body girth ( $F=5.70$ ;  $df=1,10$ ;  $P < 0.05$ ), pelvic fin length ( $F=27.73$ ;  $df=1,8$ ;  $P < 0.001$ ), and height of first dorsal fin ( $F=11.03$ ;  $df=1,10$ ;  $P < 0.01$ ).

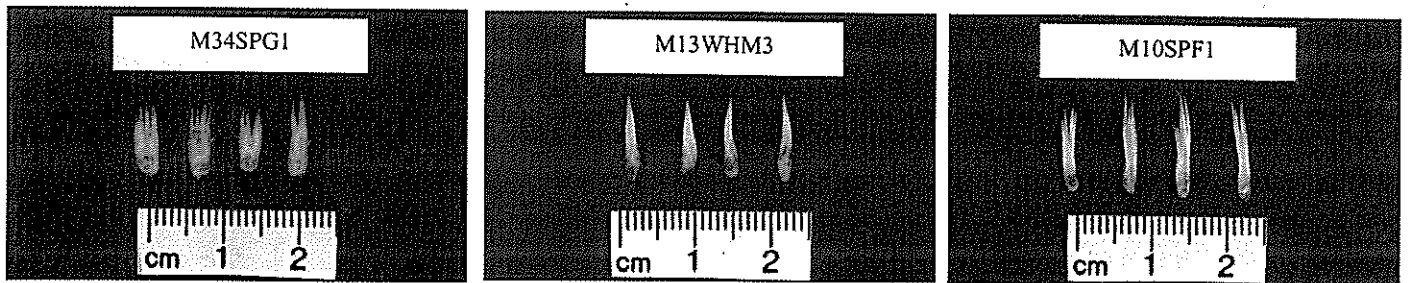


Figure 6. Comparison of lateral scale examples from 3 congeners of *Tetrapturus* found in the western North Atlantic. From left: *T. georgii*, *T. albidus*, and *T. pfluegeri*.

Comparisons of our morphometric and meristic data to those available for western North Atlantic congeners of *T. georgii* (*T. albidus* and *T. pfluegeri*) are shown in Table 3. As expected, certain characters are closely consistent for all three *Tetrapturus* species (examples: Length P2, Height D2, Head length), while for many others the consistency is only between two of the three (examples: Height D1, Length 25<sup>th</sup> D1 spine, Length P1). Certain characters, however, appear to be useful in a diagnostic sense as they show little or no overlap; they include the following percent of body length morphometrics: Greatest body depth, Height A1, and Anus to origin A1; the relationship of AFA/AFH, the counts of the first dorsal fin elements, and the morphology of the lateral scales (Figure 6). Comparisons of representative field photographs for *T. georgii*, *T. albidus*, and *T. pfluegeri* are shown in Figure 7. Comparison of branchiostegal lengths indicates that this character is possibly also diagnostic between *T. georgii* and *T. albidus*. In *T. georgii*, the

branchiostegals extend to a position about 65 – 80 % of the distance between the edge of the preopercle and the opercle; while in *T. albidus* the branchiostegals are shorter, extending only 40 – 60 % of the distance between preopercle and opercle (Figure 8).

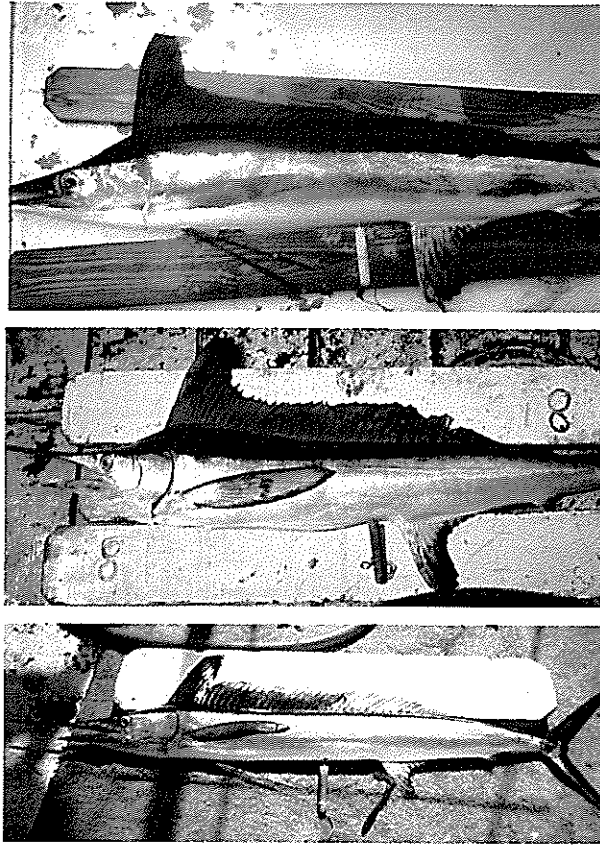


Figure 7. Comparison of field photographs from 3 congeners of *Tetrapturus* found in the western North Atlantic. From top: *T. georgii*, *T. albidus*, and *T. pfluegeri*. Probes mark position of anal opening.

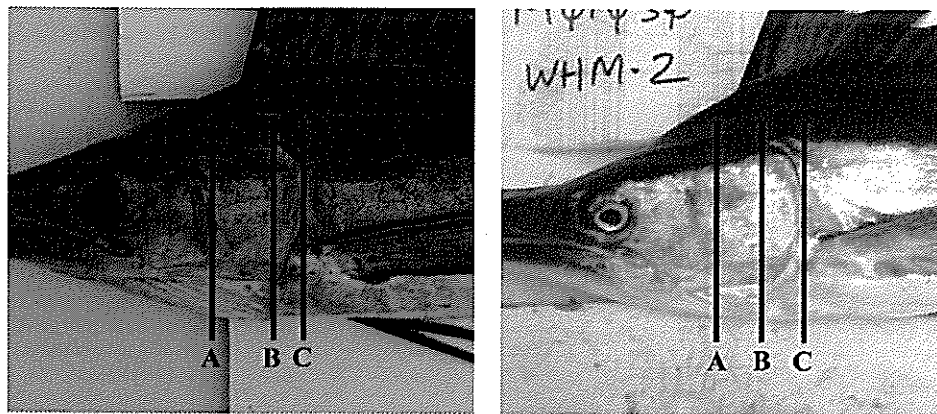


Figure 8. Comparison of branchiostegal lengths from *Tetrapturus georgii* (left) and *T. albidus* (right). Lines mark edges of: preopercle (A), branchiostegals (B) and opercle (C).

Review of existing observer information available from June 1992 - December 2007 indicated 76 additional specimens that met our criteria for identification as *T. georgii*. AFA/AFH relationships in these specimens ranged from 0.44 to 0.87 (Table 4). Scale morphology was consistent but ANOVA results suggest some significant differences between the various techniques used to produce the AFA/AFH relationship; vessel measurements produced significantly different relationships than either lab measurements ( $F=13.33$ ;  $df=1, 73$ ;  $P<0.001$ ) or image analyses of field photographs ( $F=5.72$ ;  $df=1, 74$ ;  $P<0.05$ ). There were no differences found between AFA/AFH relationships produced by lab measurements and photographic estimations ( $F=0.80$ ;  $df=1, 31$ ;  $P>0.4$ ).

In addition to the 16 whole specimens and the 76 sampled and photographed individuals which met our two criteria for identification; twenty-five other observed billfish met only one of our two criteria, either due to a poor field photograph or failure to collect scale samples. These individuals were not further considered in any analyses.

Table 4. Anal fin to anal opening distance divided by height of first anal fin (AFA/AFH relationships for *Tetrapturus georgii* observed in the western North Atlantic, using three different measuring techniques.

| Measuring technique | <i>n</i> | mean | minimum | maximum | standard deviation |
|---------------------|----------|------|---------|---------|--------------------|
| Lab measurement     | 16       | 0.60 | 0.48    | 0.81    | 0.018              |
| Image analysis      | 17       | 0.63 | 0.50    | 0.87    | 0.025              |
| Vessel measurement  | 59       | 0.69 | 0.44    | 0.87    | 0.016              |

## Coloration

Coloration of the 16 whole specimens was mostly consistent with that seen in the field photographs of dead specimens observed previously. The slight variations in coloration seen in the photographs we examined, we attribute to the various lengths of time the specimen had been dead before examination and photographing due to the nature of the pelagic longline fishery, as well as the varied light conditions and inexpensive equipment used to photograph the animals. In general, the body color is blue-black dorsally, light brown or dusky laterally, and silvery-white ventrally. In some specimens, the lateral part of the body was only slightly darker than the ventral coloration. First and second dorsal fins were dark blue with no distinct spotting evident, pectoral fins on the ventral side are silvery white at the fin origin and darken distally; the dorsal side of the pectoral fin is almost uniformly dark. First anal fin is silvery-white at the origin to the body, but darkens distally to a blue or brown color. The second anal fin is silvery white with a dusky posterior margin, in some cases the majority of the anal fin area is dark colored, in other cases the fins are mostly light colored. Pelvic fins are dusky. One specimen that was presumed very fresh dead exhibited dorsal stripes in the field photograph, some of which continued laterally until fading mid-body. The dorsal surface of the pectoral fin in this specimen was blue with some areas of lighter blue. When examined in the lab, however, this specimen's coloration was similar to all the other whole specimens.

Coloration of live animals has been difficult to determine, as conclusive species identification normally has come from dead specimens that were closely examined. However, one of the authors (GH) was able to briefly examine and photograph a live specimen (M35SPG4, Figure 9) and by measuring the AFA/AFH relationship and collecting some scale samples was able to ID the specimen as *T. georgii*. The overall body color was blue-black dorsally, brown laterally, and silvery-white ventrally. However, this specimen was also extremely colorful; there were approximately 18-20 light blue stripes dorsally as well as approximately 17 silvery-white lateral stripes, generally originating underneath (or associated with) the dorsal stripes. The lateral stripes faded into the silvery-white ventral portion of the body. The first and second dorsal fins were medium dark blue but without distinct spotting. The first anal fin was silvery-white at the origin to the body, but darkened distally to a blue color. The second anal fin was silvery white with a dusky posterior margin. The pectoral fins were blue-black with some areas of lighter blue; pelvic fins remained in the pelvic groove and the author was unable to determine color.



Figure 9. Field photograph of a live specimen of *Tetrapurus georgii* showing coloration. Probe marks position of anal opening.

### Internal morphology and reproductive biology

The internal morphology of the specimens we examined was similar in many ways to other Istiophoridae in the genus *Tetrapurus*. All specimens we examined internally ( $n = 13$ ) had 24 vertebrae (12 precaudal and 12 caudal). Otoliths (sagittae) exhibited an external morphology that was distinctive from most other Istiophoridae otoliths (Figure 10). The rostrum of the *T. georgii* otoliths was not extended relative to the antirostrum; in fact in most cases the antirostrum was as long, and in some cases longer, than the rostrum.

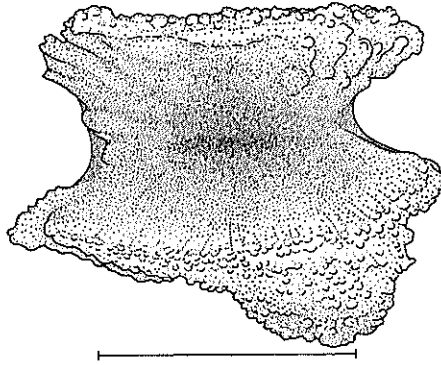


Figure 10. Illustration of an otolith (sagittae) from *Tetrapturus georgii* (specimen number M35SPG1). Scale bar is one millimeter.

In the female specimens, the gonads were slightly asymmetrical and Y-shaped, with one joining the other approximately one third the distance of the gonad from the posterior end (Figure 11). Male gonads were more symmetrical and did not appear joined *in situ*. The eight female *T. georgii* had a mean gonosomatic index (GI) of 0.414. Gonosomatic indices for female *T. georgii* from specimens caught off the northeastern coast of the United States in the summer were compared to 4 specimens caught in the Sargasso Sea in the winter. ANOVA did not indicate any significant difference in GI between the two strata ( $F=1.31$ ;  $df=1, 6$ ;  $P>0.05$ ). One female specimen, M36SPG8, exhibited a rare abnormality of only having a single, large gonad (Figure 12). One of the authors examined a female specimen (M27SPG2) that was extremely gravid when caught in the Sargasso Sea area in January, 2004. This specimen was also one of the largest specimens (1850 cm) documented in this study.



Figure 11. Lab photograph of gonads from a female *Tetrapturus georgii*.





Figure 12. *In situ* photograph of single gonad found in female *Tetraodon georgii*, specimen number M36SPG8.

### *Feeding ecology*

Gut contents for the whole specimens were not examined; approximately 30 % of the whole specimens had empty and everted stomachs. The bait type used to catch the fish examined and observed in this study was mostly Atlantic mackerel *Scomber scombrus*, but some were captured using squid bait. Hook timer data for three specimens caught off the northeastern United States in summer suggested daylight feeding activity (assumed bite times of 1845, 1452, and 1045 hrs). This is consistent with daylight feeding activity suggested by hook timer data for *T. albidus* and *T. pfluegeri* (L. Beerkircher, NMFS Pelagic Observer Program, unpublished data).

### *Spatial and temporal distribution*

Capture locations for both the 16 whole specimens and the 76 observed individuals fitting criteria for *T. georgii* are shown in Figure 13. Five of the whole specimens we examined were captured off the northeastern United States region (NEC) in July and August; two of these individuals were captured in approximately 800 m bottom depth just west of Veatch Canyon (approximately 160 km south of Cape Cod), the other three were caught off the edge of George's Bank about halfway between Lydonia and Corsair canyons in about 1000 m bottom depth. Sea surface temperatures for these five specimens were between 21.5 and 24.4 EC. The other eleven whole specimens were captured in January in the Sargasso Sea region of the western North Atlantic (SAR) and adjacent waters northwest of the Bahamas (FEC); at about 5000 m bottom depth and sea surface temperatures between 23.1 and 24.2 EC.



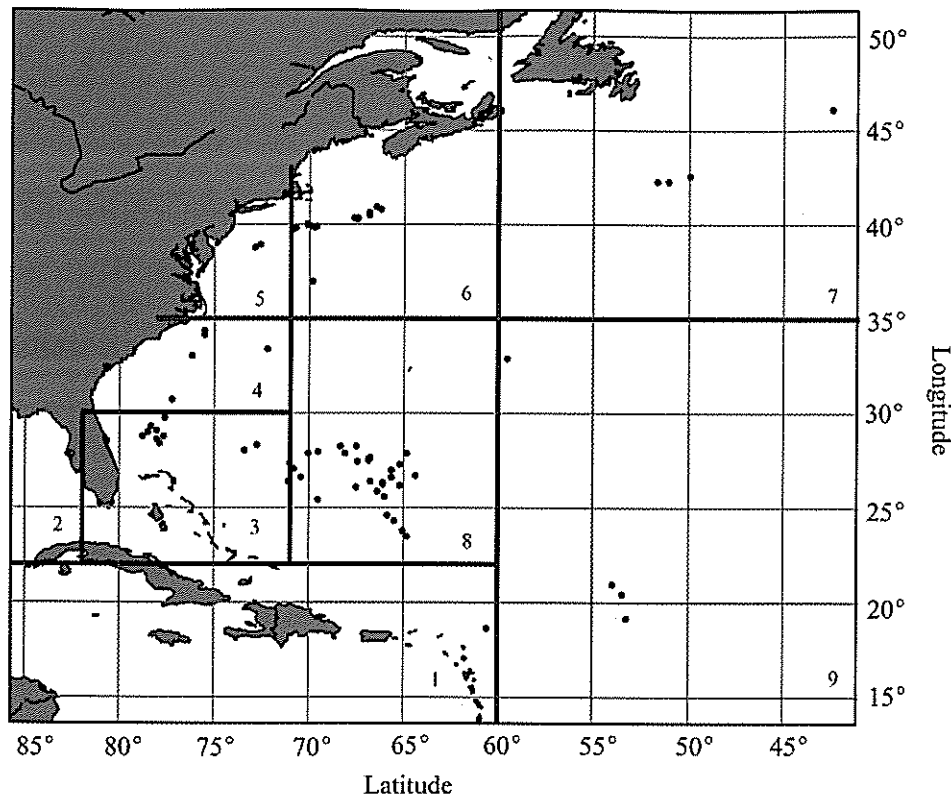


Figure 13. Locations of pelagic longline sets in the western North Atlantic that captured confirmed *Tetrapturus georgii*. Numbers represent statistical areas defined in Figure 1. Note that some sets captured multiple individuals.

These data, combined with location and temperature data from other observed individuals that fit our criteria for *T. georgii*, indicate this species is widely distributed in the western North Atlantic but exhibits certain patterns of spatial and temporal concentration. Forty-six percent of *T. georgii* were recorded from the SAR. All of these fish were observed in the months of December and January. The next greatest numbers were observed in the NEC mostly in the months of July and August; and the FEC in January, March and April (21%, and 16 %, respectively). Most other individuals were recorded in more or less equal amounts from off the coast of the Carolinas below Cape Hatteras (SAB), off the Grand Banks of Newfoundland (NED), and in the central Atlantic (NCA); a few individuals were captured near the Caribbean (CAR) and off the mid-Atlantic coast (MAB). Both collected specimens and observed individuals were captured most frequently in water with a surface temperature between 22.0 and 25.9 EC (Figure 14) and where the bottom depth exceeded 4000 m (Figure 15).

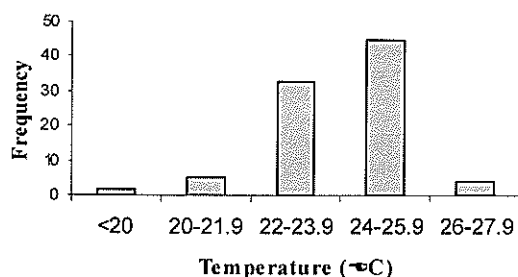


Figure 14. Frequency of capture for temperature ranges for *Tetrapturus georgii* in the western North Atlantic.

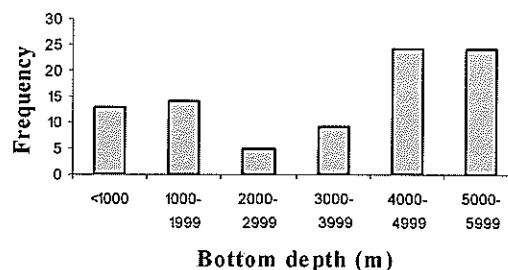


Figure 15. Frequency of capture for bottom depth ranges for *Tetrapturus georgii* in the western North Atlantic.

*Tetrapturus georgii* CPUE and species ratios of Istiophoridae observed during 18 trips by one of the present authors (GH) are shown in Table 5. The greatest CPUE, 1.39 *T. georgii* per set, occurred in the SAR during the winter; the next highest CPUE, 1.33, was seen in the FEC (northwest of the Bahamas) during the winter. In the SAR and NCA, *T. georgii* was by far the most common billfish observed.

Table 5. Season, number of sets, and locations of pelagic longline gear deployments that captured Istiophoridae from observations made by one of the current authors. See Figure 1 for definition of locations. WHM = *Tetrapturus albidus*, SPG = *T. georgii*, SPF = *T. pfluegeri*, SPX = unknown spearfish, BIL = unknown billfish, BUM = *Makaira nigricans*, SAI = *Istiophorus albicans*. SPG CPUE = catch per set of *T. georgii*.

| Season | Sets | Location | WHM | SPG | SPF | SPX | BIL | BUM | SAI | SPG CPUE |
|--------|------|----------|-----|-----|-----|-----|-----|-----|-----|----------|
| Summer | 13   | NED      | 0   | 4   | 0   | 0   | 0   | 0   | 0   | 0.31     |
| Summer | 28   | NEC      | 13  | 7   | 4   | 3   | 1   | 4   | 0   | 0.25     |
| Fall   | 15   | NEC      | 0   | 0   | 0   | 0   | 0   | 1   | 0   | 0.00     |
| Fall   | 10   | MAB      | 0   | 0   | 0   | 0   | 0   | 1   | 0   | 0.00     |
| Fall   | 11   | SAB      | 0   | 0   | 8   | 0   | 0   | 1   | 0   | 0.00     |
| Spring | 19   | SAB      | 21  | 5   | 0   | 1   | 0   | 7   | 7   | 0.26     |
| Spring | 12   | GOM      | 7   | 0   | 1   | 0   | 7   | 4   | 1   | 0.00     |
| Winter | 15   | CAR      | 15  | 2   | 3   | 1   | 1   | 13  | 5   | 0.13     |
| Winter | 23   | SAR      | 5   | 32  | 0   | 3   | 2   | 6   | 0   | 1.39     |
| Winter | 20   | NCA      | 0   | 10  | 1   | 2   | 2   | 4   | 0   | 0.50     |
| Winter | 6    | FEC      | 0   | 8   | 0   | 0   | 2   | 8   | 0   | 1.33     |
| Winter | 13   | TUS/TUN  | 121 | 0   | 7   | 1   | 13  | 67  | 127 | 0.00     |
| Summer | 4    | TUS/TUN  | 2   | 0   | 0   | 0   | 0   | 1   | 5   | 0.00     |

### Temporal change in observations

Comparisons of the observed numbers of *T. georgii*, *T. albidus*, and roundscale/white marlin (2007 only) indicated high observations of *T. albidus* and low observations of *T. georgii* during the time periods that correct identification criteria were not widely distributed and stressed to observers (Figure 16). However, as correct identification information was more widely disseminated the relative percentage of *T. georgii* observed in the *T. albidus* / *T. georgii* species complex increased. Further, the introduction of the species code WHX in 2007 seems to have had a greater effect on the percentage of observed *T. albidus* than on *T. georgii*.

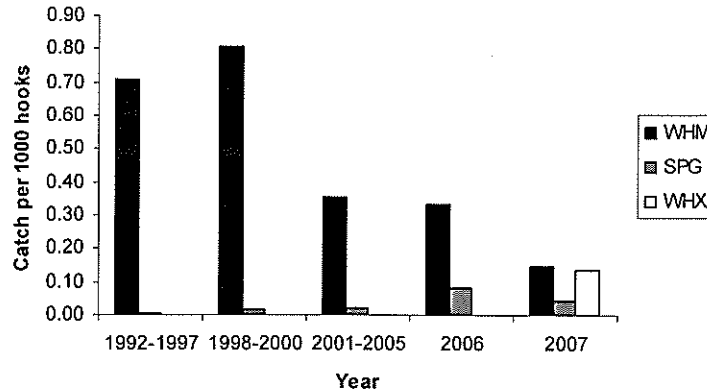


Figure 16. Catch per unit effort observed in different temporal strata for *Tetrapturus albidus* (WHM), *T. georgii* (SPG) and individuals that could not be conclusively identified, but were either *T. albidus* or *T. georgii* (WHX, 2007 only).

### Hatchet marlin

Examination of our photographs resulted in the identification of six individuals exhibiting truncated anterior lobes of the first dorsal and anal fins (many other photographs suggested such traits, but were not counted due to poor quality, insufficient lighting, etc). Of these six, four were conclusively identified as *T. georgii* and two as *T. albidus*, based on AFA/AFH relationships and scale morphology (Figure 17). No photograph of *T. pfluegeri*, of any quality, exhibited characteristics of the hatchet marlin.

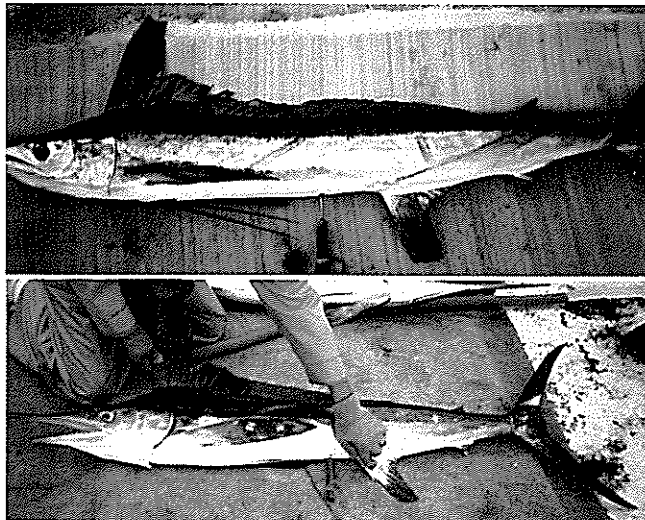


Figure 17. Examples of individuals exhibiting characteristics of the “hatchet marlin”. Top: *Tetrapturus georgii*, bottom: *T. albidus*.

## Discussion

Although our results showed some deviations from the morphometric information for *T. georgii* provided by Robins (1974a), the manner in which the whole specimens we examined match virtually all of the characters judged most diagnostic for *T. georgii* by that author leads us to conclude that the species in the present study is indeed *T. georgii*. Possibly the differences between the two studies can be attributed to intraspecific variability between populations on separate sides of the Atlantic, to the much smaller sample size of the eastern Atlantic specimens, or to variation in measuring by different measurements. In both studies the size range of the individuals examined was similar, and in each study there was not a preponderance of one sex, reducing the likelihood of allometric growth characteristics or potential sexual dimorphism affecting the comparison. Further studies of *Tetrapturus* from the eastern Atlantic, particularly around the region of Madeira, Portugal, and the straits of Gibraltar, are needed to build a larger sample size of eastern Atlantic *T. georgii* for both morphometric and molecular comparison to the western North Atlantic specimens.

The examinations and photographic evidence strongly suggests the possibility of species misidentification of *T. georgii* and *T. albidus*. Some of the more common characteristics used by fishermen and technicians to identify *T. albidus* in the field are shared characteristics in *T. georgii*. For example, often for *T. albidus* the first dorsal, first anal, and pectoral fin tips are described as “rounded”. Comparisons of data from the present study with the literature, as well as a review of photographs and field observations indicate there is little difference in fin shape between *T. albidus* and *T. georgii*. In fact, the profile of the first dorsal fin seems to exhibit a great degree of individual variability in both *T. albidus* and *T. georgii* and makes for a poor diagnostic criterion. The relative height of the 25<sup>th</sup> first dorsal spine from our data is comparable to literature values given for *T. albidus*. Another diagnostic character for *T. albidus* is the presence of multiple small, round, “polka-dot” like dark spots on the first dorsal fin. While we have not noted the presence of spots in *T. georgii*, we have observed specimens of *T. albidus* (both live and fresh dead) that did not exhibit dorsal fin spots. Therefore while we believe the presence of spots may be a strong positive identification character for *T. albidus*, the absence of spots is not necessarily a negative indicator. Our observations, although limited to a single live specimens and one fresh dead specimen, also suggest that, at least in some cases, the coloration of live *T. georgii* can be similar to live *T. albidus* in that these species may exhibit lateral stripes.

We propose that the identification criteria for *T. georgii* initially provided by Robins (1974a) be updated to reflect that the lobes of the first dorsal and first anal fins are often truncated rather than rounded and that the position of the anus be expanded and clarified from “about half the height of the first anal fin” to an AFA/AFH value between 0.48 to 0.81 or about half to three-quarters the height of the first anal fin. We believe that in the western North Atlantic *T. georgii* can almost invariably be separated from *T. albidus* and *T. pfluegeri* on the basis of only two characters; AFA/AFH relationship and lateral scale morphology. Further, our experience suggests that in the majority of the cases, an AFA/AFH relationship of between half to three quarters alone is diagnostic for the roundscale spearfish. Our field observations and morphometric data collected for the three western North Atlantic *Tetrapturus* congeners have shown very little overlap between these species for the AFA/AFH relationship. Observers have measured two *T.*

*albidus* where AFA/AFH measured 0.53; although there were no photos available to cross check the field measurements, both scale morphology and molecular analysis has confirmed these specimens were *T. albidus* (M. Shivji, pers. comm.). Overlap between AFA/AFH relationships of *T. georgii* and *T. pfluegeri* are suggested when comparing our current *T. georgii* data with those *T. pfluegeri* data found in older scientific literature; however, we have never observed overlap in our field studies.

Our use of AFA/AFH as an identification criterion was necessitated by the methods available to measure specimens on board fishing vessels (tape measures) as well as being the most practical measurement to analyze photographs. For comparison with the literature, a more consistent descriptor of the anal position would be the distance between the anal opening and the anterior origin of the first anal fin expressed as a percentage of body length. Indeed, specimens of Istiophoridae are sometimes seen with deformities of (or injuries to) the anal fin, which would render the criterion we propose here inaccurate. We believe, however, that deformed fins are usually readily apparent to even relatively inexperienced observers. None of the specimens we examined for this study, either in the laboratory or shipboard, had any deformities of the first anal fin, and no photographs of any specimens suggested injury or deformities. We suggest such deformities are relatively rare, and further suggest the AFA/AFH identification criterion is much more practical for use in the field than AFA expressed as a percentage of body length, particularly with a live fish in the water at boatside. In addition, one of the specimens we examined (M36SPG3) had a deformity of the lower jaw; in this case the AFA/AFH relationship provides a much more accurate description of anal opening location than the method typically used in the literature.

Examination of the internal morphology of the whole *T. georgii* specimens suggests a large degree of similarity with *T. albidus*. There were, however, distinct differences in otolith morphology. In most other sagittal otoliths from Istiophoridae, usually the rostrum is extended relative to the antirostrum, with the latter usually about one third as long as the former; no other northwestern Atlantic Istiophoridae exhibits a similar morphology (Radtke, 1983).

The distribution of *T. georgii* in the western North Atlantic shows the spatial and temporal variation typical of large, highly migratory pelagic species. We have confirmed the presence of this species in 7 of the 11 geographic areas defined by NMFS (Figure 1). The two areas where we have not identified *T. georgii* (Gulf of Mexico and Mid Atlantic Bight off the U.S. east coast) are both adjacent to areas where we have identified the species; we see no reason why this species would not be found in these areas. Spatially, the number of specimens observed was greatest in the SAR, followed by the FEC and the NEC. However there is a temporal limitation to this distribution; the individuals in the SAR and FEC were observed in the winter and spring, those in the NEC mostly in the summer. The fishery-dependent nature of the observer data is a very important factor to consider when attempting to define the distribution of *T. georgii*. For example, of 101 observed sets in the SAR, only 4 were observed in months other than December, January, and February. Thus, little to no observer coverage took place in the area of greatest *T. georgii* abundance during March through November, and abundance of *T. georgii*, as well as other Istiophoridae, in these areas during these months is unknown.

In fact, our records are not only fishery dependent but “observer dependent” as well; certain observers were much better informed as to the possibility of encountering *T. georgii*, and of the identification criteria to separate this species from *T. albidus*. Deployment of these observers into the Gulf of Mexico was limited; further, in the GOM it is not common for longline fishermen to bring billfish bycatch on board for close

examination (S. Allen, NMFS Fishery Observer, pers. comm.) which may account for the lack of observations in this area. Zero observations of *T. georgii* off the U.S. east coast (MAB), however, cannot be explained by this reasoning, but identification of multiple specimens from adjacent areas (NEC and the SAB), provide a rationale for the assumption that the species can be found in the MAB as well.

Perhaps more relevant than the nominal occurrence of *T. georgii*, however, is the ratio of this species to other members of the family Istiophoridae. The species ratio data we present suggest that during the winter in the SAR and NCA, *T. georgii* may be the numerically dominant species of Istiophoridae. Further, they suggest that in certain times or places where significant amounts of recreational fishing take place (summer NEC, spring SAB) this species might be more common than *T. pfluegeri* (the longbill spearfish), a species that is considered by western North Atlantic recreational fishermen to be rare (McClane, 1974). Clearly, *T. georgii* can be considered common in certain spatial and temporal strata in the western North Atlantic. The spatial distribution of the *T. georgii* in the western North Atlantic overlaps with both that of *T. albidus* (45E N – 35E S; Mather et al., 1975) and *T. pfluegeri* (40E N – 34E S; Robins, 1974c), but the southern range limit of *T. georgii* is difficult to determine as observer deployment was rare below 10E N. However, our data suggest large spatial and temporal overlaps in the distribution of all 3 western North Atlantic congeners of *Tetrapturus*. Although it will take an enhanced awareness of identification criteria throughout the recreational and commercial fishing industry, as well as the academic community, we speculate that as better data become available *T. georgii* might emerge as more common in the western North Atlantic than *T. pfluegeri*.

The distribution data, the identification difficulties, and the overall lack of awareness of the existence of *T. georgii* in the western North Atlantic is clearly an area of concern as *T. albidus* (white marlin) is a highly sought after gamefish whose recent declines in abundance have prompted proposals for increased regulatory protection, including listing under the Endangered Species Act (Anonymous, 2002). Several white marlin tournaments held along the east coast of the United States are very popular and economically important and may be “limited kill” tournaments where only potential tournament winning fish are brought back to the dock. The possibility that a tournament winning “white marlin”, worth \$1,638,915 in prize money (Jock, 2005), might not be a white marlin at all should be considered justification for raising the awareness of specific identification criteria that distinguish white marlin and roundscale spearfish.

Our review of photographs from confirmed specimens of *T. albidus* and *T. georgii* for features matching the “hatchet marlin” revealed that one of the main characteristics (truncated anterior lobe of the first dorsal and first anal fins) could be found occasionally in both species. We believe that such truncation is a rather common variation in both these species, especially in the case of the first anal fin, and conclude that this characteristic alone could not be diagnostic for a potential hatchet marlin. Another characteristic of the hatchet marlin described by one author (McClane, 1974) is pointed tips on the pectoral fins. Although this criterion is somewhat subjective, our photographic review shows no real differences in the pectoral fin shape for *T. georgii* and *T. albidus*. In all specimens, there was an angularity to the distal portion of the pectoral fin, although there was variation in the severity of the angle. Due to the subjective nature of this characteristic, the intraspecific variability we have observed, as well as the lack of mention of this characteristic by most of the other descriptions of this fish, we suggest this characteristic would not be diagnostic for a potential hatchet marlin. A third characteristic described, dark blotches on the lower portion of the first dorsal fin, can be seen in some of our photographs of both *T. albidus* and *T. georgii*, although the majority

of our photographs are from dead specimens and such marking might have faded. In any case, our experience is that dorsal fin coloration, including the often described distinct spots on the first dorsal of *T. albidus*, is somewhat variable and often absent. We therefore conclude that this criterion is also not ideal for identification of a potential hatchet marlin. A final criterion, described by Robins (1973) was rounded rather than pointed scales. Our examinations have shown that rounded scales occur only in *T. georgii*, which as noted previously may or may not exhibit the other characteristics described for hatchet marlin. Our review of the literature and our collection of observer records and photographs for evidence of the existence of the hatchet marlin does not suggest anything other than a slight morphological variant of either *T. albidus* or *T. georgii*, rather than a distinct species. For example, the specimen described by Pristas (1980) had some characteristics of the putative hatchet marlin (truncated first dorsal and anal fins) and some characteristics of *T. albidus* (position of anus relative to first anal fin, pointed scales); however, as noted above, the characteristics that indicated this specimen might be a hatchet marlin are not diagnostic, while the characteristics that suggested *T. albidus* are quite diagnostic and are without overlap with either *T. georgii* or *T. pfluegeri*. Therefore the Pristas (1980) specimen was almost certainly a white marlin. Although the existence of a separate species of *Tetrapturus* needs further study, including examinations and molecular analysis of specimens deemed “hatchet marlin”, we believe that, rather than a distinct species, the “hatchet marlin” has its roots in fishing vernacular as a descriptive term, similar to calling small tunas of various species “football tuna”.

Our data presented here on the roundscale spearfish *T. georgii* illustrate how a large pelagic species can be overlooked for a lengthy period of time. For example, when discussing the possibility that the “hatchet marlin” and *T. georgii* were the same species, Robins (1974a) wrote “This species needs publicity in game-fish circles, with arrangements made to freeze specimens and bring them to the attention of appropriate scientists for study”. Nakamura (1985) concluded his synopsis of *T. georgii* with “Further study is strongly needed to clarify the validity of this species”. However, the roundscale spearfish faded from scientific view for the next twenty years. How this could have occurred during a time period of ever increasing interest in the biology, conservation, and management of billfishes is perhaps indicative of a tendency away from basic ichthyological techniques, such as collection of morphometric and meristic information, and towards more technologically advanced activities such as molecular biology, GIS analyses, and satellite tagging. We believe there are still basic questions to be answered in the family Istiophoridae; for example, how many species, and where do they occur? Answering these questions may require a renewed emphasis on the most elemental forms of data collection.

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