Gray triggerfish ageing summary for the northern Gulf of Mexico 1999-2017 with a description of ageing methods

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Introduction

The first dorsal spine has been the preferred ageing structure for gray triggerfish because otoliths are difficult to locate, extract and process due to their small (< 5 mm) size and irregular shape (Moore 2001; Bernardes 2002) and dorsal spines are relatively easy to sample and process for ageing. Use of dorsal spines as an ageing structure for Gulf of Mexico (GOM) gray triggerfish dates to the early 1980s (Johnson and Saloman 1984). For recent assessments, dorsal spines have been processed and aged at the National Marine Fisheries Service, Southeast Fisheries Science Center in Panama City, Florida along with cooperative partners: Gulf States Marine Fisheries Commission, Ocean Springs, MS, Florida Fish and Wildlife Research Institute, St. Petersburg, FL and University of South Alabama, Dauphin Island Sea Lab, Dauphin Island, AL. This report summarizes age data made available for the SEDAR 62 GOM gray triggerfish standard assessment for collection years 1999 to 2017 and describes ageing methods in order to address concerns about how ages were assigned that were raised by Chih (2018) in a SEDAR document titled: On aging procedures for multiple reef fish species.

Methods

Data collection

Gray triggerfish dorsal spines were collected through multiple state and federal programs which sampled commercial and recreational fisheries. The majority of spines were collected by the Trip Interview Program TIP, Southeast Recreational Head Boat Survey, Marine Fisheries Recreational Statistical Survey MRFSS (includes MRIP) and the Recreational Fisheries Information Network-RECFIN. Dorsal spines were also collected through federally funded fishery-independent surveys conducted by NMFS Panama City-PCLAB, NMFS Pascagoula MS-MSLAB and by state funded surveys conducted by the Florida Fish and Wildlife Research Institute-FWRI and the Dauphin Island Sea Lab-DISL. The Cooperative Research Program (CRP) and the Expanded Annual Stock Assessment Survey (EASA) also provided dorsal spines and gonads with detailed capture locations. At-sea collection of dorsal spines and gonads from the commercial industry were made possible through two observer programs: NMFS Panama City Shark Bottom Long-line Observer Program and NMFS Galveston Reef fish Observer Program. Length was recorded as fork length (FL; mm), natural total length (NTL; mm) or maximum total length (MTL; mm), weight (whole or gutted; kg) and sex were recorded if the fish was landed whole. FL (mm) was selected for SEDAR 62 analysis and if not recorded was converted from NTL or MTL using the equations: $FL = 0.81*(NTL) + 24.36$, $FL = 0.79*(MTL) + 21.28$.

Age determination

Dorsal spines were processed using the methods described in Allman et al. (2017). An ageing protocol was established through workshops conducted by the Gulf States Marine Fisheries Commission and a set of annotated dorsal spine section digital images was created to train readers (Fioramonti and Allman 2012). Spine sections were viewed with a dissecting microscope under 10-40x magnification with transmitted light and the number of translucent zones present were counted. Opaque zones representing faster growth are relatively wide, and zones corresponding to slow growth periods are narrow and appear translucent under transmitted light (Lessa and Duarte-Neto 2004; Allman et al. 2016). The margin of each spine section was recorded as translucent or opaque and a readability code of good, fair, difficult, poor processing or unreadable was assigned. The number of translucent zones visible including any partial translucent zone on the margin was used to assign a calendar age. Annual deposition of translucent zones has been validated in gray triggerfish using OTC marked fish (Allman et al. 2016). Fish with zero translucent zones, caught from January to June were advanced to calendar age 1, fish caught from July to December and FL ≥ 160 mm were assigned to a calendar age of 1 and if the fish was < 160 mm, then a calendar age of 0 (SEDAR 2016).

A gray triggerfish reference collection composed of thin sectioned dorsal spines (n=115) was exchanged between GOM ageing laboratories. Dorsal spines were selected from gray triggerfish from a wide range of lengths (75-580 mm FL) and ages (1-12 yr). Average percent error (APE) in translucent zone counts between readers was computed with the method of Beamish and Fournier (1981) :

$$\frac{1}{N} \sum_{j=1}^{N} \left[\frac{1}{R} \sum_{i=1}^{R} \frac{Xij - Xj}{Xj}\right] ,$$

where N = number of samples ages, R = number of times fish was aged, X_{ij} is the ith age determination of the jth fish, and X_j is the average age calculated for the jth fish. APE was computed for each laboratory's age and a reference age assigned by an experienced ager. Ageing error was also estimated by calculating the standard deviation at age for each laboratory by the reference set age.

Gray triggerfish mean length at age was plotted by quarter and gear type for the PCLAB age dataset to addresses concerns that ages were assigned improperly as hypothesized by Chih (2018).

Results and Discussion

Data collection

Samples were obtained largely from the eastern GOM with Florida collections representing 56% of all ages (Table 1). Since the last assessment sampling has been similar to or greater than in previous years. In 2016, there was an increase in ages from RECFIN, as well as additional ages provided by DISL. Recreational hook and line was the most common gear type representing 40% of ages, followed by commercial hook and line at 27% (Table 2). Fishery-independent surveys collected fish using multiple gear types (neuston net, trap, trawl, spear, hook and line and vertical long-line) which accounted for about a quarter of all age samples.

Size and age distributions

Length frequency distribution indicated that gray triggerfish were sampled throughout most of their life cycle from the juvenile pelagic to adult stage (24 to 697 mm; Fig. 1a). Seven exceptionally large length measurements (773-1030 mm FL) were recorded from the same intercept and were excluded, since these fish were probably recorded incorrectly as FL instead of TL. The DISL collected the smallest pre-settlement individuals by sampling the plankton with neuston nets and fishery independent trawls collected newly settled individual (Table 3). Commercial hook and line and long-line collected the largest adults (mean size 415 and 469 mm FL respectively) with recreational hook and line fish smaller on average (380 mm FL).

Ages ranged from 0 to 14 years (Fig. 1b). Almost all pre-settlement gray triggerfish were age 0, while average age of trawl caught fish was 1.9 years (Table 3). Other fishery independent gears (hook and line and trap) also tended to target younger ages. Commercial long-line collected the oldest individuals (mean = 5.9 yr), followed by commercial hand-line (mean = 4.4 yr) and recreational hook and line (mean = 4.2 yr).

Ageing error

Ageing error was estimated using APE and standard deviation from the reference set ages. Average percent reader error was high compared to most other GOM species aged using otoliths (Table 4). The reference set has been aged twice since the last assessment and APE ranged from 4.7 to 16.2. Gray triggerfish are considered a difficult to age species, therefore an APE $\leq$ 10% was selected as an ageing error target. Three of the five ageing laboratories were above this target, however two of these laboratories had improved to near this target for the most recent ageing exercise. Standard deviation increased with age for most age classes (Fig. 2). Ageing error estimates are incorporated into the stock assessment models to take into account the imprecision and bias associated with multiple ageing laboratories.

Temporal differences in size-at-age

A report by Chih (2018) suggests that due to ageing "procedural problems" that there is a difference in length at age in gray triggerfish by quarter for fish younger than age 7. The report claims that on average fish are larger at age in the early part of the year and that this effect is due to ageing procedures. However, after duplicating Fig. 1 in Chih (2018) it was apparent that gears were combined; most records were hook and line gear (n=8300) followed by trap (n=1121) and trawl (n=539) and few records from other gears. Smallest fish at age were caught in trap and trawl versus hook and line. However, there were no quarter 1 (January – March) gray triggerfish in gears trap and trawl. Thus with quarterly comparisons by size at age, this makes quarter 1 look like an anomaly as the dominant gear is hook and line. Based only on hook and line gear, the difference in size-at-age between quarter 1 and other quarters is negated, even for age-one fish where sample size is low (n = 11) (Fig. 3).

As to the assertion by Chih (2018) that length-at-age averages decrease by quarter when they should increase, the decreasing trend is also negated when comparing within gear. Chih (2018) asserts that length-at-age should generally increase in successive quarters. Only fishery-independent trap gear shows generally increasing average length at age by quarter (Fig. 4). Thus seasonal patterns of length-at-age may depend on the particular gear and nuances of the fishery (inshore versus offshore, etc.). We note that the pattern for hand-line (Fig. 3) is quite different than for trap gear (Fig. 4).

The Chih (2018) report also suggests there is a problem assigning age for gray triggerfish since there wasn't one clear annual peak in translucent zones by month. This phenomenon has been described previously in GOM gray triggerfish (Allman et al. 2016; Ingram 2001). It has been observed that during the spawning season both males and females exhibit limited feeding due to their territoriality and resistance to capture by baited hooks and traps (Ingram 2001; Mackichan and Szedlmayer 2007). Ingram (2001) hypothesized that the appearance of "doublets" (2 bands formed closely together) in spines was due to winter deposition of a translucent zone caused by lower metabolism followed by temporary fasting of spawning/nesting triggerfish during summer (Fig. 5). Since these translucent zones were closely spaced in relation to other translucent zones, we counted these as one annulus. The winter/spring translucent zone is generally more obvious than the summer translucent zone, however there is often another peak in translucent margins later in the year (Fig. 6). Since this could lead to some ages being advanced incorrectly, age for gray triggerfish equals translucent count. This is consistent with all published GOM gray triggerfish age and growth studies. The NMFS Beaufort lab advances ages since there is likely a more distinct difference in opaque and translucent zones. Generally at higher latitudes increments in otoliths and in spines are more distinct than in more semi-tropical areas.

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Table 1. Number of gray triggerfish ages by collection year and state landed.

Year	AL	FL	LA	MS	TX	Total
1999				2		2
2000				3		3
2002				60		60
2003		149				149
2004		164				164
2005		269			1	270
2006		274				274
2007	46	234	180	4	69	533
2008	34	417	169	1	5	626
2009	57	541	92	6	49	745
2010	115	324	21		34	494
2011	197	412	66		27	702
2012	136	482	268		41	927
2013	198	582	337		41	1158
2014	76	366	287		8	737
2015	65	494	516		24	1099
2016	964	1756	419		1	3140
2017	338	461	378		4	1181
Total	2226	6925	2733	76	304	12264
Percent	18	56	22	1	3	

Table 2. Number of gray triggerfish ages by mode (CM-commercial, REC- recreational (includes charter boat, head boat and private vessels), FI- fishery-independent) and by gear (HL- hook and line, LL-longline, SP-spear, VLL-vertical longline, TR-trap, TRW-trawl, NEU-neuston net) and by state landed (1999-2017).

Mode & Gear	AL	FL	LA	MS	TX	Total	Percent
CM_HL	14	1045	2204	4	19	3286	27
CM_LL		672				672	6
CM_SP		23	6			29	0
CM_VLL		5				5	0
FI_HL	818	353	2		3	1176	10
FI_NEU	51			65		116	1
FI_SP	22	11				33	0
FI_TR		1184			2	1184	10
FI_TRW	19	417	39		84	559	4
FI_VLL	168	2				170	1
REC_HL	1131	3149	397	1	190	4868	40
REC_SP	2	30	4	6	6	48	0
Total	2225	6891	2652	76	304	12146	

Table 3. Summary statistics (range, mean, standard deviation) of aged GOM gray triggerfish (CM – commercial, REC- recreational (includes charter boat, head boat and private vessel), FI- fishery-independent) and by gear (HL-hook and line, LL-longline, SP-spear, TR-trap, TRW- trawl, NEU-neuston net, VLL-vertical longline) for all years combined (1999-2017).

Mode & Gear	n	Fork length (mm)	Age (yr)
CM_HL	3283	208 - 624	1 - 10
		415 ± 57.3	4.4 ± 1.4
CM_LL	672	229 - 697	2 - 14
		469 ± 78.2	5.9 ± 1.8
FI_HL	1166	220 - 605	1 - 9
		394 ± 76.2	3.8 ± 1.3
FI_NEU	116	24 - 157	0 - 1
		65 ± 27.5	0 ± 0.1
FI_TR	1177	120 - 50.5	0 - 8
		305 ± 52.2	3.4 ± 1.3
FI_TRW	540	74 - 559	0 - 11
		205 ± 73.7	1.9 ± 1.5
FI_VLL	170	297 - 617	2 - 10
		449 ± 73.8	4.2 ± 1.6
REC_HL	4786	164 - 1030	1 - 11
		380 ± 56.1	4.2 ± 1.4

Table 4. Average percent reader error (APE) by ageing laboratory and year of reading.

Laboratory	2016	2017
1	4.7	5.3
2	6.2	7.7
3	14.5	10.6
4	16.2	10.3
5	14.5	14.7

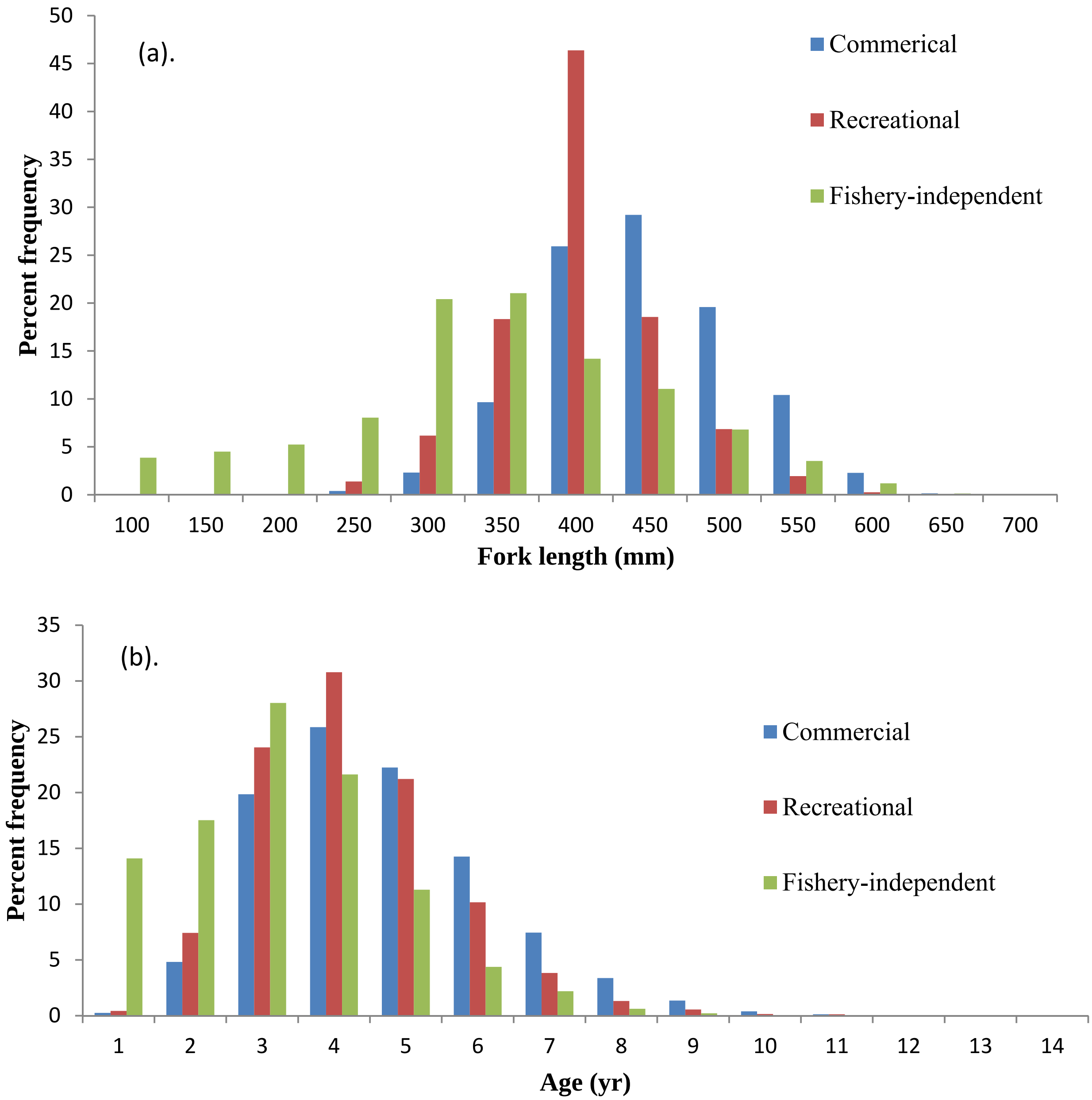

Figure 1. Gulf of Mexico gray triggerfish (a). length and (b). age frequencies by fishing mode for all years combined (1999-2017).

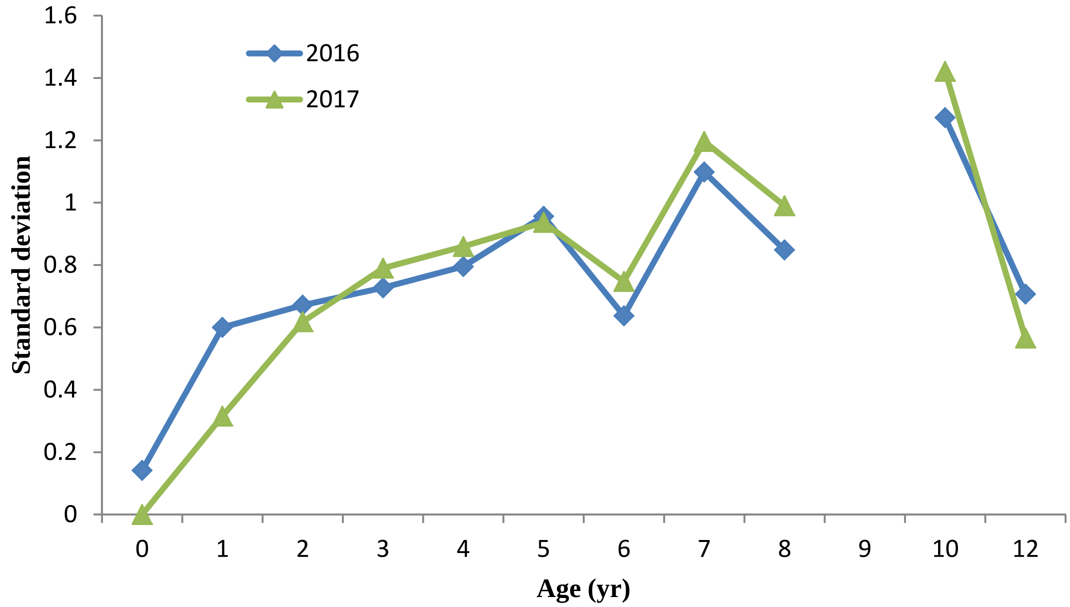

Figure 2. Mean standard deviation for the five Gulf of Mexico ageing laboratories for the reference set ages.

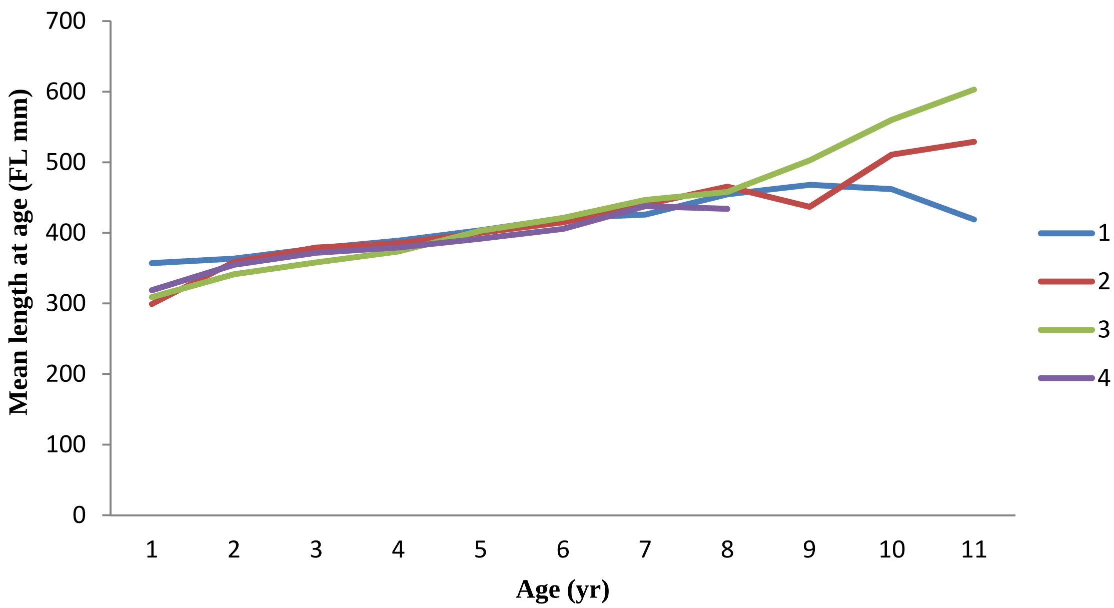

Figure 3. Length-at-age for hook and line samples (recreational, commercial and fishery-independent) for the Panama City dataset (n = 8300) by quarter.

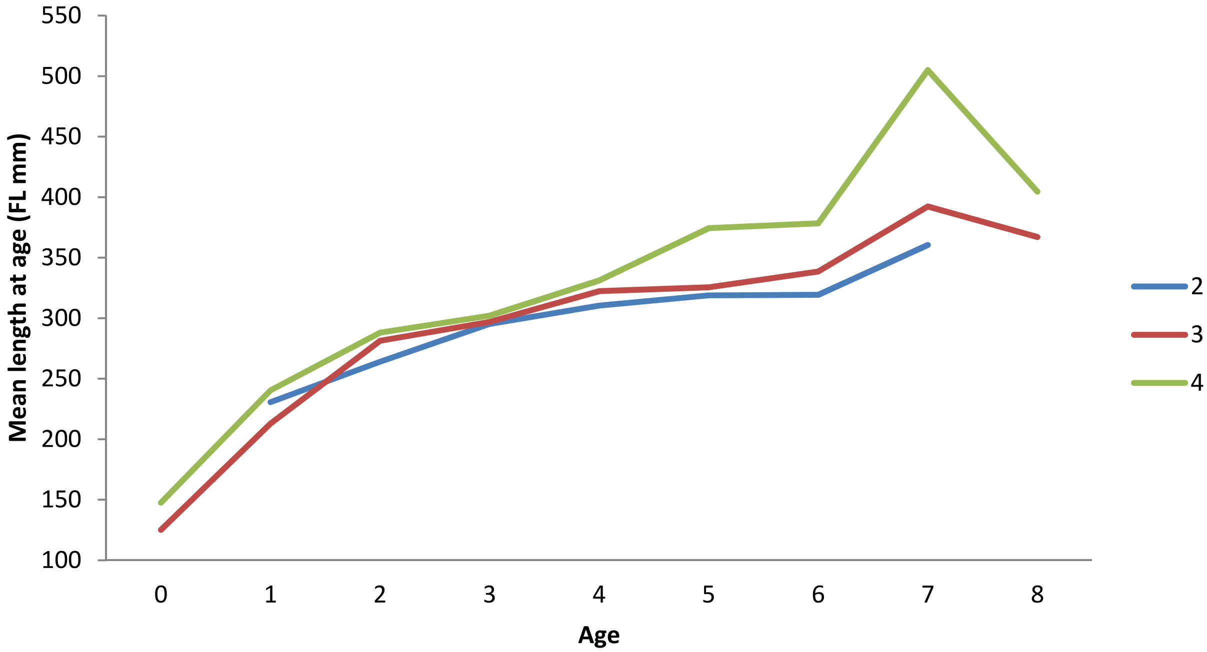

Figure 4. Length-at-age for fishery-independent trap samples from the Panama City dataset all years combined (n = 1121) by quarter of the year. There were no observations for the first quarter.

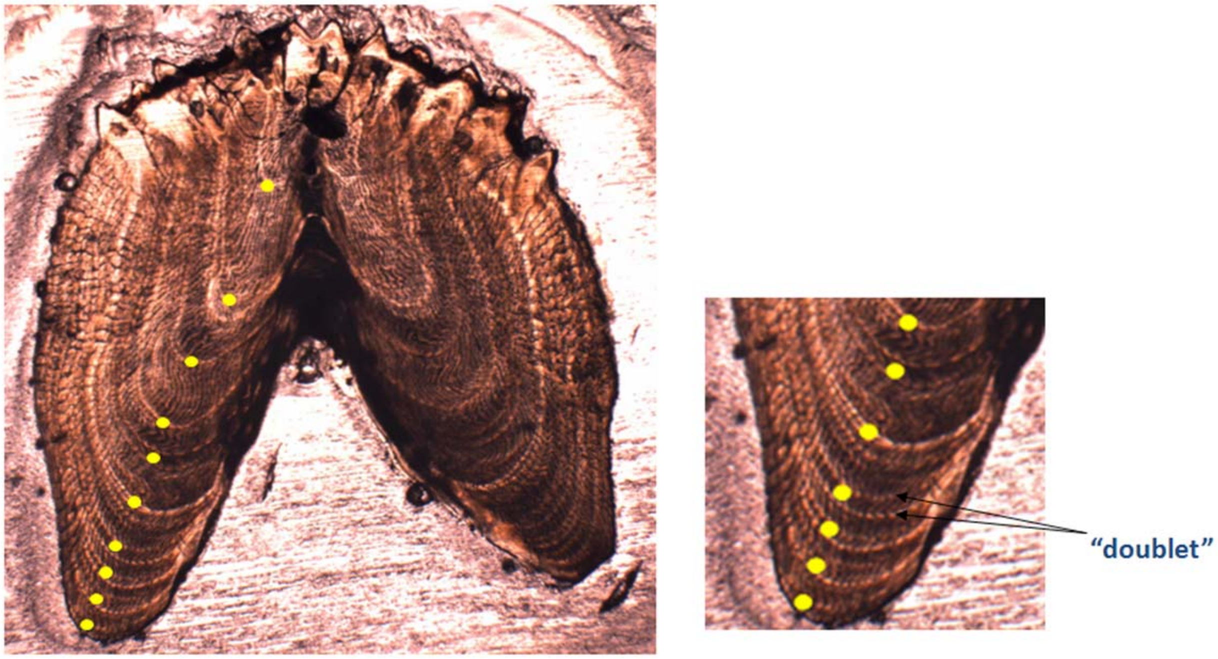

Figure 5. Digital image of dorsal spine section from a 514 mm FL, age 10 Gray Triggerfish with “doublet” pattern magnified (right) from Allman et al. (2016).

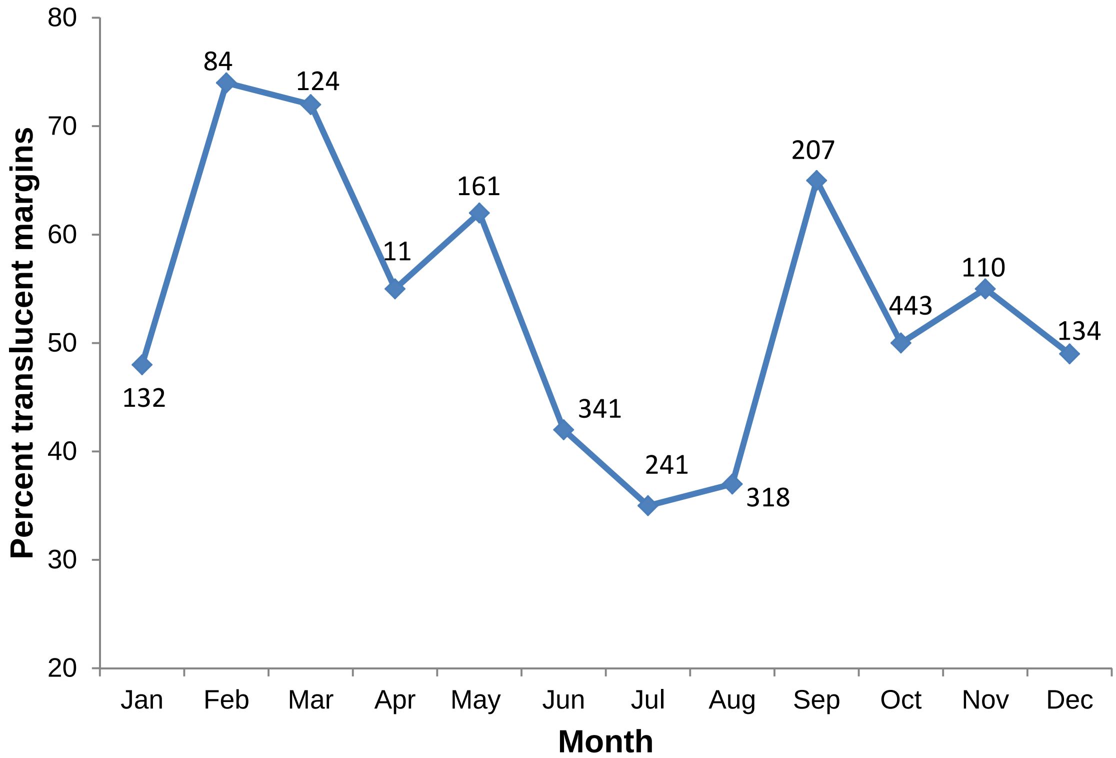

Figure 6. Percent translucent margin in Gulf of Mexico Gray Triggerfish dorsal spines collected from 2003-2010 (n = 2,411). Numbers indicate monthly sample size from Allman et al. (2016)