Potential of Fin Spines and Fin Rays for Estimating the Age of Tripletail, *Lobotes surinamensis*, from the Northern Gulf of Mexico

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ABSTRACT

The tripletail, *Lobotes surinamensis*, is a migratory, pelagic species that occurs throughout the tropical and subtropical seas of the world. In the western Atlantic Ocean tripletail occur from Massachusetts to Argentina, including Bermuda, and throughout the Gulf of Mexico and the Caribbean Sea. The tripletail supports a recreational fishery in the Gulf of Mexico, however, life history data required for stock assessment of Gulf tripletail are lacking. In a preliminary investigation of age and growth of tripletail from the northern Gulf of Mexico, 10 hardparts (dorsal fin spines #1 - 5, anal fin spines #1 - 3, the left pelvic fin spine and the first anal fin ray) from each of 10 specimens caught in the northern Gulf recreational fishery during 1996 - 1997 were examined for legibility of growth patterns on transverse thin-sections and usefulness in age estimation. Transverse sections of dorsal spines #2 - 5, anal spines #2 and #3, the left pelvic spine, and the first anal ray generally revealed only ambiguous markings and large eroded areas which essentially rendered them ineffective as ageing structures. Sections from 50% of the first anal spines were marginally acceptable. Most (90%) of the first dorsal spine sections revealed a succession of distinct, alternating opaque and translucent bands. Though not validated as annuli, translucent bands (typically comprised of multiple small rings) on first dorsal spine sections were considered probable indicators of age and were counted for a sample of 53 specimens. Interpretation of the early growth of a few large specimens was complicated by minimal vascular erosion of the first dorsal spine's central core region, however, readers were able to count with some degree of certainty the bands which were affected. Mean length-at-estimated age data based on translucent band counts were derived for the small sample.

KEY WORDS: Age, spines, tripletail, *Lobotes surinamensis*

INTRODUCTION

The tripletail, *Lobotes surinamensis* (Bloch), is a migratory, pelagic fish which inhabits the tropical and subtropical seas of the world (Merriner and Foster, 1974). In the western Atlantic Ocean tripletail occur from Cape Cod, Massachusetts (USA) to Argentina, including Bermuda, and throughout the Gulf of Mexico and the Caribbean Sea (Hardy, 1978; Robins *et al.*, 1986). Tripletail frequently associate with floating debris, artificial reefs, wrecks, pilings (Benson, 1982) and the pelagic drift-line community, including *Sargassum* (Ditty and Shaw, 1993).

Tripletail occur seasonally in bays, coastal estuaries and offshore waters of the Gulf of Mexico (Gulf), and, although not considered exceedingly abundant in the Gulf, the greatest concentrations of *L. surinamensis* are reported to occur in northern Gulf waters (Baughman, 1941). Tripletail typically occur in the northern Gulf from April through October and are considered common along the Mississippi coast during summer months (June through September) (Baughman, 1941), during which time adult specimens are taken from the Mississippi Sound and Gulf waters near the barrier islands. Juvenile tripletail apparently are not uncommon in northern Gulf estuaries (including the Mississippi Sound) during summer (Ditty and Shaw, 1993). The seasonality of tripletail occurrence in the northern Gulf suggests a migratory pattern characterized by a movement into northern Gulf waters in spring and a return to the southern Gulf during fall and winter. The extent to which *L. surinamensis* utilizes northern Gulf estuaries and coastal waters during its life history is unknown (Ditty and Shaw, 1993).

The tripletail supports a recreational fishery in the northern Gulf and is caught incidentally in commercial fisheries. With the exception of the State of Florida (USA) which regulates the recreational catch and commercial harvest of tripletail by gear restriction (hook and line only), minimum size (381 mm total length) and daily bag and possession limits (recreational, two fish per person; commercial, 10 fish per person) (Mike Ramsey, Florida Marine Patrol, pers. comm., December 1996), tripletail are not managed in U.S. waters. Published information on the biology of *L. surinamensis* is scant, and life history data required for stock assessment of tripletail in the Gulf of Mexico are lacking.

Gudger (1931) assigned a hypothetical age of one year to a very small tripletail (15 mm) collected off Cape Lookout, North Carolina (USA), and Merriner and Foster (1974) used the scale method to age fourteen specimens (ages 0 - 4 years) from North Carolina waters. Those two papers represent the only published accounts of age and growth of tripletail from the east coast of the United States. The age and growth of *L. surinamensis* from the Gulf of Mexico are lacking in the published literature.

Three authors of this paper (JSF, JRW and NMG) previously examined sagittal otoliths (whole and cross-sectioned) removed from a sample of northern

Gulf tripletail collected during 1996 and found markings which were difficult to interpret as growth bands. Based upon those findings, we initiated research in 1996 to further evaluate tripletail sagittae as ageing structures. The results of those ongoing studies will be reported at a future time. In an effort to investigate the possible use of other hardparts for ageing tripletail, we also conducted a small-scale, preliminary study of dorsal, anal and pelvic fin spines and anal fin rays. The objectives of our study were to assess the legibility of transverse sections from fin spines and rays and to investigate the potential of presumed growth markings on legible sections for age estimation. The results of that preliminary study are reported in this paper.

MATERIALS AND METHODS

Tripletail examined in this study were caught in an area of the northcentral Gulf of Mexico (88°25'W - 89°10'W long.; apex of southern boundary, 29°30'N lat.; Figure 1) located off the State of Mississippi (USA). Specimens were caught by hook-and-line gear in the recreational fishery during fall of 1996 and spring-summer of 1997 and were opportunistically sampled by us dock-side or at sport fishing tournaments along the Mississippi Gulf coast. Three small juvenile fish collected by dip-net from coastal waters also were included in our sample. Total length (TL, mm), total weight (TW, g), sex and catch date were recorded for most of the specimens examined in our study. The specimens used in our small-scale study were collected as part of an ongoing (1996 -) preliminary life history study of *L. surinamensis* from the northern Gulf.

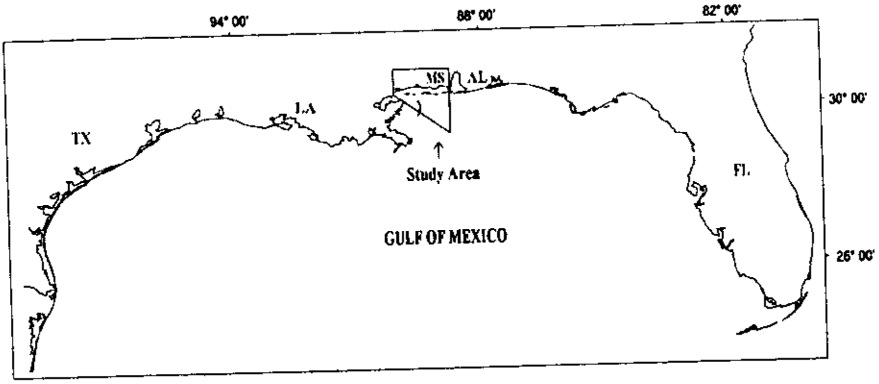

Figure 1. Location of the study area in the northern Gulf of Mexico from which tripletail, *Lobotes osurinamensis*, were collected during 1996 and 1997.

Analysis of hardpart legibility

Dorsal fin spines (#1 - 5), anal fin spines (#1 - 3), the left pelvic fin spine and the first anal fin ray were removed from each of 10 specimens (five males and five females) which represented a wide-range of sizes, labeled with a collection number and stored frozen until processed. In the laboratory, spines and rays were thawed, thoroughly cleaned of excess flesh and tissue, washed with water and air-dried (>24 hours).

Spines and rays were embedded in epoxy, and transverse cuts of varying thicknesses were made, using a Buehler Isomet low-speed saw with a diamond wafering blade, along the length of each structure beginning at the condyle base. Sections (cross-sections) were viewed under a dissecting microscope at 20 - 40x magnification using transmitted light which, for legible sections, revealed two types of markings, a translucent band that appeared white and an opaque band that appeared dark. Sections from several of the spines also were placed in a blackened-bottom watch glass containing clove oil (Manooch and Drennon, 1987) and viewed using reflected light which reversed the translucency and opaqueness of the markings. Even though preliminary observations immediately indicated that some of the hardparts had limited use as ageing structures, we, nevertheless, processed all 10 hardparts from each of the 10 specimens. Our appraisals and general conclusions on the legibility of each spine and ray were based upon observations of transverse sections using the following criteria: a clearly identifiable central core region and an obvious succession of fairly well-defined opaque and translucent bands.

Analysis of the first dorsal spine

Based upon our appraisal of all hardparts examined, the first dorsal spine (the smallest of the dorsal spines examined) was the only structure which consistently met the above legibility criteria, and an additional sample of the spine (n = 48; 21 males, 24 females and 3 unsexed juveniles) was processed, examined for legibility and further evaluated in an expanded study of the spine. A wide size-range of specimens was represented for both sexes in the sample. However, before the sample was processed for sectioning, spine length (SPL), defined as the distance from the top of the notch (hole) at the center of the condyle base to the spine tip, was measured (nearest 0.001 mm), and spine weight (SPW) was recorded (nearest 0.001 g) for some of the specimens. First dorsals were embedded in epoxy and, based upon our previous evaluation of first dorsal spines in the initial study, three serial cuts 0.24 mm thick were made above the condyle base at a location which represented ~25% of the spine's length, the area which typically provided the most legible sections. Spine sections were viewed as described above and were appraised for legibility following the above criteria. Illegible spines were excluded from further analyses.

Legible spines from the initial sample and the follow-up sample were combined into one sample for an expanded study of the potential of the spine for ageing tripletail. Two readers counted the number of translucent bands in the clearest section from each spine; the other two sections were used, as needed, for reference only. Following modified procedures of Hedgepeth and Jolly (1983) and Tserpes and Tsimenides (1995), readers counted only the most obvious translucent bands that continued around the circumference of a section (or around most of a section). In our study, we defined a translucent band as two (and occasionally three) small, conspicuous, adjacent translucent "rings", which we termed "multiples" (reported by Cayre and Diouf (1983) as "doublets" or "triplets"), which were separated by a narrow opaque zone, i.e. if two or three small translucent rings occurred closely together where the distance between them was less than the distance to the preceding and following translucent bands, they were counted as one band (Gonzalez-Garces and Farina-Perez, 1983). We assumed that each translucent band represented an annual mark, and we used this interpretation to assign an estimated age to each spine. Importantly, we defined the first translucent band as the prominent second "multiple" formed on a spine, rather than the first multiple, primarily because the first multiple (typically a doublet) was not as distinctive a feature as the second and seldom did it continue around the circumference of a section. Other rationale for our determination of the first band is presented in the Discussion.

The counts of translucent bands were compared, and if disagreements occurred, the sections were re-examined jointly, and disagreements were resolved. Length-at-estimated age data based on translucent band counts were derived for the sample. Due to sampling constraints, it was beyond the scope of this study to address the issue of validation.

The focus (core) of a section, which typically appeared as a small hole, was defined as the midpoint of the distance between the anterior and posterior portions of the spine along the mid-saggital plane. The diameter (SPD) of a section was measured (nearest 0.001 mm) as the horizontal distance between the outside margins through the core region.

To determine the relationship between somatic growth and dorsal spine growth, TL was modeled with SPL, SPW and SPD for each sex using regression analysis. Statistical inferences were made with a significance level of $p \leq 0.05$. Regression lines of males and females were tested using analysis of covariance (ANCOVA). To test the assumption that the number of bands increased with the growth of the spine, the relationships between band counts and SPW and between band counts and SPD were determined with regression analysis; degree of significance, $p \leq 0.05$. Male and female regressions of band count-SPW data were tested using analysis of covariance (ANCOVA).

RESULTS

Examination of transverse sections from ten individual hardparts (dorsal fin spines #1 - 5, anal fin spines #1 - 3, the left pelvic fin spine and the first anal fin ray) from each of 10 tripletail (five males, range 426 - 660 mm TL; five females, range 447 - 664 mm TL) revealed considerable variation in the clarity of the sections and the legibility of markings. The number of acceptable specimens of each hardpart, i.e. those that met the appraisal criteria, is shown in Figure 2. Sections from illegible hardparts appeared cloudy and severely eroded and usually were devoid of any definitive markings regardless of their thickness or the location of their removal from the hardpart.

The first dorsal spine produced the most legible sections among all of the hardparts examined (nine of ten first dorsals were found acceptable) (Figure 2); sections from the single illegible first dorsal spine were cloudy and contained vague markings. Sections from acceptable first dorsals typically showed a reasonably well-defined core with minimal erosion and a surrounding cortical region which contained a succession of concentric translucent bands, albeit there was variation in the quality of the bands. Although dorsal spines #2 - 5 were much larger (longer and wider) than the first dorsal spine, they yielded sections which displayed an eroded core matrix and an opaque, severely eroded cortical region with ambiguous markings and thus were categorized as having no value as ageing structures (Figure 2). Sections from 5 of the 10 first anal spines were considered legible (Figure 2), but only marginally so, however, sections from the other five first anals were found totally unacceptable because they were too eroded or the opaque-translucent zonation was exceptionally unclear. Anal spines #2 and #3 yielded illegible sections, and only 20% and 30% of the first anal rays and the pelvic spines, respectively, were legible (Figure 2), primarily because most sections from those two hardparts showed uninterpretable markings.

First dorsal spine as an ageing structure

Since the first dorsal spine was found to be the most acceptable (legible) hardpart examined during our appraisal of the various hardparts, we appraised an additional sample of first dorsals (n = 48) and found that 44 (92%) of the spines produced legible sections; among those were three unsexed early juveniles.

The results reported in the remainder of this paper are for a combined sample (n = 53; 24 males, 26 females, and 3 unsexed juveniles) of specimens found legible in the initial appraisal of first dorsal spines (n = 9) and the follow-up appraisal (n = 44), and thus deemed acceptable for further evaluation as to their potential for ageing tripletail. Not all specimens were included in all statistical analyses.

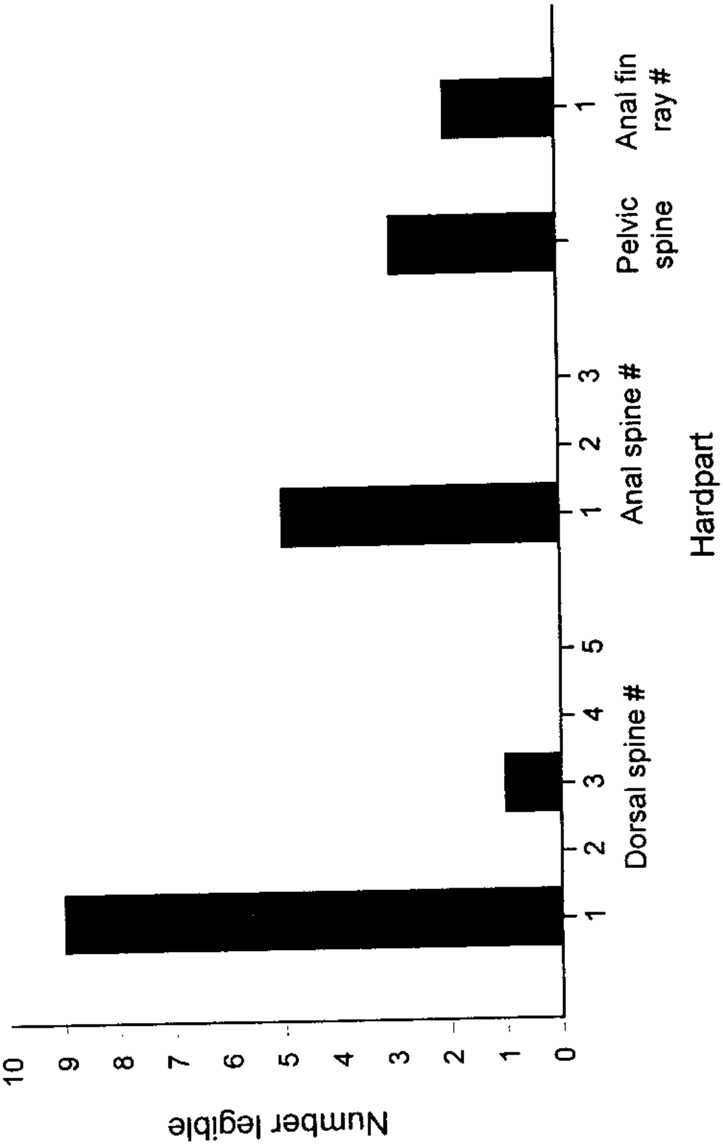

Figure 2. The number of each of 10 different hardparts (9 fin spines and 1 fin ray) determined to be legible based upon examination and appraisal of transverse sections. Samples of each hardpart were removed from 10 specimens of tripletail, *Lobotes surinamensis*.

Total lengths ranged 116 - 725 mm, and total weights ranged 0.025 - 10.4 kg. Total length-total weight relationships for males and females were significantly correlated. Neither slopes nor elevations of the TL-TW regressions for each sex were found to be significantly different, therefore the data were pooled, and one relationship was established (Table 1).

Fish length was significantly correlated with spine weight and spine diameter for each sex. Male and female regressions for fish length and spine weight did not differ significantly, nor did the regressions for fish length and spine diameter. Therefore, fish length-spine weight data were pooled, and one relationship was established (Table 1), as was done for fish length-spine diameter data (Table 1). The small sample size makes the above results tentative. Fish length was not significantly correlated with spine length, and the lack of a positive relationship probably was attributable to the slight bending of the spine with growth.

We presumed that two, and occasionally three, small, generally well-defined rings (a multiple) formed every year, and the closely associated rings were counted as one translucent band (Figure 3). However, the one notable exception was the first band (presumed first annual mark) (Figure 3) which we identified as the prominent second multiple, rather than the less well-defined first multiple, formed on a spine. The first multiple typically was separated from the core of the spine by a slightly eroded, opaque region which often contained enigmatic markings. Our examinations revealed that the first multiple had not yet formed on the spines of our smallest specimens (n = 3, 116-255 mm TL) which we aged as 0 years old but was observed on the spines of three larger specimens (427- 444 mm TL) which we also designated as 0-age fish. Specimens (n = 16, 425-551 mm TL) which showed an obvious second multiple were assigned an age of one year.

The quality of translucent bands varied among individual fish, and interpretation of banding patterns on some spine sections required considerable effort on the part of the readers. Not all bands retained their prominence around the entire circumference of a section, and as spine size increased with increased fish size, outer bands typically were most prominent in the anterior region of a section and less obvious in the lateral and posterior regions. Sections from a few of the larger specimens showed translucent bands that were crowded around the periphery of a section, and those bands were not easily enumerated because of their close proximity; considerable scrutiny was required to identify the boundaries of the individual bands. Consultations between readers were customary in order to obtain a mutual interpretation of bands.

Table 1. Total length - total weight, total length-spine diameter, totala length-spine weight, and band count-spine weight for tripletail, Lobotes surinamensis, from the northern Gulf of Mexico. TL = totala length (mm), TW = total weight (kg), SPD = spine diameter (0.001 mm), SPW = sine weight (0.001gJ) and BC = band count. Values in parentheses are standard errors.

			Y = a + bX		
Y	X	n	a	b	x^2
$\log_{10}$WT	$\log_{10}$LT	45	-12.101 (0.422)	3.222 (0.068)	0.98
SPD	TL	45	-799.702 (328.531)	7.023 (0.598)	0.76
$\log_{10}$SPW	$\log_{10}$TL	23	-16.583 (1.814)	2.319 (0.293)	0.75
SPW	BC	23	0.030 (0.156)	0.067 (0.010)	0.70

We observed bands (and partial bands) on the margin (edge) of sections from 45% of the specimens, which suggested that band formation was a recent occurrence for those fish. Marginal bands were observed for fish captured during the months of May through September, and the highest percentage of marginal bands occurred on the spines of fish collected during July. However, since our small sample did not include tripletail sampled throughout the year, we did not conduct marginal increment analysis (Manooch and Drennon, 1987) to determine periodicity of translucent band formation. Thus, we were unable to validate translucent bands as annular deposits suitable for accurate age determination.

Both readers agreed on the final band count (estimated age) for each of the 53 spines. We found no significant difference in mean length at estimated age between the sexes for all age classes in the sample (ANOVA, $p \leq 0.05$). Mean TL (mm) at each estimated age for the combined sexes is shown in Figure 4. Mean length (±SE) at each age was: Age-0, 301 (63.69); Age-1, 476 (8.91); Age-2, 546 (8.23); Age-3, 578 (18.45); and Age-4, 675 (14.61).

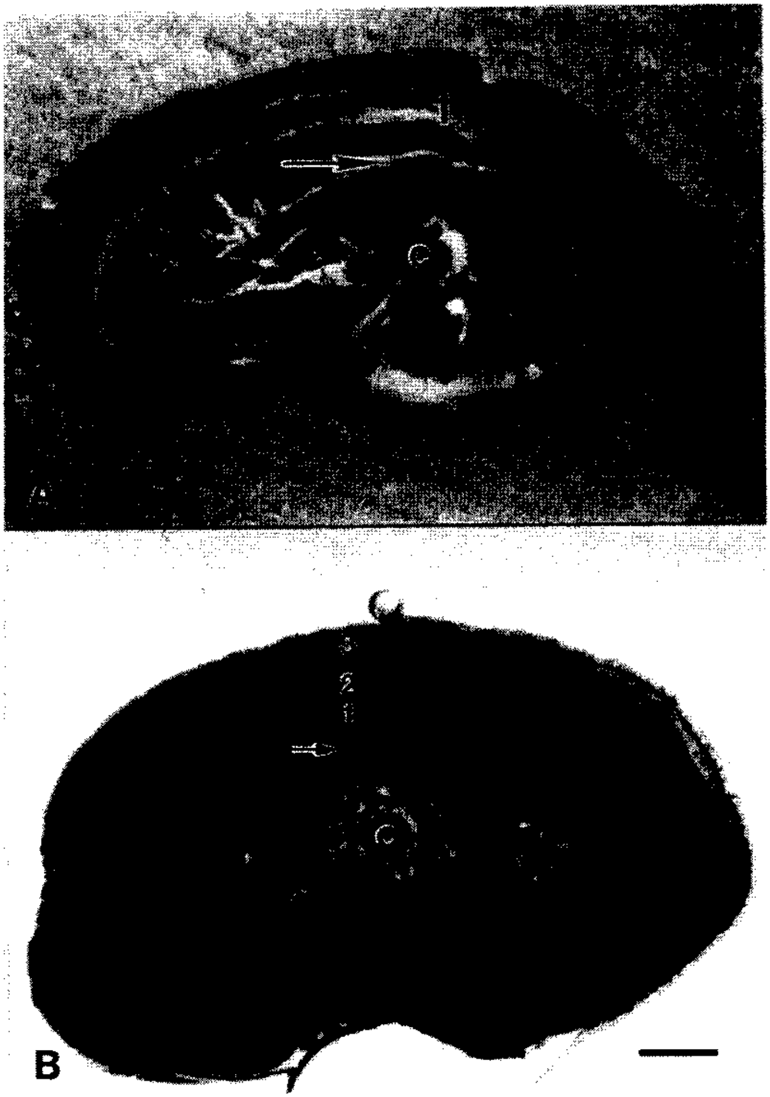

Figure 3. Transverse sections of first dorsal spine from tripletail, *Lobotes surinamensis*, with 1 translucent band (and the probable onset of the second band shown on the dorsal margin of the section) (**A**) and 3 translucent bands (**B**). First "multiple" formed on each spine is indicated by an arrow. C = spine core. Sections viewed with transmitted light. Total lengths of fish **A** (male, collected 15 July 1996) and **B** (female, collected 31 August 1996) were 571 mm and 660 mm, respectively. Scale bars = 0.500 mm.

Some vascular erosion was observed within the core region of a small number of the larger spines, however, in those instances the erosion obscured only small portions of the first band, and readers were able to count with some degree of certainty all first bands which were affected. The largest male (660 mm TL) and female (725 mm TL) in our study were both estimated to be four years old. Lengths varied within estimated age classes, and length ranges overlapped between age classes (Figure 4). For example, fish with one translucent band ranged from 425 to 551 mm TL, and those with three translucent bands ranged from 524 to 703 mm TL, however, a progressive increase in mean size was observed as the number of band counts increased (Figure 4). The limited age and length ranges of the data restricted our ability to effectively describe growth patterns.

Dorsal spine band counts were significantly correlated with spine weight for each sex. The regressions for each sex were not significantly different, therefore, the data were pooled, and one relationship was established (Table 1). Band number was not significantly correlated to spine length or, surprisingly, spine diameter for either sex.

DISCUSSION

We believe the techniques we used in processing hardparts did not bias legibility among the various hardparts, and that the first dorsal fin spine was clearly the hardpart which showed the greatest potential for use in ageing tripletail. First dorsal spines contained cross-section information we presumed to be annular in nature. Even though a few first anal fin spines produced legible sections, we did not further evaluate the spine.

Multiple rings (doublets or triplets) within individual growth zones on spines has been reported for numerous oceanic pelagic fishes (Hedgepeth and Jolley, 1983). We report the occurrence of multiple rings within each translucent band (presumed annulus) in cross-sections of tripletail first dorsal fin spines. Hedgepeth and Jolley (1983) attributed the occurrence of doublets in the fourth dorsal fin spine of sailfish, *Istiophorus platypterus*, to the "splitting" of the band in an area located "ventral to the core of the spine". In many of the spines we examined, multiples appeared to merge into a single, broad band ventral (posterior) and lateral to the core. We frequently observed less clearly defined markings that we presumed to be false bands. Interestingly, the tripletail is a coastal pelagic species and not an oceanic pelagic fish such as sailfish, however, tripletail are migratory, and the formation of doublets or triplets on their spines may be related, in part, to their seasonal migratory movements, as has been postulated for numerous migratory fishes (Compean-Jimenez and Bard, 1983).

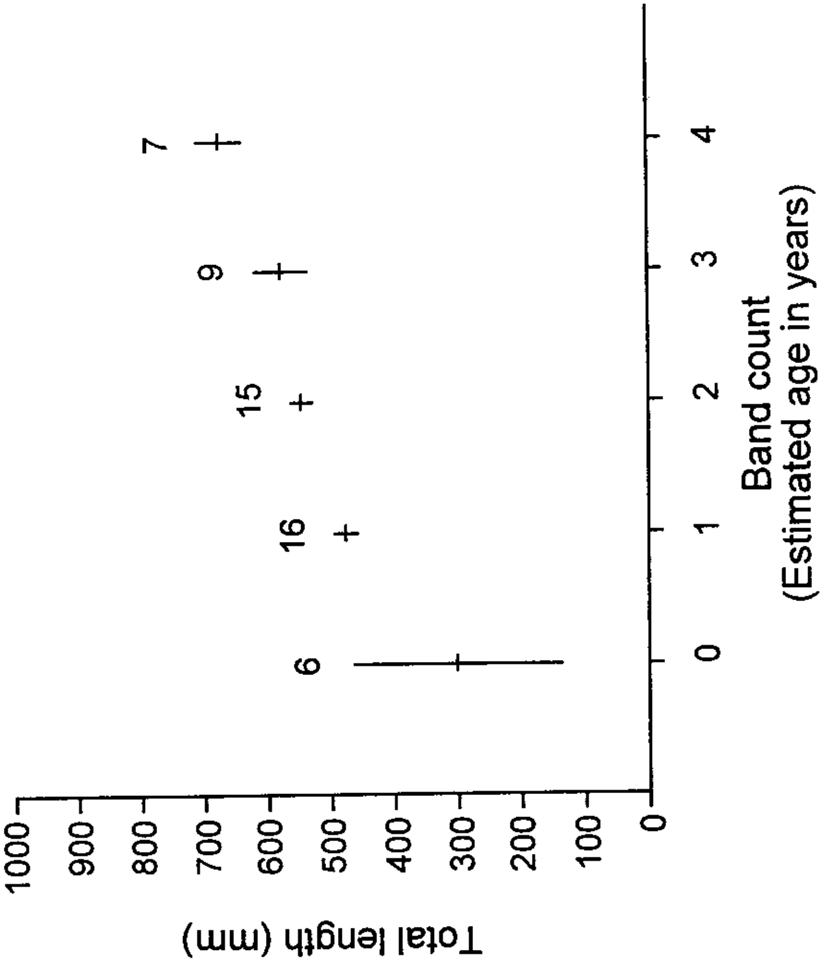

Figure 4. Mean length at estimated age, based on first dorsal fin spine band counts, for a small sample of tripletail, *Lobotes surinamensis*, from the northern Gulf of Mexico; combined sexes. Vertical lines represent 95% confidence intervals.

We defined the first transparent band as the second multiple observed on spine sections. The decision for our designation was based upon not only the prominence of the second multiple and its continuance around the circumference of a spine but also our observations of:

i) the occurrence only of the first multiple, followed by a relatively wide opaque zone (suggestive of imminent formation of the first annular band), on spines from specimens ~450 mm TL which were captured in May and June and, based upon their sizes, presumably were spawned during the previous summer
ii) the occurrence of the second multiple near the margin of spines from several specimens ~500 mm TL which were collected during July-September and, based upon their sizes, presumably were spawned the previous summer, and
iii) the rapid growth of small, captive tripletail (at our GCRL fish holding facility) which indicated that lengths exceeding 500 mm could be attained during the first year of life.

We surmised that the first multiple was formed too early on a spine during the first year of life to represent the first annual mark. If future studies show that the first multiple formed on tripletail spines actually represents the first annual mark, then we possibly under-aged some fish in our sample by one year.

Our findings suggest that distinctive transparent bands are probable indicators of age. Despite some problems encountered in the interpretation and reading of some sections, mutual agreement was reached on band counts for all legible first dorsal spines, and preliminary length-at-age estimates were derived for the sample. Since our study of the markings on first dorsal thin-sections was a groundwork investigation, both readers continuously consulted with each other on the interpretation of bands and conducted a joint count of bands for final age estimations, therefore, a test of the consistency of age estimates between readers, e.g. the Average Percent Error (APE) method of Beamish and Fournier (1981), was not feasible for our preliminary study.

We found that spine weight and diameter, but not spine length, were proportional to the increase in fish length, and that translucent band counts progressively increased with increased fish length and spine weight. We also found higher levels of correlation between fish length and spine weight than between band number and spine weight. Additionally, females had slightly stronger relationships between fish length and spine weight and between band count and spine weight when compared to males.

Gudger (1931) reported an age of one year for his specimens which measured only 15 and 52 mm TL. By comparison, the fish we estimated to be less than one year of age ranged from 116 - 444 mm TL, and our smallest one-year-old specimen was 425 mm TL. Merriner and Foster (1974) reported ages of 0 for one fish (190 mm TL), one year for six fish (445 - 591 mm TL), two years for five fish (562 - 706 mm TL) and three years for two fish (568 and 706 mm TL), ages that compare favorably with our age estimates for a similar range of lengths. Based upon our age estimations, tripletail appear to grow extremely fast during the first year of life. The oldest males and females in our sample were estimated to be 4 years of age, however, we believe our sample was comprised of young-to-medium age fish. We know from anecdotal accounts and fishing tournament weight records that specimens much larger than those reported by us have been caught in the northern Gulf of Mexico, and we can only presume that those fish were older than the largest specimen in our sample.

Marginal increment analysis was not attempted for our sample because the seasonal nature of the recreational fishery off Mississippi (and in the northern Gulf of Mexico) results in sample collections which span only 6 months (May through October), therefore, validation of translucent bands on first dorsal spines as annuli was not achieved. Our observations of gonadal maturation in tripletail (unpublished data) tend to confirm a spring to fall spawning reported by Ditty and Shaw (1993). We have collected gravid females and ripe-running males from May through September in the northern Gulf, and our observations indicated that some individuals of both sexes were sexually mature at one year of age.

The estimated age data presented here represent the first published account of age of tripletail from the northern Gulf of Mexico. Obviously, a larger data base is needed to adequately study the age and growth of tripletail and to develop useful information about the status of tripletail stocks that "seasonally" visit northern Gulf waters. Given that the total seasonal recreational catch in the northern Gulf is unknown, but probably is not great, researchers will have to collect intensively and continue to rely on the cooperation of anglers for samples from both inshore and offshore waters. Studies on the validation of band formation periodicity in first dorsal spines, as well as sagittal otoliths, using tag/recapture or chemical marking should provide information useful in age determination. Successful ageing of tripletail will represent a crucial step toward a greater understanding of the life history of tripletail from the Gulf of Mexico.

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