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Age, Growth, Diet, and Reproductive Biology of the Tripletail, *Lobotes surinamensis*, From the North-Central Gulf of Mexico

ANDREW J. STRELCHECK, JERED B. JACKSON, JAMES H. COWAN JR., AND ROBERT L. SHIPP

Tripletail, *Lobotes surinamensis*, are migratory fish that occur worldwide in warm seas, including the Gulf of Mexico and Caribbean. In the north-central Gulf of Mexico, tripletail support small recreational and commercial fisheries from April to Oct. and are commonly caught in bays and estuaries. Few studies have evaluated the life history and biological characteristics of tripletail; therefore, the objective of this study was to examine the age and growth, reproductive biology, and diet of tripletail caught off coastal Alabama. Our primary goal was to use life history information to determine a minimum size limit for harvest. A secondary goal was to compare the results of our study with those of previous tripletail studies. A total of 119 specimens, ranging in size from 293- to 763-mm total length (TL), were collected from recreational anglers and from a wholesale seafood dealer between May 1998 and Aug. 2000. Female specimens were significantly longer and heavier than males. Total length varied greatly with age, although significant overlap in lengths was observed among ages. Age ranged from 0.87 to 4.09 yr. No male was older than 3.15 yr of age, whereas five females were estimated to be more than 4 yr old. Fifty percent of females reached sexual maturity by 494- to 594-mm TL and approximately 1 to 2 yr of age. All males greater than 380 mm were sexually mature. Diets were composed primarily of penaeid shrimps, various pelagic fish species, and portunid crabs, with the proportion of fish consumed increasing with tripletail length. On the basis of the results of this study as well as previous research on the life history and population dynamics of tripletail, the state of Alabama implemented a 406 mm (16 inch) minimum size limit for this species. This size limit is below the female size at 50% maturity (19.5–23.5 inch) and should be increased if large increases in fishing pressure occur.

Tripletail, *Lobotes surinamensis*, are migratory fish that occur worldwide in warm seas. In the western Atlantic, they range from Cape Cod to Argentina and throughout the Gulf of Mexico (Gulf) and Caribbean. Tripletail are the only member of the family Lobitidae found in the Gulf (Hoese and Moore, 1998), and they commonly occur in north-central Gulf estuaries from April to Oct. (Baughman, 1941; Franks et al., 1998). Along coastal Alabama, most tripletail are caught in Mobile Bay and Mississippi Sound. They congregate around sea buoys and pilings in inshore waters and are commonly caught offshore under floating debris and vegetation. Their seasonal occurrence in the northern Gulf suggests a northerly migration during spring and a return to southern latitudes as water temperatures decline in fall (Franks et al., 1998).

Tripletail are recognized by anglers as a sport species, and because of their reputation as “strong fighters,” they are commonly included as a category in Gulf coast fishing rodeos (Shipp, 1986). Data on recreational tripletail landings and effort in the Gulf is sparse because only a small number of angler inter-

cepts occur each year during recreational creel surveys. Gulfwide commercial landings of tripletail have averaged less than 4,000 pounds annually since 1991 (NMFS, 2002).

Several studies have described the behavior, distribution, natural history, and population dynamics of both larval and adult tripletail (Gudger, 1931; Baughman, 1941; Breder, 1949; Merriner and Foster, 1974; Ditty and Shaw, 1994; Armstrong et al., 1996; Franks et al., 1998; Brown-Peterson and Franks, 2001). These studies have provided information about the age, growth, larval development, and reproductive biology of tripletail, although findings in some cases have been inconsistent. In general, tripletail growth is considered to be rapid, and estimates of maximum age have ranged from 4 to 7 yr, with several studies speculating that tripletail reach even older ages. Spawning is thought to occur offshore, although few females in the final stages of oocyte maturation have ever been collected. Tripletail can reach sexual maturity by age 1, with estimates of the size at sexual maturity ranging from 350- to 500-mm TL.

Because tripletail life history information is

incomplete and only a few studies have been conducted in the north-central Gulf of Mexico (Franks et al., 1998—age and growth; Brown-Peterson and Franks, 2001—reproductive biology), the intent of this study was to evaluate tripletail life history characteristics to assist resource managers in developing a minimum size limit for tripletail harvest. The primary goal of this study was to determine the age and size at maturity for tripletail caught in the recreational and commercial fisheries off coastal Alabama. Secondary goals included gathering and analyzing additional biological information about the age, growth, reproductive biology, and diet of tripletail, so that the results of this study could be compared with the results of previous studies.

MATERIALS AND METHODS

Tripletail were caught off the Alabama coast from July 1998 through Aug. 2000. Samples were collected opportunistically from a wholesale seafood retailer ($n = 22$) and at recreational fishing tournaments ($n = 85$). An additional 12 specimens were donated by local recreational anglers or collected during scientific sampling trips. Tripletail were caught primarily by hook and line near buoys, pilings, and channel markers in the nearshore waters of Mississippi Sound and Mobile Bay. A few specimens were also caught in offshore waters, south of the Alabama–Mississippi coast, under floating debris and sargassum vegetation (personal communication, recreational anglers).

Biological sampling.—Morphometric measurements were collected from 118 fish (measurements from one fish were not taken) and sex was recorded. Standard length (SL) and total length (TL) were measured to the nearest millimeter and total wet weight (TW) was recorded to the nearest gram. Total weights were determined for 82 specimens that had not been filleted or gutted. Total lengths and weights by sex were compared using Student's t -test ($\alpha = 0.05$). Sagittal otoliths were removed and weighed and later used for estimation of age. A total of 63 sets of sagittal otoliths were collected during the first 2 yr of the study. Sagittal otoliths were not collected during the third year of the study. After the first year of sampling, the first dorsal spine was also removed from each fish and used to estimate age. A total of 105 dorsal spines were collected from specimens during the second and third year of the study. Stomachs, including the esophagus and alimentary canals, were removed and fro-

zen and later used to evaluate fish diet. Reproductive organs were extracted and weighed and later used to assess time of spawning and size and age at maturity.

Morphometrics.—Simple linear regression was used to determine relationships between SL, TL, TW, and otolith weight (OW). When necessary, data were $\log_{10}$ transformed. Otolith weight–TL and TL–TW relationships for male and female tripletail were compared using analysis of covariance to test for differences between sexes in slopes and elevations. If both slopes and elevations were not significantly different, data were pooled and nonsex specific relationships were developed.

Age and growth.—Ten left sagittal otoliths and 105 dorsal spines (spines were not collected from 14 specimens during year 1 of this study) were sectioned using a Hilliquist Model 800, thin-sectioning machine (Cowan et al., 1995). Each otolith was cut along the transverse plane with a petrographic cutoff saw; dorsal spines were cut with the same equipment, but the transverse cut was made 5–10 mm above the condyle. Otoliths and spines were then secured cut-side down on microscope slides with Loc-tite (#349) ultraviolet setting epoxy. After otoliths and spines had securely dried to mounting slides, they were placed in the calibrated guiding arm of the cutoff saw to remove all but approximately 100–200 μm of the otolith or spine. Mounted spines and otoliths were then ground to approximately 40–50 μm with a water-cooled precision grinder. A thickness of 40–50 μm was determined to be the most appropriate thickness for observing opaque and translucent bands.

Otoliths and spines were viewed with a compound microscope and reflected light. Age was estimated from the number of translucent bands observed for each otolith or spine, timing of translucent band formation, assumed birth date, and sampling date. Each translucent band was assumed to be an annual mark; however, annulus formation was not validated. In many cases, closely spaced translucent bands were present in spine sections. If the distance between closely spaced bands (commonly referred to as doublets or triplets) was less than the distance to the next or previous translucent band, then the bands were counted as a single band (Gonzalez-Garces and Farina-Perez, 1983; Franks et al., 1998). Translucent band formation was assumed to begin on 1 July (see Results). The birth date for tripletail was also assumed to be 1 July and was based on a

peak in tripletail spawning in the north-central Gulf of Mexico (see Results; Brown-Peterson and Franks, 2001). Age (in days) was estimated (for most fish) by multiplying the number of translucent bands (including translucent bands that were forming on the edge) by 365 d, then adding the number of sampling days after the date of peak spawning. If an opaque band was present on the edge of the spine, the age of the fish was advanced 365 d, and the number of sampling days occurring before or after peak spawning were added or subtracted from the estimate of age. To estimate age in years, all estimates of age in days were divided by 365.

Two readers independently counted bands without reference to the fish's date of capture or length, and counts were compared between readers. If band counts differed, readers jointly reexamined otolith or spine sections and discussed disagreements. Age was not estimated for spines that were poorly sectioned ($n = 3$) or in cases where readers could not resolve count differences ($n = 6$).

Von Bertalanffy growth models of TL vs age were not fit to age estimates because of low sample sizes and the lack of young tripletail sampled ($< \text{age } 1$). Instead, fish were grouped into biological age classes (i.e., 1 Jan.–31 Dec.) after fractional ages were assigned and mean lengths ($\pm$ standard deviation) for each biological age class were calculated by sex (GSMFC, 2003).

Reproductive biology.—Gonads were removed, blotted dry, weighed, and stored on ice. Sex was determined on the basis of the presence of ovaries or testes. If no gonads were present, sex was specified as unknown. Gonads were held on ice for a maximum of 12 h before being sectioned and fixed in 10% buffered formalin. One section ($\sim 1\text{--}2 \text{ cm}^2$) was taken from the central portion of each gonad and placed in a tissue cassette. For histological observation, tissue samples were dehydrated, embedded in paraffin, sectioned, stained with Gill hematoxylin, and counterstained with eosin (histological slides were prepared at the Louisiana State University School of Veterinary Medicine). Reproductive maturational stages for females were classified from the prepared histology slides according to the procedures of Wallace and Selman (1981). Stages of oocyte maturation included: primary growth (PG), cortical alveoli (CA), early vitellogenesis (EV), late vitellogenesis (LV), and hydration (H). In addition, to aid in determining sexual maturity, as well as the cessation of spawning, histo-

logical sections were examined for the presence of postovulatory follicles (POFs) and atretic oocytes following the methods of Hunter and Macewicz (1985). Maturity status for female specimens was classified using the methods of Hunter et al. (1992). All fish were classified as active and mature, inactive and mature, or inactive and immature (see Hunter et al., 1992). Males were not assigned reproductive maturational stages but were determined to be mature or immature on the basis of the presence or absence of active spermatogenesis.

Size at 50% sexual maturity was determined for females following the methods of Barbieri et al. (1994). Females were grouped into 25 mm length intervals, and the fraction of mature fish per interval was fit to a nonlinear, logistic regression function. Maturity was defined in two ways to evaluate the sensitivity of size-at-maturity estimates for varying stages of oocyte maturation. Fish were considered mature if CA or later oocytes stages were present. We also defined maturity as fish having oocytes entering EV or later. In both cases, fish were also mature if POFs or major atresia of advanced stage oocytes were present (Hunter et al., 1992). From the logistic regression, size at 50% maturity corresponded to the smallest length in which 50% of the fish were mature.

Diet analysis.—Contents were removed from each stomach and identified to the lowest taxonomic level practicable. If the consumed prey could not be identified, it was included in an unidentified prey category. The number and wet weight of each prey consumed were recorded and data were calculated for percent numeric abundance (%N), percent relative weight (%W), percent frequency of occurrence (%FO), and percent index of relative importance (%IRI = $(\%N + \%W) \times \%FO$; Hacunda, 1981) for each prey category. Percent abundance and percent weight of fish, shrimp, and portunid crabs were then compared among five length intervals (<450 , 451–500, 501–550, 551–600, and >600 mm) to examine the relative importance of each prey type with increasing tripletail size.

RESULTS

A total of 119 tripletail were collected and sampled. Total lengths for all fish collected ranged from 293 to 763 mm and total weights ranged from 0.54 to 10.6 kg. The maximum observed length for females was 763 mm TL, whereas the maximum observed length for males was 685 mm TL (Fig. 1). Females col-

Fig. 1. Total length frequency distributions for male and female tripletail sampled during 1998–2000 in the north-central Gulf of Mexico.

lected during the study were significantly longer (mean = 578.3 mm $\pm$ 86.7 mm; 5.26 kg $\pm$ 2.58 kg; P = 0.001, t -test) and heavier than males (mean = 526.3 mm $\pm$ 78.6 mm; 3.99 kg $\pm$ 1.64 kg; P = 0.002, t -test).

Morphometrics.—Relationships among SL, TL, TW, and OW are summarized in Table 1. Neither slopes nor y intercepts of TL-TW and SL-TW equations for male and female tripletail were significantly different, so data were pooled (Table 1). Total weight was nearly a cubic function of both SL and TL (Fig. 2), and SL was highly correlated with TL (r^2 = 0.995). Weights of left and right sagittal otoliths were not significantly different (t = 0.60, P = 0.54), nor were slopes and y -intercepts of the OW-TL

Fig. 2. Total length–TW relationships for male and female tripletail sampled during 1998–2000 from the north-central Gulf of Mexico.

and OW-TW equations for male and female tripletail. Otolith weight was significantly correlated with both TL (r^2 = 0.928) and TW (r^2 = 0.926; Table 1).

Age and growth.—Otoliths were determined to be inadequate aging structures and were abandoned early in the study (only 10 were sectioned and read). Opaque bands were either not present or difficult to distinguish from the surrounding otolith matrix.

Alternating opaque and translucent bands were observed in the first dorsal fin spine of most specimens, although the periodicity of annulus formation was not validated. Age was estimated from 96 of 105 spine sections. Only three spines were not readable because of poor preparation. Reader agreement was 94.1% (96 of 102). Inferred ages ranged from 0.87 to 4.09 yr. Translucent bands were observed to be forming on the edge of spines as early as July. Thirty-six percent (26 of 71) of fish spines collected in July, 23.5% (four of 17) of spines collected in Aug., and 75% (six of eight) of spines collected in Sep. had translucent rings present

TABLE 1. TL-SL, SL-TL, TW-TL, TW-SL, OW-TW, and OW-TL regression for tripletail collected from the north-central Gulf of Mexico.^a

y	x	$y = a + bx$			
		n	a	b	r^2
TL	SL	118	25.483	1.1024	0.995
SL	TL	118	-20.89	0.903	0.995
$\log_{10}$ TW	$\log_{10}$ TL	82	-8.2208	3.2152	0.969
$\log_{10}$ TW	$\log_{10}$ SL	82	-7.5664	3.0469	0.967
$\log_{10}$ OW	$\log_{10}$ TW	39	-1.3384	0.8469	0.926
$\log_{10}$ OW	$\log_{10}$ TL	64	-8.0685	2.636	0.928

^a TL, total length; SL, standard length; TW, total weight; OW, otolith weight.

TABLE 2. Percent oocyte maturation stage, percent POFs, and percent atretic oocytes by month for tripletail collected in the north-central Gulf of Mexico from 1998–2000.^a

Month	n	Percent oocyte stage					POFs (%)	Atresia (%)
		PG	CV	EV	LV	H		
May	2		100.0				0	0
June	0							
July	42	14.2	30.9	38.0	21.4		7.1	11.9
August	15	6.6	66.6	13.3	13.3		26.6	26.6
September	1	100.0					0	0

^a n, sample size; PG, primary growth; CA, cortical alveoli; EV, early vitellogenesis; LV, late vitellogenesis; H, hydrated; and POFs, postovulatory follicles.

on the edge of the spine. No translucent rings were observed on the edge of spines collected during May and June, although few samples were collected during this time.

Mean TL increased with age and considerable variation in size at age was observed (Fig. 3). The youngest fish collected during the study was estimated to be 0.87 yr of age, whereas the oldest fish was estimated to be 4.09 yr of age. Males ranged in age from 1.0 to 3.15 yr, whereas females ranged in age from 0.87 to 4.09 yr of age. No male was estimated to be older than 3.15 yr of age, whereas five females collected were older than 4 yr of age. Each of these age 4+ females only had three translucent bands, but age was advanced 1 yr because of the presence of a wide opaque band on the outer margin of the dorsal spine.

Sizes varied greatly within age classes: age 1 (304- to 603-mm TL), age 2 (407- to 673-mm TL), age 3 (490- to 719-mm TL), and age 4 (521- to 707-mm TL). On the basis of estimated ages, tripletail between 500- and 600-mm TL were 1 to 4 yr of age. Tripletail less than 400 mm were all estimated to be 1 yr old or less. Mean lengths at age for females were: 492

mm $\pm$ 32 mm (age 1), 540 mm $\pm$ 62 mm (age 2), 608 mm $\pm$ 72 mm (age 3), and 624 mm $\pm$ 72 mm (age 4). Mean lengths at age for males were slightly smaller than females for ages 1 and 2 (469 mm $\pm$ 84 mm and 524 mm $\pm$ 67 mm, respectively), but similar for age 3 (610 mm $\pm$ 54 mm).

Reproductive biology.—A total of 61 female and 49 male tripletail were sampled for gonads. Sex was not determined for nine tripletail collected because the wholesale dealer had gutted the fish before sampling. The sex ratio of 1.26 females:1 male was not significantly different from 1:1 ($\chi^2 = 1.99$, $df = 1$, $P > 0.25$). The smallest mature male (undergoing spermatogenesis) observed was 304 mm and the smallest mature female was 381 mm (CA oocytes present). All male tripletail greater than 380 mm TL were sexually mature and undergoing active spermatogenesis during June–Aug. Fifty percent of females were sexually mature (CA or later stage oocytes) by 494 mm TL (Fig. 4; $r^2 = 0.98$, $P < 0.0001$). If maturity was defined as the presence of early vitellogenic or later stage oocytes, rather than CA or later stage oocytes, then size at 50% maturity was 594.4 mm (Fig. 4; $r^2 = 0.82$, $P < 0.0001$). Age at 50% maturity was approximately 1 to 2 yr of age.

Maturity status was determined for all tripletail. Most fish were either classified as mature and active, but not spawning, or immature and inactive. Two female fish collected during May both possessed CA oocytes, and no female tripletail were collected during June (Table 2). Fifty-nine percent ($n = 25$) of female tripletail collected in July were undergoing EV or LV oocyte maturation. During Aug., a majority of specimens possessed CA, EV, or LV oocytes. Postovulatory follicles were observed in seven ovarian tissue samples collected during late July and Aug. All fish possessing POFs in July had EV oocytes present. In Aug., most fish (three of four) possessing POFs had CA oo-

Fig. 3. Relationship between TL and age for male and female tripletail collected from the north-central Gulf of Mexico during 1998–2000.

Fig. 4. Logistic regressions of the percentage of sexually mature female tripletail by 25 mm TL intervals. Two logistic regressions are presented: one defines maturity using females that possess CA or later stage oocytes and the other defines maturity using females that possess EV or later stage oocytes. The circled data point was an outlier and was excluded when fitting the logistic regression.

cytes. Similarly, atretic oocytes were present in nine fish, although most atresia observed was minor. Atresia was present in a wide size-range of fish (500- to 710-mm TL). Eleven percent of fish collected in July and 26% of fish collected in Aug. were observed to have at least minor atresia of oocytes (Table 2).

Diet.—Eighty percent of stomachs sampled contained food. Twelve taxa of fishes and invertebrates were identified in the stomach contents of tripletail. The primary prey items consumed were penaeid shrimps, portunid crabs, and pelagic fish species. Whole fish and fish parts were found in 66.3% of the nonempty stomachs, whereas penaeid shrimps were found in 60.6% of the nonempty stomachs. Portunid crabs (genus *Callinectes*), such as blue crabs (*Callinectes sapidus*), were found in 10.1% of tripletail stomachs. Butterfish (*Peprius burti*) was the most abundant fish con-

sumed (Table 3; $n = 130$), followed by bay anchovies (*Anchoa mitchilli*; $n = 11$), round scad (*Decapterus punctatus*; $n = 8$), and Gulf menhaden (*Brevoortia patronus*; $n = 6$). One Atlantic cutlassfish (*Trichiurus lepturus*), one pinfish (*Lagodon rhomboides*), one sea robin (Family Triglidae), one pipefish (Family Sygnathidae), two filefish (Family Balistidae), and a single squid (class Cephalopoda) were also observed.

Fish comprised 66.4% (66.6% TW) of all consumed prey, whereas penaeid shrimps and various crab species comprised 19.4% (30.1% TW) and 14.1% (3.2% TW), respectively, of all prey consumed. More than 40% of all fish consumed were not identified. Of those fish that were identified, 80.7% were Gulf butterfish, 6.8% were bay anchovy, and 6.2% were round scad. Shrimp and unidentified fish were the most abundant prey items consumed in terms of weight (Table 3). Penaeid shrimps were also the most frequently occurring prey item and had the highest index of relative importance for all consumed prey items (Table 3).

The percent weight of fish consumed increased with TL but the %N of fish consumed did not. The percent weight of prey consumed by tripletail of <450 mm TL was 49% fish, 41% shrimp, and 9% crabs. For tripletail of 451- to 500-mm TL, the percent weight of prey consumed was 52% fish, 34% shrimp, and 13% crabs. The percent weight of prey consumed by tripletail of 501–550, 551–600, and >601 mm TL ranged from 63–76% fish, 18–35% shrimp, and 0–5% crabs.

DISCUSSION

The results of this study support the findings of previous studies that have examined the life history and biology of tripletail. Our findings were similar to those of Franks et al. (1998) and Brown-Peterson and Franks (2001), whose research overlapped ours both temporally and

TABLE 3. Percent number (% N), weight (% W), frequency of occurrence (%FO), and index of relative importance (%IRI) for prey species consumed by tripletail.

Prey	% N	% W	%FO	%IRI
Blue crab	0.478	1.25	2.35	0.10
Portunid crabs	13.63	1.93	10.58	3.92
Penaeid shrimps	19.37	30.2	63.5	74.87
Bay anchovy	2.63	4.23	5.88	0.96
Butterfish	31.1	4.94	8.23	7.06
Gulf menhaden	1.43	12.15	4.7	1.52
Miscellaneous fishes	3.58	13.3	10.58	4.25
Unidentified fish	27.75	31.9	5.17	7.34

spatially. Only a few differences (e.g., estimated ages) were noted between our study and those of past studies and were likely the result of differences in methodologies. Although sample size was small for this study, it does not appear that the sample size limited our results, except pertaining to information about the reproductive biology of tripletail.

Previous studies examining the growth of tripletail have generally agreed that tripletail grow rapidly during their first few years of life (Armstrong et al., 1996; Franks et al., 1998) and reach sizes of >400 mm by 1 yr of age. The results of this study support this finding and reveal that tripletail can grow to 600 mm TL during their first year of life. Fish collected during this study had ages similar to those collected by Merriner and Foster (1974) and Franks et al. (1998). This result was expected because the tripletail examined by Franks et al. (1998) were of similar size to those in the present study and were also aged with dorsal spines. Franks et al. (1998) estimated ages on the basis of ring counts and concluded that the largest males and females in their study were age 4.

Sizes of tripletail were also similar to a previous study by Armstrong et al. (1996), who observed wide ranges in TL by age. Armstrong et al. (1996) found age-1 tripletail to range in size from less than 400 mm to nearly 600 mm TL. They also concluded that males were slightly smaller than females at similar ages and that size ranges significantly overlapped between ages 1–3. All these findings are similar to those of the current study.

In contrast, Franks et al. (1998) estimated sizes at age that were smaller than those observed in this study. Franks et al. (1998) estimated sizes at age to be 476, 546, 578, and 675 mm for ages 1–4, respectively. Differences between their study and the current study could be attributed to differences in aging techniques. Franks et al. (1998) estimated ages only on the basis of dorsal spine ring counts, whereas this study assigned fractional ages on the basis of an estimated birth date and date of translucent band (annulus) deposition.

In a study off North Carolina, tripletail were estimated to range in age from 0–4 yr, although it was speculated that tripletail reach 7–10 yr of age (Merriner and Foster, 1974). These speculated ages were later supported by the findings of Armstrong et al. (1996), who used otoliths to age commercially caught tripletail in Florida. Ages ranged from 1 to 7 yr, although most fish were 1–4 yr of age. However, on the basis of the results of this and pre-

vious studies, both otoliths and scales are considered poor aging structures for tripletail and dorsal fin spines are considered to be more reliable for estimating age. The use of scales for aging is not considered reliable for many species of fish because scale-derived estimates of age are typically less than estimates derived from otoliths and fin spines (Casselman, 1983; Beamish and McFarlane, 1987). Similarly, the use of otoliths to age tripletail appears even less suitable than scales, especially considering that two of 10 otoliths examined during this study had faint, difficult to interpret, alternating opaque and translucent bands. Franks et al. (1998) reported similar conclusions and also considered otoliths poor structures for determining the age of tripletail. Franks et al. (1998) also noted that vascular erosion in the core of dorsal spines might compromise the ability to use these structures for aging. Regardless, maximum ages are likely much greater for tripletail considering that many state record tripletail (e.g., Alabama state record is 16.92 kg) weigh 60% more than the largest fish sampled during this study.

Further research is needed to validate the formation and deposition of annuli in dorsal spines of tripletail. Translucent bands were assumed to represent annual rings, but these bands have yet to be validated. Marginal increment analyses are also needed to validate when ring deposition occurs. Because samples during this study were only collected over a 5-mo period, more sampling is needed throughout the year to evaluate whether ring deposition occurs during summer, as indicated by this study. Because dorsal fin spines appear to be adequate aging structures, mark-recapture experiments could be used to assess age and ring deposition. For instance, at the time of tagging, dorsal fin spines could be removed from the fish for comparison with dorsal fin spines upon fish recapture (Beamish and McFarlane, 1987). This type of mark-recapture study would need to occur in areas of greater tripletail abundance (e.g., Indian River Lagoon, FL; Armstrong et al., 1996) because of the low abundance and low levels of fishing pressure for tripletail in the north-central Gulf.

Examination of the reproductive biology of tripletail revealed that females begin sexually maturing between 400- to 450-mm TL. Size-at-50% maturity was 494- to 594-mm TL and 1 to 2 yr of age, depending on how maturity was defined. A similar estimate of size and age at maturity was made by Brown-Peterson and Franks (2001), who found female tripletail from the north-central Gulf to reach 50% ma-

turity by 485 mm TL and 1 yr of age. Although several female and male tripletail were observed to be sexually mature by 1 yr of age (<500 mm), it is unknown whether these fish are actively spawning because none possessed hydrated oocytes. A few POFs were observed in a small fish but more samples are needed to determine whether these fish have spawned.

Failure to find direct evidence of spawning may be attributable to location of capture. In this study, most tripletail were captured in inshore waters. Previous studies have presumed that tripletail spawn offshore (Ditty and Shaw, 1994; Brown-Peterson and Franks, 2001), although there is no direct evidence for this contention. Ditty and Shaw (1994) did note that larval tripletail were most abundant in the north-central Gulf of Mexico during June–Aug. Most tripletail larvae were taken in surface waters at stations located at depths of >50 m, thus revealing that tripletail likely spawn in surface waters >20 nautical miles offshore. It is unclear whether the presence or absence of POFs is related to tripletail samples being collected offshore or tripletail actively spawning in inshore waters. More data and samples are needed, especially from offshore waters, to resolve when and where spawning occurs.

Before this study, only sparse information about the diet of tripletail had been published. Tripletail appear to be opportunistic feeders, feeding on both benthic and pelagic prey. The abundance of penaeid shrimps in their diet is likely overemphasized, considering that live shrimp are the most common bait used by recreational tripletail anglers. However, tripletail are occasionally caught in inshore shrimp trawls along coastal Alabama, and thus, shrimp are likely a major component of their diet. The increasing importance of fish in their diet as they grow larger is likely because of the ability of tripletail to ambush prey through rapid short bursts of speed (Shipp, 1986). Shrimp and portunid crabs are more easily captured, and thus, smaller, slower tripletail may rely less on speed for capturing prey. In contrast, large tripletail are often seen floating on the surface, under debris and vegetation, waiting passively for fish to prey upon (Shipp, 1986).

Only the states of Florida and Alabama currently have management regulations for the recreational harvest of tripletail. Florida implemented a two fish bag limit and a minimum size limit of 381 mm (15 inch) in 1996. Alabama regulations were implemented in 2001, based in part on the results of this study, and include a three fish bag limit and 406 mm (16 inch) minimum size limit. On the basis of this

study, size limits implemented in both states are below the size-at-50% maturity and would inadequately protect spawning stock biomass when fishing pressure is high. A minimum size limit of 508 mm (20 inch) is recommended if large increases in fishing pressure occur. A 508-mm size limit corresponds to 1 yr at age and would ensure that >50% of all females reach sexual maturity before harvest. However, because of uncertainty with regard to whether age 1 tripletail spawn, more research is needed to develop appropriate management benchmarks.

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LITERATURE CITED

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