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Growth and reproductive aspects of white mullet, *Mugil curema*, in Lake Maracaibo, Venezuela

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Abstract

A 5-year research study, including a 2-year mark-and-recapture program, was developed to estimate growth and reproductive aspects of white mullet, *Mugil curema*, in Lake Maracaibo. A single model did not fit the white mullet growth curve from juvenile stages to adult, but there were two different segments: fish <130 mm total length (TL) grew at a rate of 0.359 mm/d and fish >130 mm TL grew at a rate of 0.232 mm/d. Parameters of the von Bertalanffy growth function for the growth phases were: $L\infty$ = 231 mm and k = 1.368 $year^{-1}$ for fish <130 mm TL; $L\infty$ = 282 mm and k = 0.827 $year^{-1}$ for fish >130 mm TL. The female:male proportion was 37:1. Mean length of immature females was 134.7 mm TL, and sexual maturity began at ~200 mm TL for both sexes. Fecundity estimates ranged from 586,872 to 799,022 oocytes; fecundity correlated well with total length and body weight. Two lines of evidence suggested that white mullet in Lake Maracaibo is a multiple spawner: 1) Oocyte diameters differed among three designated zones of the ovary left lobe, and 2) Gonadosomatic index (GSI) values typical of heterochronal spawners; GSI values for ripe females ranged from 2.14 to 8.72%. In the light of these results, initiatives should be developed to protect coastal areas for white mullet in Lake Maracaibo.

Key words: White mullet; growth; reproduction; mark-and-recapture; gonadosomatic index; oocyte diameter; Lake Maracaibo, Venezuela.

Crecimiento y aspectos reproductivos de la lisa blanca, *Mugil curema*, en el Lago de Maracaibo, Venezuela

Resumen

Se efectuó una investigación durante cinco años, que incluyó un programa de marcaje y recaptura, para estimar el crecimiento y aspectos reproductivos de la lisa blanca, *Mugil curema*, en el lago de Maracaibo. Un solo modelo no ajustó la curva de crecimiento desde la etapa juvenil hasta la adulta, sino que hubo dos diferentes segmentos de crecimiento: los peces < 130 mm de longitud total (LT) crecieron a una tasa de 0,359 mm/d y los peces >130 mm LT crecieron a una tasa de 0,232 mm/d. Los parámetros de la ecuación de crecimiento de von Bertalanffy para las fases de crecimiento fueron: $L\infty$ = 231 mm y k = 1.368 $año^{-1}$ para peces <130 mm LT; $L\infty$ = 282 mm y k = 0,827 $año^{-1}$ para peces >130 mm LT. La proporción hembra:macho fue 37:1. La longi-

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tud promedio de las hembras inmaduras fue 134,7 mm LT y la madurez sexual comenzó a ~200 mm LT para ambos sexos. Los estimados de fecundidad variaron entre 586.872 y 799.022 ovocitos; la fecundidad se correlacionó con la longitud total y el peso corporal. Dos evidencias sugirieron que la lisa blanca en el lago de Maracaibo es un desovador múltiple: 1) el diámetro de los ovocitos difirió entre tres zonas del lóbulo izquierdo de los ovarios y 2) los valores del índice gonadosomático (IGS) fueron típicos de desovadores heterocronales. Los valores del IGS para las hembras maduras variaron entre 2,14% y 8,72%. Debido a estos resultados, se deberían desarrollar iniciativas para proteger las áreas costeras para la lisa blanca en el lago de Maracaibo.

Palabras clave: Lisa blanca; crecimiento; reproducción; marcaje y recaptura; índice gonadosomático; diámetro de ovocitos; Lago de Maracaibo, Venezuela.

Introduction

White mullet *Mugil curema* (Valenciennes, 1836) is the most abundant and widely distributed of the six species of mugilids that occur as juveniles and adults in the Venezuelan coastal areas (1), and it is an important migratory estuarine species that supports an extensive artisanal fishery in Lake Maracaibo (2). Although there is some evidence of white mullet spawning inside Lake Maracaibo (2-4), available data indicate that all mullet species are catadromous and must spawn in the sea. This requirement entails regular migration, changes of environment, and exposure to a variety of potential mortality factors (5). Thus, disturbance of the potential migration routes of white mullet to and from Lake Maracaibo could have great effects on the artisanal fishery (2). Landings of this species in Lake Maracaibo have declined 35% in the last six years, with annual catches ranging from 1,842 metric tons in 2000 to 1,193 metric tons in 2005 (6).

Despite the economic importance of white mullet, its biological and fishery features are not well documented in Lake Maracaibo (2-4, 7). For example, there is some information on reproductive development of white mullet in eastern Venezuelan coasts (8), but it is nonexistent in Lake Maracaibo. Also, some population parameters of white mullet have been documented in Lake Maracaibo (3, 7) and Gulf of Cariaco (9), including aspects relative to length frequencies, sexual maturity, and determinations of growth in length using modal progression analyses with program packages (e.g., ELEFAN, FiSAT).

In northeastern Venezuela white mullet is considered an isochronal spawning fish (10), i.e., they have synchronous gamete development and individuals spawn all their reproductive material at once or in batches over a few days (11); however, there have not been observations supporting this in Lake Maracaibo. Knowledge on its reproductive patterns has implications for future management purposes, since closed fishing seasons may be implemented to protect spawning stocks. Tagging may provide valuable data on movements, abundance, age, growth, and mortality (12-15). Consequently, the purpose of this study addressed aspects on growth and reproductive biology of white mullet in Lake Maracaibo, Zulia State, Venezuela.

Materials and Methods

Lake Maracaibo, located on the western coast of Venezuela (Figure 1), is relatively shallow, much of it less than 6 m deep, except for a shipping channel, 12-18 m deep and 182 m wide, which leads from the lake to the Gulf of Venezuela. Extensive tidal salt marshes exist along the shoreline of the lake, and the shallow, open-water areas contain islands, tidal flats, and tidal streams. The southern part of the lake receives substantial fluvial input, and the surface water

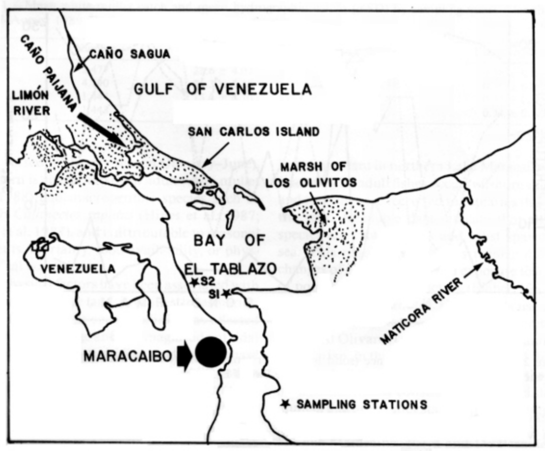

Figure 1. Sampling area and its relative position on the Venezuelan coast. S1 and S2 represent the collection stations.

salinity throughout the lake fluctuates strongly. Sampling was concentrated at two stations within the Bay of El Tablazo, in the north entrance of the Strait of Maracaibo, one in the eastern side (Punta de Palmas) and one in the western side (Playa Universitaria); near the sampling stations salinity ranges from 10 to 28 ppt (6). The sampling area has a maximum depth of about 12 m at mean low water, and its substrates are primarily fine sand and mud.

White mullet were captured for tagging semi-monthly from May 1995 to April 1997, hourly between 800 and 2400 hours, by means of beach seines 12.7-mm mesh, 70 m long x 2 m deep, and cast nets 25.4-mm mesh, 2.5-m diameter. Beach seines were number-9 multifilament nylon; cast nets were number-12 multifilament nylon. Captured fish were tagged with internal anchor tags with an attached external blue or green streamer. Tags were imprinted with a unique tag number so that individual specimens could be identified. Before tagging, tags and applicators were dipped in Betadine (Bruce Medical Supply, Waltham, MA) to minimize the possibility of infection. Anchor tags were inserted through a 2-mm diameter hole made with a pointed, stainless-steel rod on the left dorsal side of the fish near the dorsal fin, with the streamer protruding through the body wall. Total length, location, method of capture, tag number and tagging date were recorded for each fish tagged. Posters advertising a reward were distributed to marinas and boat launch sites along the northeast coast of Lake Maracaibo. The poster requested that the location of catch, total length and date of capture were sent, along with the tag and, if possible, the specimens, to the Instituto Nacional de Investigaciones Agrícolas at Maracaibo or any marina in the area. Marinas and boat launch sites were provided with formaldehyde and plastic bags to preserve specimens until taken to the laboratory.

For estimating the von Bertalanffy growth function (VBGF) using growth increments, we used the Appeldoorn's method based on Appeldoorn (16) and Soriano and Pauly (17) from the FAO-ICLARM Fish Stock Assessment Tools (FiSAT II, Version 1.2.0; 18). This method allows using growth increment data to estimate the parameters of a seasonally oscillating version of the VBGF. The method minimizes the following function using the Marquardt's algorithm for a nonlinear fit:

$$SSE = \sum \left\{ L_{i+\Delta t} - \left(L\infty - \left(L\infty - L_i \right) \exp\left(-\left(k\Delta_t - S_t + S_{t+\Delta t} \right) \right) \right) \right\}^2$$

where SSE = squared sum of errors, $L\infty$= asymptotic length, L_i = length at age i, $L_{i+\Delta t}$ = length at age i+Δt, k = growth coefficient, S_t = (C k/2∏ sin (2∏ (t-ts)), $S_{t+\Delta t}$ = (C k/2∏) sin (2∏((t+Δ_t)-ts)), and ts = 0.5 + WP (where WP= winter point). The parameter C determines the amplitude of the periodic oscillations relative to the mean annual value of k; C takes a value between 0 and 1. If C= 0, we obtain the growth equation without seasonality. The higher the value of C, the more pronounced are the seasonal oscillations. If C= 1, then the growth rate becomes zero at the so called winter point denoted by WP.

A modification of the Hotelling's T^2 test (19) was used to compare growth curves of the two growth phases found. This test assumes that estimations of L∞ and k (also t_0 in the original version) for the two growth phases (two sexes in the original version) were obtained from two normal distributions of joint probability with two (three in the original version) variables and one common variance.

In addition, each two hours (between 0900 and 2300 hours of each sampling day) a random sample (typically 25 specimens) of white mullet was taken to determine some biological features. Additional samples collected from the commercial artisanal fishery were also used. Commercial artisanal fishers typically use gill nets 6.4-,7.6-, 8.9- and 10.2-cm stretch-mesh monofilament nylon. Samples used for these analyses covered 24 months, and were obtained from the commercial artisanal fishers at normal operation time (typically late afternoon and early evening). Standard morphometric measurements included total length (TL; mm), body weight (W; g), sex, and female maturity stage. Maturity stages were recorded following a modification of the generalized classification of maturity stages in fish of Nikolsky (20). Females were judged to be in a specific maturity stage based on external characteristics of the gonads (e.g., weight, color) and on the developmental stage of the oocytes. Four maturity stages were identified (3, 8, 20): I) Ovaries fully transparent and inconspicuous, whitish-yellow and rounded with a small diameter, oocytes not distinguished neither macroscopically nor microscopically, weight of gonads less than 2.4 g; II) Ovaries rounder and wider than in stage I, yellow, oocytes only distinguished microscopically, weight of gonads ranged 2.4-7.2 g, oocyte diameter less than 0.20 mm ; III) Ovaries large, pale yellow, smooth, turgid and rounded. Oocytes easily distinguished macroscopically (as granular), weight of gonads ranged 7.2-39.5 g, oocyte diameter ranged 0.266-0.622 mm; IV) Spent ovaries purple and wrinkled. There was no histological confirmation of maturity stages. Ovaries were excised from specimens, blotted dry and weighed to the nearest 0.01 g, and then preserved in 10% buffered formalin. Fecundity was estimated by counting the number of oocytes in three tissue subsamples, 0.5 g each, randomly selected from the left lobe. Each subsample was counted three times and counts were averaged. Total fecundity was then estimated by extrapolating from the number of oocytes in each subsample to the total number of oocytes for each ovary based in weight. To determine oocyte diameter (OD), three different subsamples, 0.25 g each, were taken from each of three designated zones of the left lobe (anterior, medial, and posterior) and placed in a Petri dish. Two hundred fifty oocytes were measured from each designated zone. Oocyte diameters were measured along the longest axis with a micrometer mounted in a stereoscopic microscope. A gonadosomatic index (GSI) was calculated for each female white mullet following the method of Render et al. (21), where GSI was expressed as ovary weight (OW) divided by W such that GSI = (OW/W) x 100. All of the samples were analyzed within twenty-four hours after preservation before the preservative could cause any significant shrinkage and weight loss.

A TL-W relation was determined by the equation $W = aTL^b$, where W was weight of an individual fish and TL was total length. Length-weight relations were calculated independently for fish judged as immature and for fish judged as developing+ripe. A Student's t-test (PROC MEANS, 22) was used to discern whether fish showed isometric (b = 3) or allometric growth (b≠ 3). The Pearson product-moment correlation (PROC CORR, 22) was used to discern degrees of linear associations between reproductive and morphometric variables, and one-way analysis of variance (ANOVA; PROC GLM, 22) was used to detect possible differences in oocyte diameters among the three designated zones of the ovary left lobe (i.e., anterior, media, and pos-

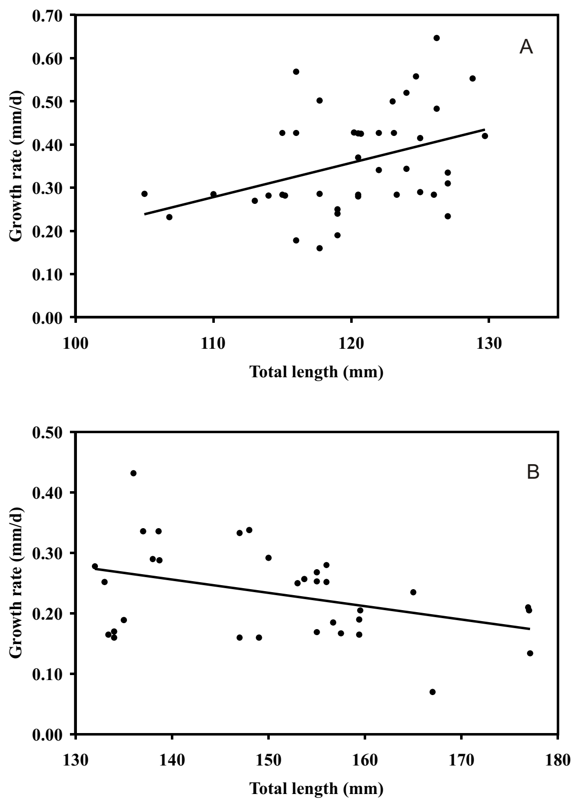

Figure 2. Relation between total length and growth rate as derived from mark-and-recapture data for (A) small (105-130 mm TL) and (B) large (132-177 mm TL) white mullet (*Mugil curema*) collected at Lake Maracaibo, Venezuela.

terior) and length classes. Significance for all analyses was declared at α= 0.05; all ANOVA underlying assumptions were tested. A $\log_e$ transformation of oocyte diameters corrected heterogeneity of variances.

Results

In all, 3,840 individuals (104 to 225 mm TL) were tagged, of which 2,120 were collected by beach seines and 1,720 were collected by cast nets. After initial handling mortality and tag shedding, 2,842 individuals were successfully tagged. Seventy-eight (2.7%) individuals (females) and their tags were returned from both commercial and experimental fisheries. Time elapsed between tagging and recovering ranged from 28 to 326 days, averaging 186 days. Length range of fish returned was 105-177 mm TL, and estimates of growth rate (GR) from returned tags varied widely (0.07 mm/d for a fish 167 mm TL to 0.647 mm/d for a fish 126 mm TL; in this case TL represents average from length at tagging and length at recovery). Results suggested two distinct growth phases for females; mean GR was relatively fast until fish attained ~130 mm TL (GR= 0.359 mm/d, se= 0.02; Figure 2), and then slowed down once fish attained >130 mm TL (GR = 0.232 mm/d, se = 0.01). Parameters of the VBGF for the two growth phases were: L∞ = 231 mm, se = 19.862, CV = 0.147, and k= 1.368 $year^{-1}$, se = 0.429, CV = 0.371 for fish <130 mm TL; L∞ = 282 mm, se = 10.037, CV = 0.089, and k = 0.827 $year^{-1}$, se = 0.289, CV = 0.241 for fish >130 mm TL. Growth parameters differed between growth phases (T^2= *8657.21; P* < 0.01).

A total of 1,450 individuals (102 to 389 mm) collected from the experimental and commercial fisheries was used to analyze reproductive aspects. Females significantly outnumbered males in the samples collected (Chi^2 = 984; *P* < 0.001); the female:male sex ratio was 37:1. Mean length of immature females was 134.7 mm TL (95% confidence limits: 109-283 mm TL). Gonad development to attain sexual maturity began at approximately 200 mm TL for both females and males, although many small (~110 mm TL) individuals coming from the commercial fishery were in late maturity stages. Fecundity for a combined sample (experimental + commercial) of 400 females white mullet ranged from 586,872 oocytes for a 353 mm TL specimen to 799,022 oocytes for a 382 mm TL specimen. Fecundity correlated well with TL (r = 0.722, *P*= 0.0122) and W (r= 0.663, *P* = 0.0263). Regressions of fecundity with TL and W were linear (TL: Fecundity = $-1.05x10^6$ + 4,568.3 TL, adjusted r^2 = 0.505, *P*= 0.0058; W: Fecundity= $1.44 \times 10^5 + 1,190.4$ W, adjusted r^2= 0.431, *P*= 0.0122). The GSI for developing females averaged 0.92% (range: 0.65 to 1.84%); in contrast, the GSI for ripe females averaged 5.97% (range: 2.14 to 8.72%). Total length, OD, and fecundity were all highly linearly correlated with GSI (TL: r = 0.719, *P* = 0.0127; OD: r = 0.950, *P* < 0.0001; fecundity: r = 0.604, *P* = 0.048).

There was a high degree of variability in oocyte diameters over the entire length range of white mullet analyzed. Mean oocyte diameter for fish judged as developing + ripe ranged from 0.266 to 0.622 mm. Oocyte diameters differed across different zones of the same ovary, but there was a marginal significant difference (F= 34.56, df= 2, *P*= 0.0496) in oocyte diameters among the three designated zones of the left lobe (i.e., anterior, medial, and posterior). When fish were grouped by length, a significant difference in oocyte diameters among length classes was obtained (F= 122.12, df = 2, *P*= 0.0123), indicating that diameters decreased as fish length increaed. Mean oocyte diameter was 0.524 mm for fish ranging from 327 to 347 mm TL, 0.475 mm for fish ranging from 348 to 368 mm TL, and 0.453 mm for fish ranging from 369 to 389 mm TL.

The TL-W relation for immature female was calculated from a combined sample of experimental and commercial fisheries (N = 800). The equation was: $W = 6.53 \times 10^{-6} TL^{3.06}$ (r^2 = 0.985, *P* < 0.0001). The smallest immature female white mullet collected measured 102 mm TL and weighed 12.5 g, whereas the largest measured 283 mm TL and weighed 241 g. The TL-W relation for developing + ripe females was calculated from a sample (N= 650) of the commercial fishery. The equation was: $W = 2.43 \times 10^{-4} TL^{2.43}$ (N = 650, r^2 = 0.734 *P* < 0.0001). Student's t-tests on the b coefficients indicated that growth for immature fish was isometric (H_0: b = 3; t = 0.978, df = 799, *P* = 0.0781), whereas for developing + ripe fish was negative allometric (H_0: b = 3; t = 4.567, df = 649, *P* = 0.0012).

Discussion

Fishery research on mugilids in general (e.g., 5, 23), and on white mullet in particular (e.g., 24-27), show a relatively high growth rate. Many fish species have indeterminate growth, and many important aspects of their biology change with body size (28). Knowing growth is a prerequisite for stablishing and optimal fishery management, and particularly for understanding a species' population dynamics. In Lake Maracaibo, it was not possible to age white mullet by conventional procedures (e.g., scales, otholiths), as seasonal marks are not evident on hard structures. Thus, using tagging for growth determinations was viable. Small fish (<130 mm TL) grew faster than large fish as demonstrated by differences in the growth coefficient (k) from the VBGF.

Estimates of L∞ for both growth phases are not comparables with those of other works (e.g., 24-27) with the same species, because they include estimations of L∞ for an entire range of lengths. However, current results indicated that k values for both growth phases of white mullet from Lake Maracaibo were higher relative to those calculated by the above works elsewhere. For example, Alvarez Lajonchere (26) reported a k of 0.10 $year^{-1}$ in Cuba; whereas Richards and Castagna (25) reported a k of 0.78 $year^{-1}$ in Virginia, USA. In our case, the k values reached 0.827 $year^{-1}$ for fish >130 mm TL, and 1.368 $year^{-1}$ for fish < 130 mm TL. This feature may indicate overexploitation of white mullet stocks at Lake Maracaibo, because when fishing is very intense, the commercial fish size decreases and the variations of the k coefficient increases (24). For example, Ferrer Montaño (3) reported a length range from 272 to 387 mm TL for white mullet from the commercial fishery in 1986, with most fish ranging from 302 to 367 mm TL; whereas Toledo et al. (7) reported a length range from 240 to 435 mm TL for white mullet from the commercial fishery in 1993, with most fish ranging from 240 to 335 mm TL, indicating that in a period of seven years the total length of the commercial fishery decreased 35 mm, and that fishers were catching smaller fish in 1993 than in 1986.

Growth rates of fish are density-dependent, and vary with factors such as temperature, food availability and exploitation rates (29-33). Results of this study indicated that growth stages of white mullet took advantage of Lake Maracaibo waters, particularly the Bay of El Tablazo. The Bay of El Tablazo is a very productive open system which provides an abundant supply of food for young fish and serves as refuges from predators (2), providing the most suitable conditions for growth and survival (34). Food availability has been indicated as an important primary attribute reflecting habitat value for coastal lagoons and estuaries in general (e.g., 35-36). This feature could have accounted for differences in the growth coefficient between the two growth phases of white mullet in Lake Maracaibo and the growth coefficient of white mullet elsewhere.

The decreasing growth rate for Lake Maracaibo white mullet >130 mm TL was associated with the process of sexual maturation. Growth is most rapid before sexual maturation because, with maturity, much energy is devoted to developing sexual products rather than to growth (37-38). As it was indicated, many white mullet in the Bay of El Tablazo reached sexual maturity at small lengths, although average length at maturity was ~200 mm TL, corresponding to the length at which white mullet left the Bay of El Tablazo and move to more saline, deeper waters in the Gulf of Venezuela. Ferrer Montaño (2) indicated that juvenile white mullet longer than 150 mm TL were uncommon in the coastal waters of Lake Maracaibo. Thus, habitat use of the bay by juvenile stages of white mullet appeared to be vital for populations of the species. This finding was not just based on the paradigm that fish presence reflected habitat functional value, but a confirmation that the Bay of El Tablazo, along with many other estuarine areas of Lake Maracaibo (especially the Marsh of Los Olivitos in the northeastern portion of the Bay of El Tablazo), provided white mullet with habitat, refuge and food.

The length-weight relation has both applied and pure applications. Ricker (39) expressed the importance of length-weight relations in population assessment. In ecology, the length-weight regression coefficient is often used as a measure of fish condition (40). Generally, a cyclical change in condition occurs as the fish, particularly the female, develops its gonads (41). In this case, the length-weight relation showed that there were variations in relation to the maturity stage. Results of this study showed that for the length range studied, there were two stages with distinct characteristics for the corresponding length-weight relation. According to Tesch (42), critical stages in the biology of fish (e.g., metamorphosis, change of habitats, sexual maturity), may cause changes in the length-weight relation. For white mullet in Lake Maracaibo, the change in the slopes of the regression took place for the length in which white mullet reached the sexual maturity and migrated to deeper zones. Ferrer Montano (2) reported that with growth white mullet moved from coastal shallow areas to other estuarine habitats.

Estimates of fecundity reported in this study were similar to those reported for white mullet in other areas of Venezuela (10, 43-45); fecundity of white mullet in Lake Maracaibo was also similar relative to size compared to those reported for other mugilids elsewhere (21, 45-46). However, compared to white mullet in coastal areas of northeastern Venezuela (10, 43-44), fecundity was less variable in Lake Maracaibo, ranging from 586,872 oocytes for a 353 mm TL specimen to 799,022 oocytes for a 383 mm TL specimen; whereas Marin and Dodson (10), analyzing specimens ranging from 230 mm standard length (SL) to

420 mm SL, reported fecundities ranging from 190,000 to 110 x 10^4 oocytes. High degree of variation in fecundity for fish of similar lengths and weights has been reported for other fish species (e.g., 47-48 for skipjack tuna *Katsuwonus pelamis*), and evidences suggest that this may be due to the selection of fish which had not yet spawned, and others which had already spawned at least one group of ova and were preparing to spawn again. Joseph (47), concluded that there may be some decrease in fecundity during successive spawnings of the yellowfin tuna, *Thunnus albacares*. Probably, a similar decrease occurs in the white mullet which would account for the variations observed in fecundities of fish from northeastern Venezuela and Lake Maracaibo.

Although there was a high degree of variability in oocyte diameters over the entire length range of white mullet analyzed, current results indicated that white mullet at Lake Maracaibo was a multiple spawner [*sensu* Batts (48)]; however, as it was indicated above, ANOVA only confirmed a marginal significant difference in oocyte diameters among the three designated zones of the left lobes studied. Batts (48) indicates that there are two lines of evidence to be considered to determine whether a fish is a multiple spawner or an isochronal spawner. The first evidence is several modes in oocyte diameters, and data of the current study substantiate this observation; and the second evidence (not determined in this study) is ovaries containing residual oocytes, accompanied by a new ripening group. In this case, another line of evidence indicating white mullet in Lake Maracaibo is a multiple spawner is GSI values. Values of GSI for Lake Maracaibo white mullet were quite low compared with those of many marine teleosts, including mugilids (e.g., 21, 49); GSI for white mullet in Lake Maracaibo ranged from 2.14 to 8.72%, compared with values of up to 37% reported by Render et al. (26) for striped mullet (*M. cephalus*) in Louisiana estuarine waters. An examination of published GSI values for some multiple spawners shows that most GSI are below 10%. Burt et al. (49) indicated that multiple-spawning species would have smaller ovaries because of the sequential nature of oocyte maturation and egg release, which results in a decreased need for storage space within the body cavity. Non-conclusive evidences on whether white mullet in Lake Maracaibo is a multiple spawner or not, warrants further research on the topic. Histological examination is necessary to fully discern on the issue.

Fecundity correlated well with TL and the regression was a linear relation, indicating that fecundity increased with length; however, a significant difference in oocyte diameters was detected when fish were grouped by length classes, indicating that oocyte diameters decreased with length. If we use length as a surrogate for age, this could be reasonable evidence that although white mullet increased their fecundity with age, these oocytes could be less viable as the fish get older. Hoyt (50), reported that oocyte diameters of silverjaw minnow (*Ericymba buccata*) decreased with age; the average oocyte diameters was highest (0.768 mm) in fish of age group I, intermediate (0.746 mm) in fish of age group II, and lowest (0.737 mm) in fish of age group III. In the present study, mean oocyte diameter was 0.524 mm for white mullet in the 327-347 mm TL class, 0.475 mm for white mullet in the 348-368 mm TL class, and 0.453 mm for white mullet in the 369-389 mm TL.

Growth, reproduction and feeding habits represent important characteristics of the general life history of fish. Our results demonstrated that growth rate for white mullet varied according to total length and thus, a single model did not fit the white mullet growth curve from juvenile stages to adult, but there were two different segments. Estimates of growth for white mullet provide one of the three basic statistics prerequisite to estimate of total production and sustainable yield (the other two are mortality and a reliable ichthyomass estimate). Current results also indicated that juvenile stages of white mullet used intensively the Bay of El Tablazo, and that, at least for a segment of the white mullet population, the onset of maturation was initiated when they were present in the study area. Considering that white mullet forms the basis of an important artisanal fishery in Lake Maracaibo, and that the Lake Maracaibo basin is under extensive development pressure, which has led to extensive modification of coastal areas and loss of mangroves that serve as nursery and feeding areas (2), it is important to develop initiatives to protect coastal areas as the ones sampled in this study. These initiatives would not only assure feeding and nursery areas for white mullet in Lake Maracaibo, but probably spawning stocks of white mullet for Lake Maracaibo and many other northwestern coastal areas of Venezuela.

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