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# Reproduction, Movements, and Population Dynamics of the Southern Kingfish, *Menticirrhus americanus*, in the Northwestern Gulf of Mexico

Stephen M. Harding
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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

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## ABSTRACT

***Menticirrhus americanus* in the northwestern Gulf of Mexico mature at 150-220 mm TL and 12-14 months of age, with males maturing when 10-40 mm smaller than females. Spawning occurs within a broad period from February through November with two discrete peaks which coincide with the periodicity of down-coast alongshore currents (towards Mexico) in spring and fall. This species occurs at depths of less than 5 to 27 m, being most abundant at 5 m or shallower. Young-of-the-year recruit primarily at 5-9 m or shallower and gradually expand their bathymetric range. Age determination by length frequency is feasible in *M. americanus* but not as simple as in species that spawn in one major period of the year. Only one or two spawned groups normally predominated at any one time and no more than three co-occurred with few possible exceptions. Observed mean sizes were 138 mm TL at 6 months, and 192 and 272 mm at ages I and II, respectively. Typical maximum size was 296-308 mm and typical maximum age is probably 2-3 years. The largest fish captured were 392 and 455 mm. Observed sex ratio was 1.2 females to 1 male. Weight, girth, and length-length regressions are presented.**

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## INTRODUCTION

The southern kingfish, *Menticirrhus americanus*, is an inshore bottomfish ranging from Long Island, New York to Florida, through the Gulf of Mexico (Gulf), and south to Buenos Aires, Argentina (Schaefer 1965; Johnson 1978). In U.S. waters, this species is most common south of Chesapeake Bay (Welsh and Breder 1923). It is a popular sport and food fish along the southeast coast of the U.S. and in the Gulf where it is taken incidentally in commercial fisheries (Dunham 1972; Knowlton 1972; McIlwain 1976). Although its distribution in estuaries is not well documented, *M. americanus* is considered estuarine-dependent (Gunter 1945) and uses all estuarine areas primarily as a nursery (McHugh 1967).

The life history of *M. americanus* is poorly known. Detailed studies have been made only along the southeast coast of the U.S. (Bearden 1963; Smith and Wenner 1985). Knowledge of this species in the Gulf is general and based chiefly on faunal studies, including Gunter (1945), Hildebrand (1954), Moore et al. (1970), Franks et al. (1972), and Christmas and Waller (1973); however, they are sometimes conflicting, e.g., widely different spawning seasons have been suggested (Welsh and Breder 1923; Hoese 1965; Miller 1965; Jaanke 1971).

This report describes maturation, spawning periodicity, bathymetric distribution, seasonal abundance, recruitment, size at age, maximum size, sex ratios, length-weight, length-girth, and length-length relationships of *Menticirrhus americanus* in the northwestern Gulf of Mexico.

## METHODS

*Menticirrhus americanus* were collected along a transect off Freeport, Texas (Fig. 1) on 71 monthly or twice-monthly cruises from October 1977 to August 1981 aboard a chartered shrimp boat using 10.4 m (34 ft) trawls with 4.4 cm stretched mesh cod end and tickler chain. Stations were initially located at 9, 13, 16, 18, 22, 27, 36, and 47 m depths. This was expanded to include 5 and 24 m after November 1978 and 55, 64, 73, 82, 86, and 100 m after May 1979. Day collections were made through September 1978 with usually alternating day and night cruises in each month thereafter. Two 10-minute tows (bottom time) were made at each depth, except that only one tow was made at each depth prior to October 1978, usually 8 tows were made at 16 m, and 24 tows at 22 m.

All *M. americanus* were measured to the nearest millimeter in total length, fixed in 10% Formalin, and later preserved in 70% ethanol. After preservation the following data were taken on all fish captured from September 1979 to August 1981: total length (TL), standard length (SL), girth between first and second dorsal spine (G), total weight (TW), gonad weight (GW), sex, and ovary maturity stage. All sizes reported in this paper are mm TL. Size at maturity and/or spawning periodicity were determined from

1) maturity stages (Table 1) using a modification of Kesteven's system (Bagenal and Braum 1978);

2) length frequencies by maturity stage (Fig. 2) or cruise (Fig. 3);

3) gonadosomatic indices (GSI) calculated as GSI = 100 GW/TW; and

4) regressions of ovary weight on total length.

Age was determined from length frequencies using the Petersen Method (Lagler 1956). Spawned groups were specified by season and year hatched, e.g., Fall 1980 (Table 2, Fig. 3). Descriptions of spawning periodicity using length frequencies assume the following size-at-age combinations predicted from regressions of size on age for Fall 1980 and Spring 1981 groups: 20-30 mm at 1 month, 50-60 mm at 3 months, and 100-130 mm at 6 months. These regressions were chosen because (1) the Spring 1981 group was the only clear spring-spawned cohort and (2) the Fall 1980 group clearly showed growth, was easily followed, and, unlike other Fall cohorts, all regression equations gave reasonably similar hatching dates and sizes at age.

Hatching dates used to set time scales for calculating growth were determined by a one-step iteration process following Standard and Chittenden (1984). Initial hatching dates of 1 February and 1 October were assigned to respective spring and fall groups to start the process. Data used in these regressions were based on early life periods when cohorts were most clearly identifiable, beginning when the groups appeared fully recruited, as evidenced by increasing size (growth), in successive collections (generally February-March and May for fall- and spring-spawned fish, respectively), and continuing until the group identity and/or boundaries became less certain (usually at 4-8 months after recruitment). Calculated hatching dates and spawning period duration are sensitive to the time intervals chosen because the slope of the line varied. Hatching dates, for example, were 1-2 years early when data included the period November-January when only the oldest, largest fish of a cohort had recruited. Linear equations were used for prediction if the quadratic term was not significant at $\alpha = 0.07$ or produced a curve unsuitable for growth analysis, i.e., upwardly concave with no $x$-intercept (Table 3, Fig. 4C).

Duration of the spawning period was approximated following Geoghegan and Chittenden (1982) as:

$$\frac{\text{Time-specific mean size range early in life}}{\text{Mean growth/day early in life}}$$

Calculations were based on May-August data for spring groups and February-May data for fall groups, months when they first appeared fully recruited. Time-specific size range was calculated for each group as the mean of the 99% confidence intervals for observations in these specific time periods (Table 4). Growth increments were estimated as the difference between mean lengths at the initial and final collections in these time periods predicted from regressions used to calculate hatching dates (Table 4). Mean growth/day was estimated as the growth increment divided by the time interval between initial and final collections.

Typical maximum length was approximated as a length ($l_L$) exceeded by only 0.5-1.0% of a catch (Standard and Chittenden 1984). Percent values were derived from a cumulative percent length-frequency curve for all fish captured from October 1977 to August 1981. Regression relationships were calculated following standard procedures in Snedecor and Cochran (1980). All length frequencies herein were smoothed by moving averages of three size intervals.

## RESULTS

### Maturation

*Menticirrhus americanus* in the northwestern Gulf mature at 150-220 mm, and males mature at a smaller size than females. Mean sizes of males were 10-40 mm less than females in each named stage after maturing virgin (Fig. 2, Table 5). No fish remained in the maturing virgin stage when greater than 250 mm, and few were greater than 220 mm in this stage. Gonad maturation was distinct at 130-150 mm as a few females and many males entered the early developing stage. Extrapolated $x$-intercepts and inflection points of regressions of gonad weight on total length for females were 180-230 mm (Fig. 5, Table 6). Most fish in the late developing through resting stages, particularly females, were greater than 200 mm (Fig. 2). Age compositions and sizes presented later indicate *M. americanus* mature to first spawn at 12-14 months.

Little or no somatic growth occurs after *M. americanus* enter later stages of maturation. Mean sizes for females were 258 mm in the late developing stage, 262 mm when gravid, 265 mm when ripe, 258 mm when spawing/spent, and 247 mm when resting (Fig. 2, Table 5). Mean sizes for males were 225 mm for the late developing stage, 222 mm for ripening/spawning, and 238 mm when resting. Maximum and minimum sizes and 99% confidence limits of observations also generally remained similar from the late developing through the resting stage for both sexes (Table 5). The broad 99% confidence interval for ripening/spawning males resulted from the small number of fish ($n = 2$) collected in this stage. Seemingly decreased size of females in the resting stage may reflect incomplete separation of resting and maturing virgin stages.

### Spawning periodicity

*Menticirrhus americanus* spawn within a broad period from February or March through November. Females in the ripe, gravid, or spawning/spent stages, and/or with high GSI values, occurred in most calendar months throughout this period except September and October (Figs. 6, 7); fish in the late developing stage were collected in every calendar month except September. At least a few fish 40-60 mm and 2-3 months of age were collected in every calendar month except September and November (Fig. 3, see especially 1981); a few fish 60-80 mm and 3-4 months of age were collected in September and/or November of 1979 and 1980.

Little spawning of *M. americanus* apparently occurs in the period June-September. Few fish 40-80 mm and 2-4 months old were captured July-November, although fish this size, clearly part of an abundant group of recent recruits, were common or abundant in December-March most years and in late May through June 1981 (Fig. 3). High GSI values after April or May are based on only a few males or females, and mean values distinctly declined after that time (Fig. 7). That some spawning may occur in summer, however, is suggested by the presence of a few fish 40-80 mm during July to November, some labeled as Sm 79 (Fig. 3), and by the presence of a few females in the gravid and ripe stages or with high GSI values in the summer (Figs. 6, 7).

Although *M. americanus* spawn over a broad time period, spawning primarily occurs during two discrete periods: spring (January-April) and fall (August-November).

**Spring**—Modal groups of spring-spawned fish are readily followed in length frequencies (Fig. 3) from 19 May 1981, when fish 40-80 mm and 2-4 months of age recruited, through 6 August 1981 when they were 80-150 mm. Minor groups of fish 60-120 mm also appeared in June and early July of 1979 and 1980; they were apparently spring spawned because fish this size made up the clear Spring 81 cohort in June and July. Calculated hatching dates for the Spring 81 cohort, the only spring group that could be followed for any length of time, were 2 January, 8 March, or 20 April 1981, depending on the data included and whether linear or quadratic regression is used (Fig. 4; Table 3, Eq. 1, 2, 3). The first date may be too early because it includes one 40-mm fish collected on 2 March and may be biased towards an early date by the incomplete recruitment suggested by that one large, early hatched fish. Moreover, the linear equation it is based on explains much less variation in total length ($100r^2$ = 86.2%) than the linear ($100r^2$ = 92.7%) or quadratic ($100r^2$ = 98.4%) equations with the 2 March collection deleted (Table 3). Hatching dates are 8 March-20 April, regardless of the data set manipulated if the collection of 2 March is deleted. Gonadal data also indicate a spring spawning period: 1) mean GSI values of males and females rise to a peak in March and April 1980 and 1981 and decline thereafter (Fig. 7), and 2) slopes of the regressions of gonad weight on total length for females were at a maximum in the period February-April (Fig. 5, Table 6).

**Fall**—Fall-spawned cohorts initially recruit in abundance each year in the period December-February at 50-150 mm (Fig. 3), although their upper size boundaries may not be clear from then through February or March. Following this initial period, well defined modal groups of fall-spawned fish are readily followed in the period early April-July in 1979, mid February-late July or later in 1980, and mid March-early August in 1981; cohort mean sizes and observed size ranges were similar at comparable times each year (Table 2; Harding 1984, Appendix 1). Calculated hatching dates (Table 3) varied depending on the collections used, but generally occurred in the fall for the seemingly best data sets. Dates for the Fall 80 cohort, the clearest fall cohort with the best fitting regressions ($100r^2$ = 89-94%), were 11 August, 20 September, 3 October, and 5 November 1980 (Fig. 4, Table 3). Dates for the Fall 79 cohort were 3 June and 15 March 1978, and 17 June, 9 November, and 20 November of 1979; the former two equations explain only half the variation ($100r^2$ = 42-45%) of the latter three ($100r^2$ = 79-92%) and seem unrealistic because their hatching dates appear to be a year too early. The 17 June date, moreover, is based on linear regression and has a lower $100r^2$ value than the two remaining quadratic equations. Dates for the Fall 78 groups were 25 November 1977, 4 September 1976, and 5 August or 31 December 1978; the former two equations explain much less variation ($100r^2$ = 30-63%) than do the latter two ($100r^2$ = 73-87%), which may reflect incomplete recruitment in February, and seem unrealistic because their hatching dates appear to be 1-2 years too early.

Little or no spawning seemingly occurs in late fall or early winter during an interval of about 2-3 months duration between spring and fall spawning. This is suggested by the distinct gap between modes for Spring 81 and Fall 80 cohorts in late May and June of 1981 (Fig. 2). Differences between mean sizes of these cohorts were 98, 86, and 84 mm on 19 May, 7 June, and 16 June, respectively (Table 2), which suggests an interval of about 4-5 months between mean hatching dates.

Length-frequency and gonad data conflict on whether spring or fall spawning predominates; the former data suggests predominant fall spawning and the latter data indicates predominant spring spawning. As noted, mean and maximum GSI values for males and females rose to a peak in March and April and declined thereafter (Fig. 7), and slopes of the regressions of gonad weight on total length for female *Menticirrhus americanus* were at their greatest in the period February-April (Fig. 5, Table 6). However, mean and maximum GSI values were generally low in the fall (Fig. 7), and no ripe or gravid fish were captured in September and October (Fig. 6). In contrast, length frequencies show a clear and abundant spring-spawned group only in 1981 (Fig. 3); few spring-spawned fish were captured in 1979 and 1980. Fall-spawned fish recruited in abundance from December through February each year, and their modes are dominant and readily followed.

Spawning intensity is greatest over a 2-4 month period in spring and seemingly longer in fall. Calculated spawning period durations based on mean 99% confidence limits of observations and predicted growth/day for the Spring 81 group, the only usuable spring cohort, were 120, 68, and 75 days (Table 4). Spawning durations for fall groups varied depending on the data used and were more prolonged than for spring groups. Durations were 155-217 days for the Fall 80 group, 183-275 days for the Fall 79 group based on the three seemingly most realistic regressions (see above paragraph, also Table 3), and 139-174 days for the Fall 78 group (Table 4). Estimates of growth/day used to calculate spawning period durations are sensitive to data intervals used and considerations noted in the previous paragraph about most realistic regressions apply here also.

## Bathymetric distribution and recruitment

*Menticirrhus americanus* occur at depths of less than 5 to 27 m in the northwest Gulf off Freeport. Catch per tow was greatest at 5 m, the shallowest depth occupied (Fig. 8). It decreased sharply between 5 and 13 m and then gradually to 27 m. Only 30 fish were captured in 124 tows at 24 m and 12 fish in 126 tows at 27 m. No fish were captured in 789 tows at 36 to 100 m.

Young-of-the-year recruit primarily at depths of 5-9 m if not shallower. Recent fall-spawned recruits 40-160 mm were abundant at 5-9 m in the December-March period (Fig. 9A, B); few of these fish less than 150 mm recruited at 13-16 m or deeper. Greatest recruitment was at 5 m, the shallowest depth occupied. Similarly, new spring-spawned recruits 30-110 mm were most abundant at 5-9 m in the period June-August and during May (Fig. 9C, D); few of these fish less than 100 mm were captured at 13-16 m or deeper.

Fall-spawned young-of-the-year gradually expand their bathymetric range. Although few fall-spawned recruits, and only larger ones, occurred deeper than 9 m in the period December-March, they were common at 13-16 m in the period April-May when they were 100-200 mm (Fig. 9C) and reached 18-27 m by the period July-August (Fig. 9D). Despite this offshore dispersal, fall-spawned fish remained most abundant at 5-9 m throughout their first year.

Larger, presumably older, fall-spawned young-of-the-year apparently lead the offshore dispersal. No fall-spawned recruits less than 100 mm were captured deeper than 9 m in the period December-May, with the exception of one 71-mm fish at 16 m in the period February-March and two fish 96 and 100 mm at 13 m in the period December-January (Fig. 9A, B, C). In contrast, presumably younger fish 50-100 mm were abundant at 5-9 m, a contrast that suggests offshore dispersal of larger, older fish after an inshore recruitment. This interpretaion is supported by the clear size gradient of fall-spawned recruits in the period February-March during which the smallest fish occurred at 5 m (Fig. 9B).

Age I and II fall-spawned fish are distributed throughout their bathymetric range without clear patterns of seasonal movement. Newly Age I fish were most abundant at 5-9 m depths during the period September-January and April-May (Fig. 9A, C, E); these fish were common to 16 m. Their abundance at 5 m was much lower in February-March and June-August compared to other depths at other periods. Large Age II fish appeared uniformly distributed throughout their depth range.

## Age determination and growth

Few spawned groups of *M. americanus* exist at any one time in the northwest Gulf and only one or two normally predominate. No more than three spawned groups occurred in one month with the possible exception of groups on 10 June and 24 September 1979, 11 July 1980, and 19 May, 16 June, 22 July, and 6 August 1981, when spring- or summer-spawned individuals occurred along with the generally predominant fall cohorts (Fig. 3). Three fall-spawned groups often occurred in one month, these being young-of-the-year and Ages I and II, although age designations often may not be exact for the larger individuals, for example, on 4 and 19 May, 16 June, 22 July, and 6 and 18 August 1981 when only one or two fall groups generally predominated. Fall groups were generally most clear just after they began to recruit during December-February through the following September-October, when their boundaries became uncertain at modal lengths of about 170-190 mm and 10-14 months of age. Spring fish were clearly identifiable only in 1981, but even this cohort was readily followed only from 19 May through 6 August 1981 when they were 80-145 mm and 4-8 months old (Fig. 3). Spring-spawned fish evident in June, July, and August of 1979 and 1980 were negligible in abundance and did not persist.

Observed mean sizes of fall-spawned *M. americanus* were consistent between years. Mean sizes, based on averaging mean sizes at age over collections in the period September-November, were 138 mm at 6 months, and 193 and 272 mm at Ages I and II (Table 7). Mean lengths at Age I were 181 mm for Fall 77, 207 mm for Fall 78, 184 mm for Fall 79, and 200 mm for Fall 80 groups. Mean sizes at Age II were 270 mm for Fall 76, 285 mm for Fall 77, 262 mm for Fall 78, and 278 mm for Fall 79 (Table 7).

## Maximum size, life span, and sex ratio

The typical maximum size attained by *M. americanus* in the northwest Gulf is 300-310 mm, although individuals may reach 450 mm. The largest fish we captured were 392 and 455 mm, although a preserved specimen did not exist to confirm the latter value. The largest male and female sexed were 303 and 345 mm, respectively. During October 1977 to August 1981, 99% of the 9,447 fish captured were less than 296 mm, and 99.5% were less than 308 mm (Fig. 10). Fish of 296-308 mm would seem to be typically only 2-3 years old at most, because mean size at Age II was 272 mm, with the mean upper 99% confidence limit about observations being 352 mm (Table 7).

Female *M. americanus* were more numerous than males. The observed sex ratio was 1.2 females to 1 male among 3,076 mature fish examined. This ratio differed significantly from 1:1 ($\chi^2$ = 23.7, df = 1, $\alpha$ = 0.05).

## Weight, girth, and length relationships

Regressions of total weight-total length, girth-total length, and standard length-total length are presented with supporting statistics in Table 8. Length-weight regressions were not significantly different in slope between sexes ($F$ = 0.57; df = 1, 3141; $\alpha$ = 0.05), but they differed in elevation ($F$ = 25.8; df = 1, 3142; $\alpha$ = 0.05). Regression slopes for males and females differed significantly from immatures ($F$ = 68.8; df = 1, 5762; $\alpha$ = 0.05). However, pooled regressions are presented for males and females and for males, females, and immatures, because they may be more useful in stock assessment than individual regressions. For simplicity, pooled regressions are presented for length-length and length-girth relationships.

Length-weight regression slopes for mature and immature fish significantly exceeded a hypothesized $\beta$ = 3.0 (matures: $t$ = 69.9, df = 3143, $\alpha$ = 0.05; immatures: $t$ = 18.12, df = 2554, $\alpha$ = 0.05) indicating allometric growth for both groups.

# DISCUSSION

## Maturation

Little information is available on maturation of *M. americanus*. Our finding that males and females in the northwest Gulf mature at 150-220 mm at Age I agrees with sizes of 135 and 192 mm in the South Atlantic Bight at age I (Smith and Wenner 1985; Hildebrand and Cable 1934). Bearden (1963) believed males matured at 240 mm TL (195 mm SL) at Age II and females at 280-300 mm TL (230-250 mm SL) at Age II-III, but Smith and Wenner felt Bearden collected primarily at estuarine stations which lacked smaller, mature, Age I fish. The smallest "ripe" fish (Irwin 1970) obtained off Louisiana were a 260 mm TL (215 mm SL) male and a 265 mm TL (218 mm SL) female, but he did not define "ripe."

## Spawning periodicity

The broad spawning period of February or March through November that we found for *M. americanus* agrees with many other studies in the Gulf and Atlantic. However, the literature on spawning periodicity conflicts and has been interpreted in a variety of ways, including (1) a broad spawning period in the Gulf of fall and/or winter through spring (Welsh and Breder 1923; Miller 1965; Jaanke 1971) or (2) a broad spawning period of spring through late summer or fall in the Gulf (Gunter 1945; Hoese 1965; Moe and Martin 1965; Christmas and Waller 1973) and along the Atlantic coast north and south of Cape Hatteras (Pearson 1941; Bearden 1963; Smith and Wenner 1985). Peak spawning, moreover, has been interpreted to occur in a variety of ways, including (1) a peak in spring or early summer in the Gulf (Reid 1954; Springer and Woodburn 1960) and along the Atlantic coast north and south of Cape Hatteras (Hildebrand and Schroeder 1928; Hildebrand and Cable 1934; Bearden 1963) and (2) a peak in the fall along the Atlantic coast north of Cape Hatteras (Welsh and Breder 1923). In reality, it appears that *M. americanus* in the gyre of the northwestern Gulf (Kelly et al. 1984) at least, has a complex spawning periodicity and life history, described below, which has not been recognized because few studies have been made in detail on this species and/or few have had the frequent sampling over such a long duration of time as ours.

Our finding that spawning occurs in two primary discrete periods, spring and fall, has generally not been recognized. However, Welsh and Breder (1923) suggested peak spawning in spring and fall along the southeast Atlantic coast off Fernandina, Florida, although Hildebrand and Cable (1934) and Smith and Wenner (1985) suggested this might reflect insufficient collecting in the intervening summer months. That criticism, however, can not be applied to our study. Our finding of peak spawning in discrete spring and fall periods, moreover, is similar to recent findings that several other fishes also spawn with this periodicity in the northwestern Gulf, including *Peprilus burti* (Murphy 1981; Murphy and Chittenden unpubl.), *Cynoscion arenarius* (Shlossman and Chittenden 1981), *C. nothus* (DeVries and Chittenden 1982), *Fundulus grandis* (Waas and Strawn 1983), and *Larimus fasciatus* (Standard and Chittenden 1984). This occurs in a variety of families and may represent a broad phenomenon in the Gulf (Murphy and Chittenden unpubl.).

Standard and Chittenden (1984), based on Murphy and Chittenden (unpubl.), suggested a hydrographic basis for spring and fall spawning peaks in *P. burti*, *C. nothus*, and *L. fasciatus* which probably applies also to *C. arenarius* and *M. americanus*, both of which have pelagic eggs and larvae (Johnson 1978): spawning is timed to coincide with the periodicity of downcoast alongshore currents (toward Mexico). These currents probably transport pelagic eggs and larvae "downstream" to nurseries in the northwest Gulf from spawning grounds located "upstream" in or toward the north central Gulf. Reversed current transport mechanisms in the summer (Temple and Martin 1979) would carry pelagic eggs and larvae offshore, which presumably would be unfavorable to *M. americanus*, or toward the north central Gulf. The latter possibility could explain the apparent absence of summer spawning in length frequencies in *M. americanus* and other species. However, *M. americanus* is abundant in summer off Texas at Port Aransas (Gunter 1945; Miller 1965), in the Padre Island surf (Chittenden pers. observ.), and off the jetties of Brownsville (Standard pers. observ.) based on angling. Presumably, summer-spawned individuals from these locations would be transported upcoast to Freeport where our study was made unless (1) transport occurs over even greater distances towards the north central Gulf or (2) summer spawning is truly negligible.

We have interpreted spawning of *Menticirrhus americanus* as occurring in two main periods. However, spot (*Leiostomus xanthurus*) spawn in one discrete period but recruit to the Gulf in two widely speparate periods (Hata 1985). It is possible that this pattern could apply to *Menticirrhus americanus*, because our collections were made towards the deeper part of its bathymetric range. Time-frequent collections in estuaries, the surf zone, and/or shallow Gulf inshore of our collections would resolve whether *Menticirrhus americanus* has two discrete spawning periods as we have suggested or possibly one spawning period (presumably late winter and early spring based on gonad data) with two periods of recruitment.

## Bathymetric distribution and recruitment

*Menticirrhus americanus* is essentially an inshore species of the white shrimp community described by Hildebrand (1954) and Chittenden and McEachran (1976). We found that it occupies a primary depth range of 5-27 m off Texas, which agrees with other studies done in the Gulf (Miller 1965; Moe and Martin 1965; Chittenden and McEachran 1976) and the Atlantic (Hildebrand and Cable 1934; Bearden 1963; Smith and Wenner 1985). Although we captured no *M. americanus* deeper than 27 m, they have been reported as deep as 36-45 m off Mississippi and Texas (Irwin 1970; Hildebrand 1954) and to 54 m off South Carolina (Bearden 1963).

We found that the gradual dispersal offshore after inshore recruitment and size gradient with depth (fish <160 mm shallower than 9 m; fish >200 mm at 13-27 m) agrees with Hildebrand (1954) who found only fish greater than 200 mm TL at 22-32 m off Texas, and with Irwin (1970) who found fish less than 185 mm TL (150 mm SL) in depths shallower than 16 m but larger fish to 23 m depths off Mississippi.

Our finding that young *M. americanus* recruit primarily in inshore areas in the Gulf (5-9 m when 40-160 mm TL) agrees with Miller (1965) who captured them at 5-8 m off Port Aransas, Texas. This species also recruits to the Gulf in the same general periods (May-June and December-February) as several other Gulf fishes that spawn in two periods a year, such as *P. burti*, *C. arenarius*, and *L. fasciatus* (Murphy 1981; Shlossman and Chittenden 1981; Standard and Chittenden 1984).

## Age determination and growth

Age determination of *M. americanus* is feasible using length frequencies. However, as in our study, collections must be made frequently in time and over a long duration, because boundaries of age groups and age designations are not clear every month, especially for larger individuals. Despite that problem, age designation and group boundaries are quite clear in certain months (for examples, the Spring 81 and Fall 80 groups in May and June 1981, the Fall 79 group in April 1979). From the clear groups, one may work chronologically backward or forward in time and gradually assign age designation and boundaries with reasonable certainty. Age determination by length frequencies in *M. americanus* is similar in these respects to *P. burti* (Murphy 1981), *C. arenarius* (Shlossman and Chittenden 1981), and *C. nothus* (DeVries and Chittenden 1982), all of which appear to spawn over a broad period of time but in two discrete major spring and late summer or fall periods. In contrast, age determination by length frequency is simple and very clear in other species of Gulf shrimp communities such as *Micropogonias undulatus* (White and Chittenden 1977; Chittenden unpubl. data), *Stenotomus caprinus* (Geoghegan and Chittenden 1982), *L. fasciatus* (Standard and Chittenden 1984), and *Polydactylus octonemus* (Dentzau 1985), all of which spawn in one discrete period each year (*Micropogonias* and *Stenotomus*) or spawn in one major and one very minor spring and/or fall period, such as *Larimus* and *Polydactylus*. Therefore, it appears the simplicity of age determination via length frequencies may suggest life history patterns: those shrimp community fishes for which this procedure is difficult may have a complex life history and multiple major spawning periods; those for which it is simple may have one discrete major spawning period, with or without a second minor period.

The limited literature on growth of *M. americanus* is mostly for the Atlantic coast. Mean sizes of fish we captured at 6 months and Age I (138 and 193 mm, respectively) agree with mean sizes reported throughout this species range [125 mm TL = 100 mm SL at 6 months, and 185-200 mm TL = 150-160 mm SL at Age I off South Carolina (Bearden 1963); 145 mm TL = 117 mm SL at 5-6 months off Tampa Bay, Florida (Springer and Woodburn 1960); 160 mm TL at Age I off New Jersey (Welsh and Breder 1923); 170 mm TL at Age I at Fernandina, Florida (Welsh and Breder 1923); 170-180 mm TL at Age I in the South Atlantic Bight (Smith and Wenner 1985); 180-220 mm TL at Age I off North Carolina (Hildebrand and Cable 1934)]. The mean size of fish we captured at Age II (272 mm TL) agrees with sizes of 270-280 mm TL (220-230 mm SL) reported by Bearden (1963) but is a little larger than those reported by Welsh and Breder (1923) off New Jersey (250 mm TL) and Smith and Wenner (1985) (220-240 mm TL). The latter authors reported mean sizes of 260 mm TL at Age

III and felt Bearden's size-at-age estimates, which agree with ours, were too large.

### Sex ratio and maximum size

Sex ratios of *M. americanus* have not been reported. Smith and Wenner's (1985) data give a ratio of 1.48 females to each male in the South Atlantic Bight, while we found a 1.2:1 ratio.

The 392 and 455 mm maximum sizes we found for *M. americanus* off Texas are much greater than those in other Gulf studies, where maxima were 330 mm (Franks et al. 1972), 320 mm (Hildebrand 1954), and 318 mm (Gunter 1945). However, maximum lengths reported by these authors are similar to the typical maximum sizes of 300-310 mm we found. Typical maximum sizes in the Gulf appear similar to those in the South Atlantic Bight where Smith and Wenner (1985) found 99% were less than 300 mm and 90% less than 230 mm (we found 90% less than 233 mm). The largest fish reported in the Gulf and South Atlantic Bight have been 405 mm (Hammond and Cupka 1977), 404 mm (Smith and Wenner 1985), and 392 and 455 mm (this study), although no specimen was found to confirm the 455 mm fish and it may be an error. If this indeed represents an error, a 419 mm specimen from the Chesapeake region (Hildebrand and Schroeder 1928) is the largest record and may reflect the zoogeographic variation in population dynamics near Cape Hatteras, North Carolina, suggested by White and Chittenden (1977), Murphy (1981), Shlossman and Chittenden (1981), and Geoghegan and Chittenden (1982).

### General discussion

Our studies suggest *M. americanus* is a species of small size, early age at maturity, short life span ($t_L$ = 2-3 year), and high total annual mortality rates (theoretically 80-90% for a 2-3 year life span from the procedure of Royce 1972: 238). These attributes are similar to those of other members of the white shrimp community, such as *Micropogonias undulatus* (White and Chittenden 1977), *Peprilus burti* (Murphy 1981), *Cynoscion arenarius* (Shlossman and Chittenden 1981), *C. nothus* (DeVries and Chittenden 1982), and *Larimus fasciatus* (Standard and Chittenden 1984). This lends further support to the suggestion (Chittenden and McEachran 1976; Chittenden 1977) that members of this community have a common pattern of population dynamics.


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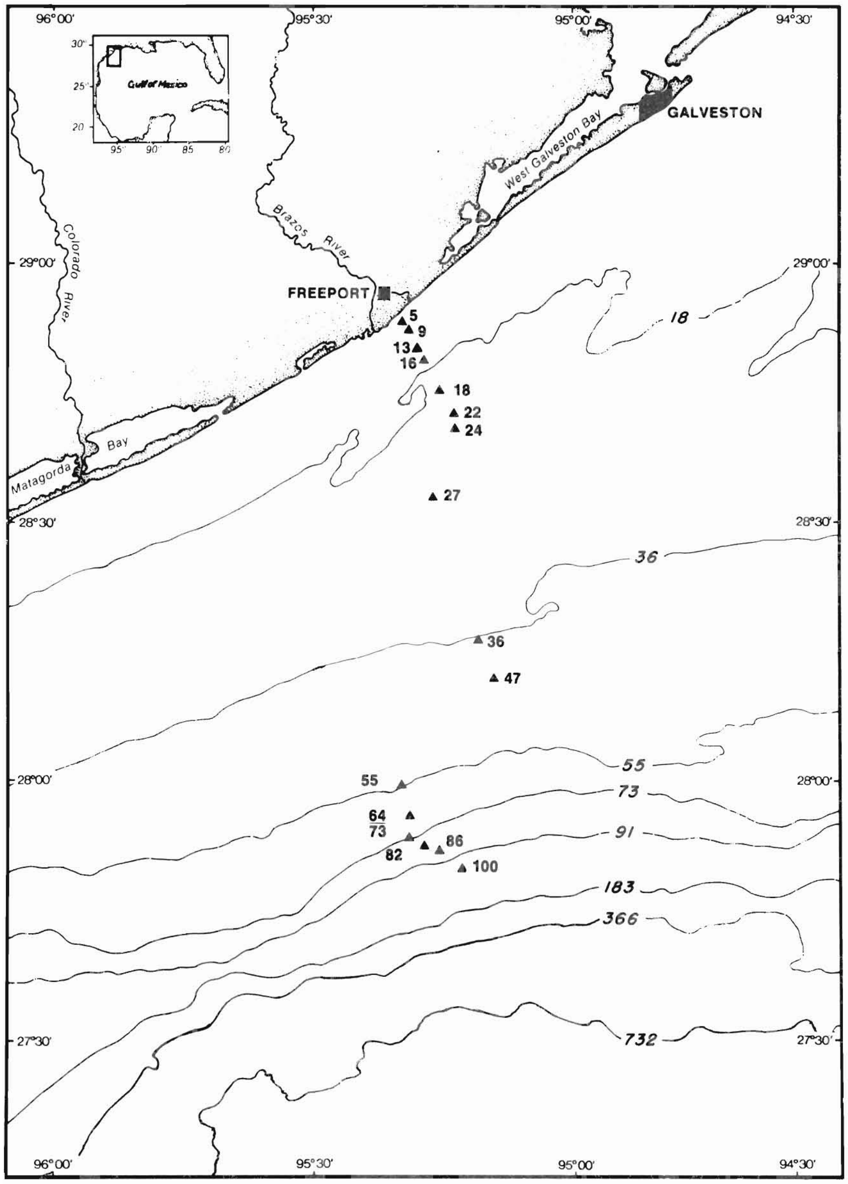



Figure 1—Location of sampling area. Station depths and bathymetric contours are in meters.

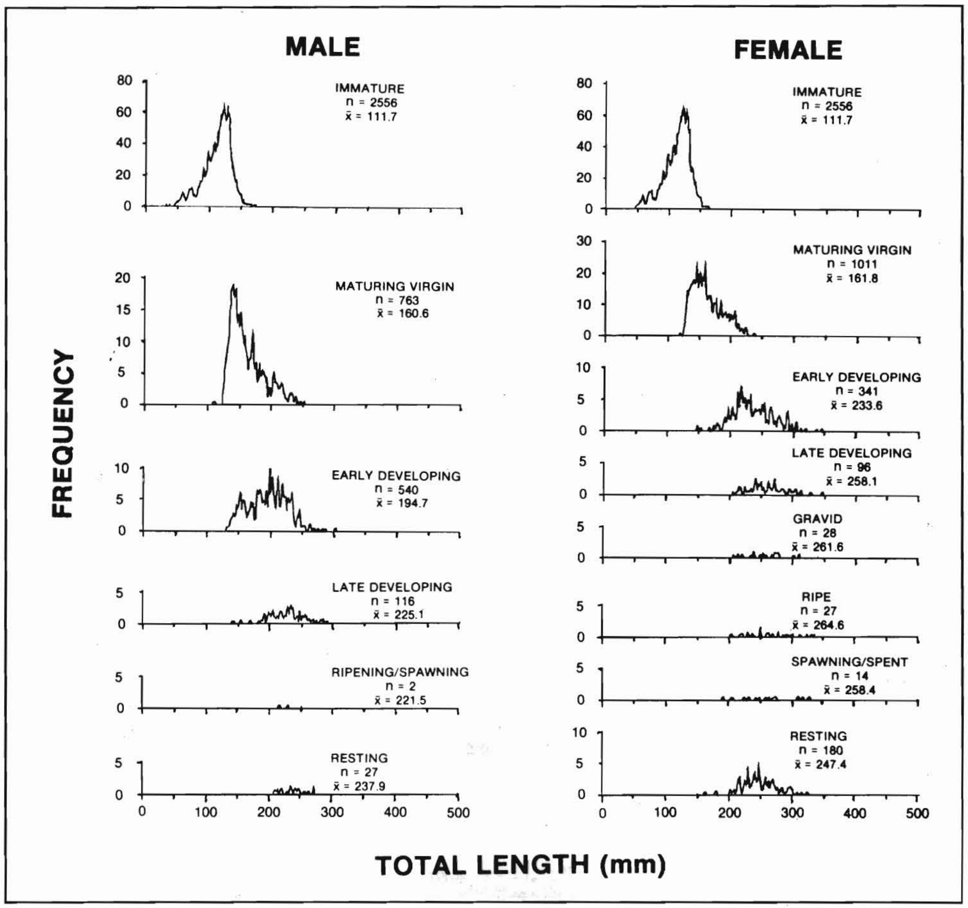



**Figure 2—Length frequencies of male and female *Menticirrhus americanus* by maturity stage. See Table 1 for maturity stage criteria.**

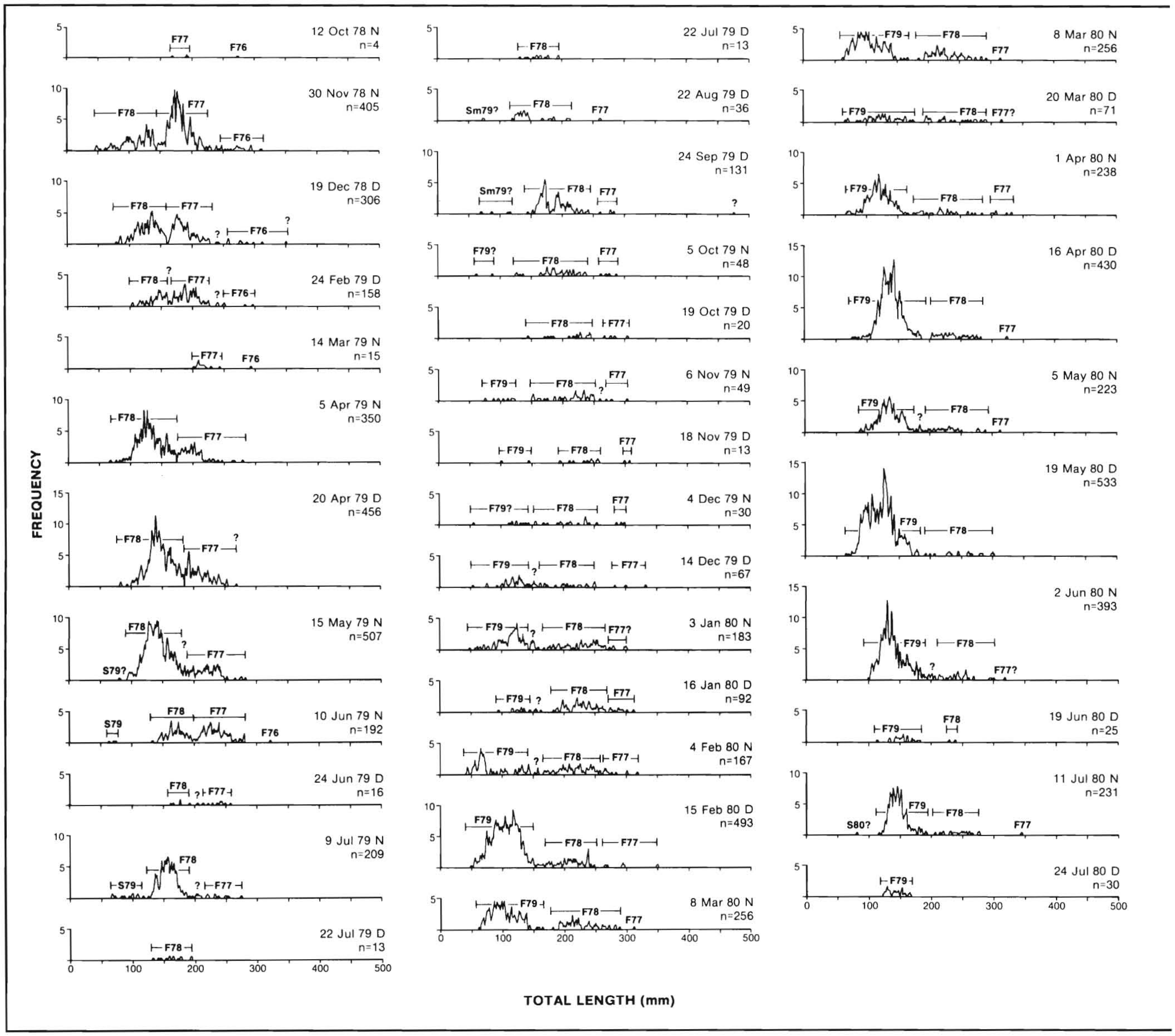
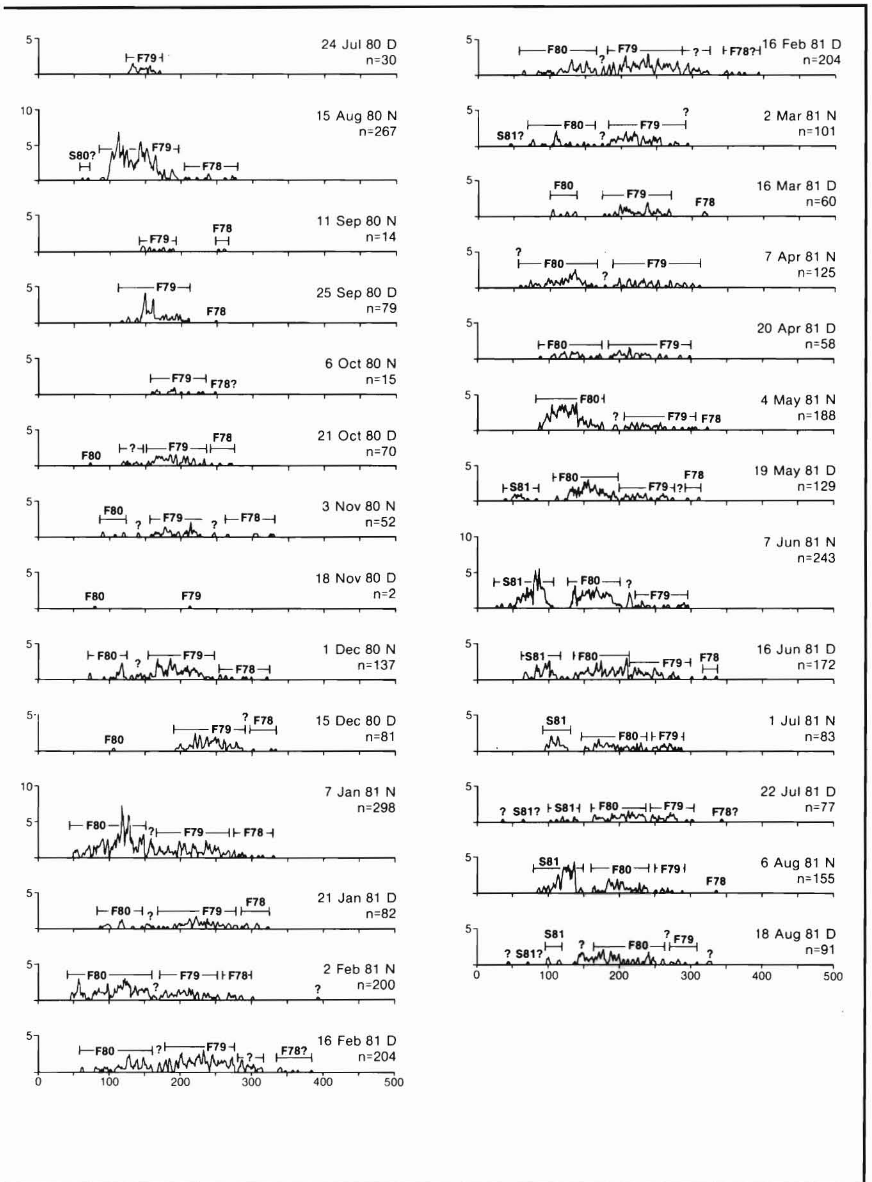



**Figure 3—Monthly length frequencies of *Menticirrhus americanus* off Freeport, Texas, October 1977-August 1981. Day and night cruises are indicated by D and N.**



24 Jul 80 D n=30
15 Aug 80 N n=267
11 Sep 80 N n=14
25 Sep 80 D n=79
6 Oct 80 N n=15
21 Oct 80 D n=70
3 Nov 80 N n=52
18 Nov 80 D n=2
1 Dec 80 N n=137
15 Dec 80 D n=81
7 Jan 81 N n=298
21 Jan 81 D n=82
2 Feb 81 N n=200
16 Feb 81 D n=204
0 100 200 300 400 500
16 Feb 81 D n=204
2 Mar 81 N n=101
16 Mar 81 D n=60
7 Apr 81 N n=125
20 Apr 81 D n=58
4 May 81 N n=188
19 May 81 D n=129
7 Jun 81 N n=243
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1 Jul 81 N n=83
22 Jul 81 D n=77
6 Aug 81 N n=155
18 Aug 81 D n=91
0 100 200 300 400 500

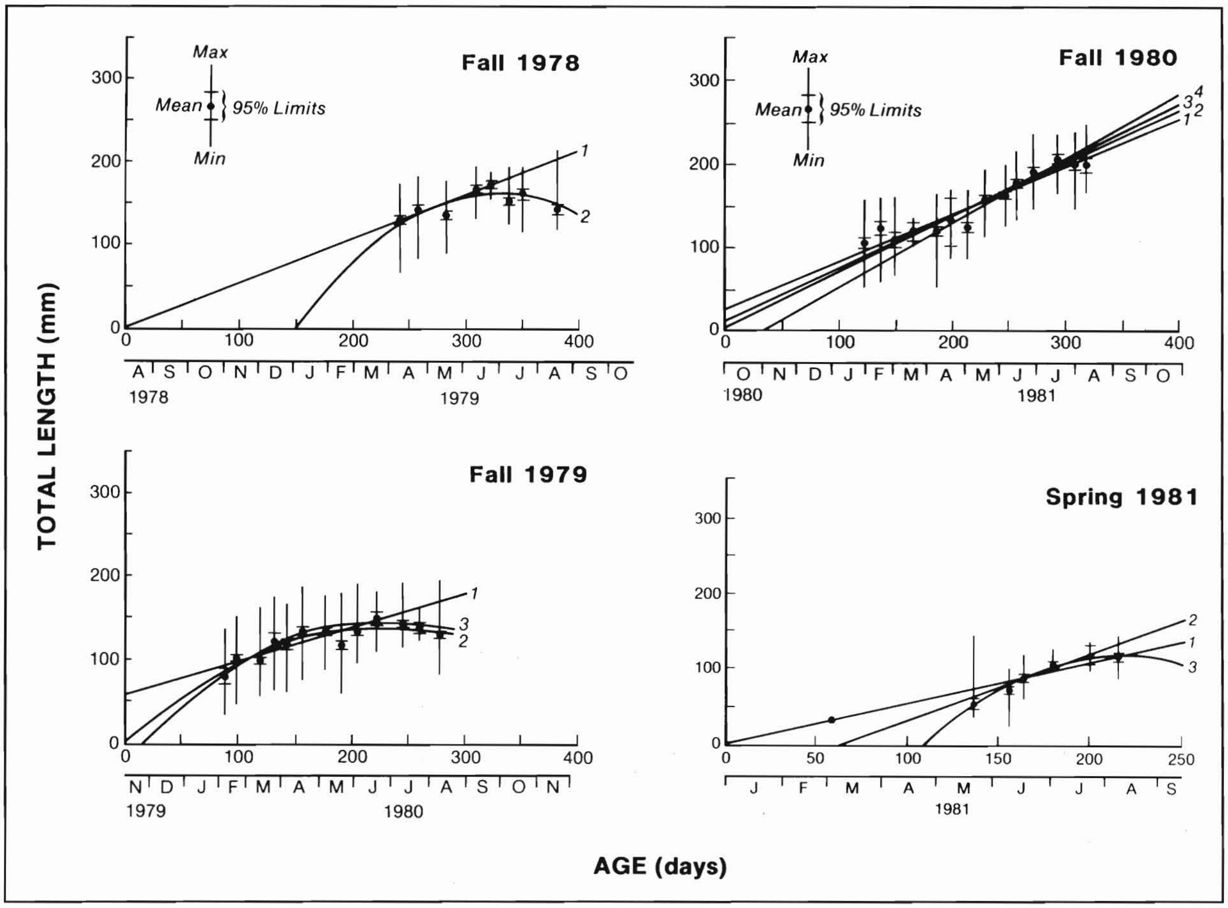


**Figure 4**—Regressions of total length (mm) on age (days) used to calculate hatching dates for spring and fall groups of *Menticirrhus americanus* off Freeport, Texas. All regressions were significant at $\alpha = 0.07$ or higher, and collections used are summarized in Table 3.

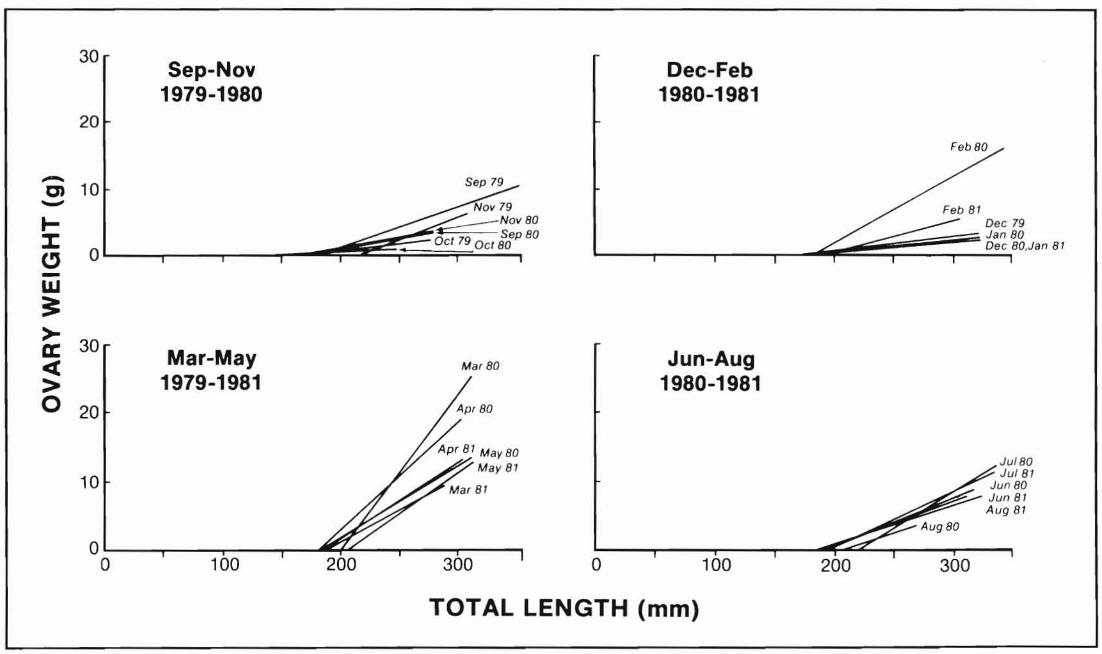


**Figure 5**—Regressions of gonad weight (g) on total length (mm) by month for female *Menticirrhus americanus*, October 1977-August 1981. Regression statistics are presented in Table 6.

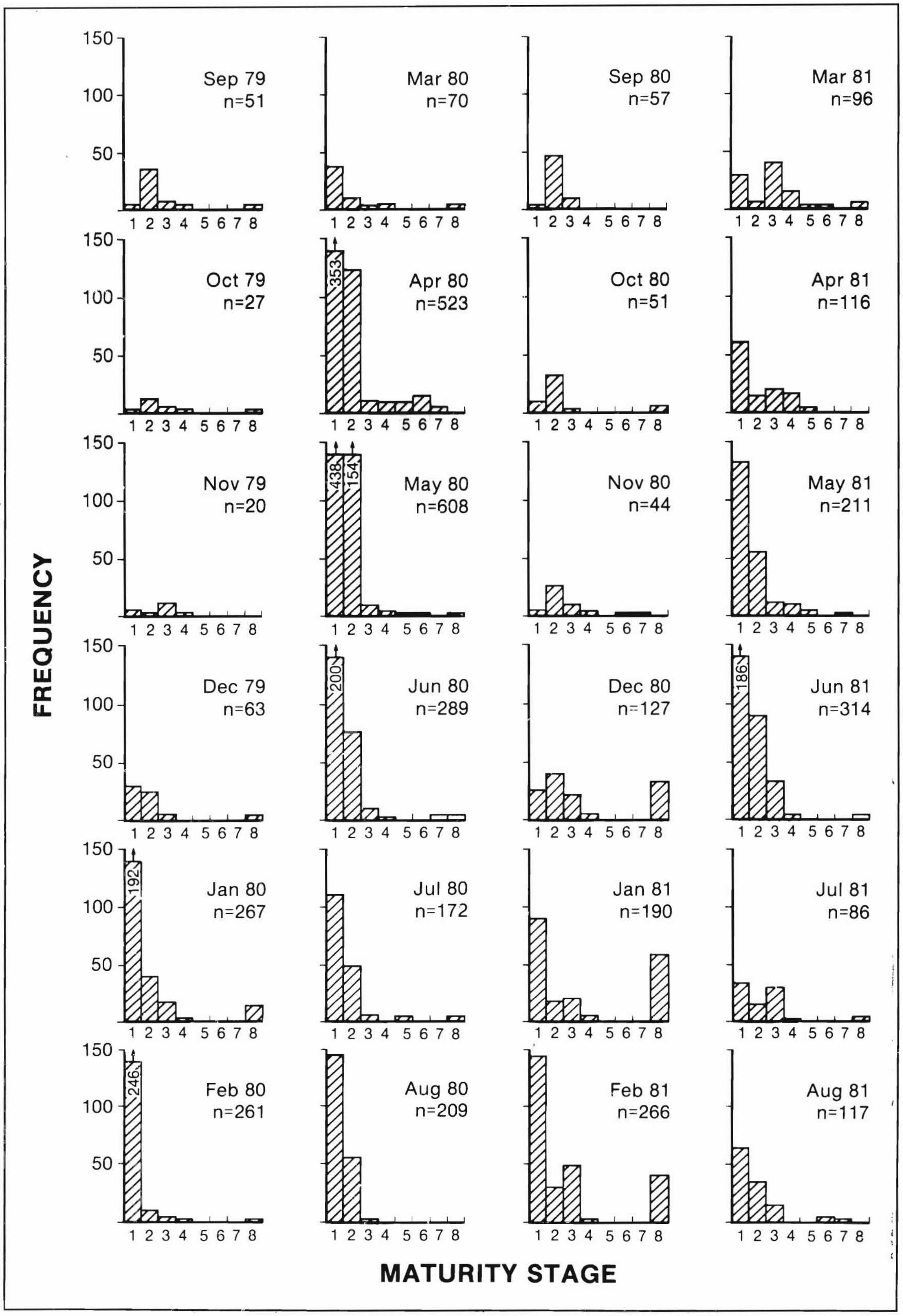


**Figure 6**—Monthly maturity stage compositions for female *Menticirrhus americanus*. Maturity stages (see Table 1): 1 = Immature; 2 = Maturing virgin; 3 = Early developing; 4 = Late developing; 5 = Gravid; 6 = Ripe; 7 = Spawning/Spent; 8 = Resting.

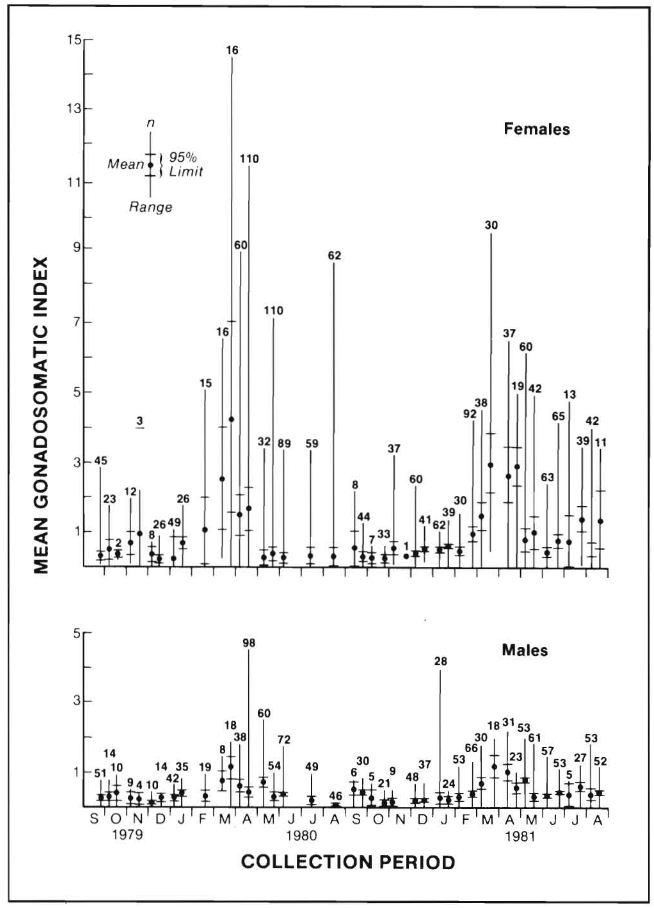


**Figure 7—Mean gonadosomatic indices, ranges, and 95% confidence intervals by cruise for *Menticirrhus americanus* in early developing and later maturity stages. Sample sizes are depicted for each cruise.**

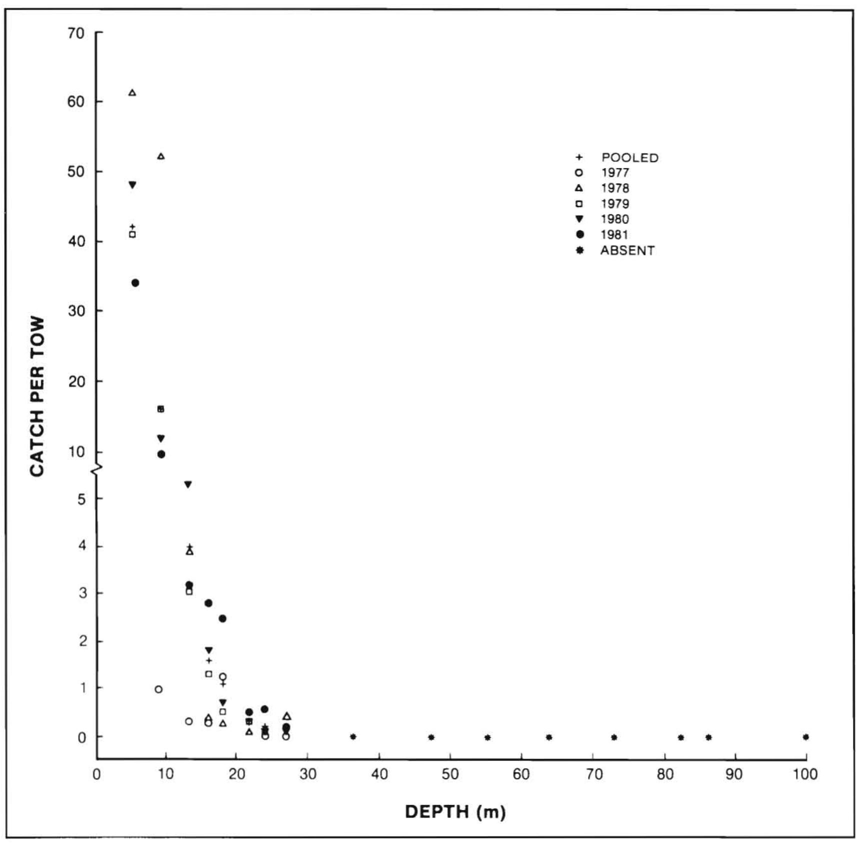


**Figure 8—Mean catch per tow (number of individuals) by depth for *Menticirrhus americanus* off Freeport, Texas, each year and pooled, October 1977-August 1981.**

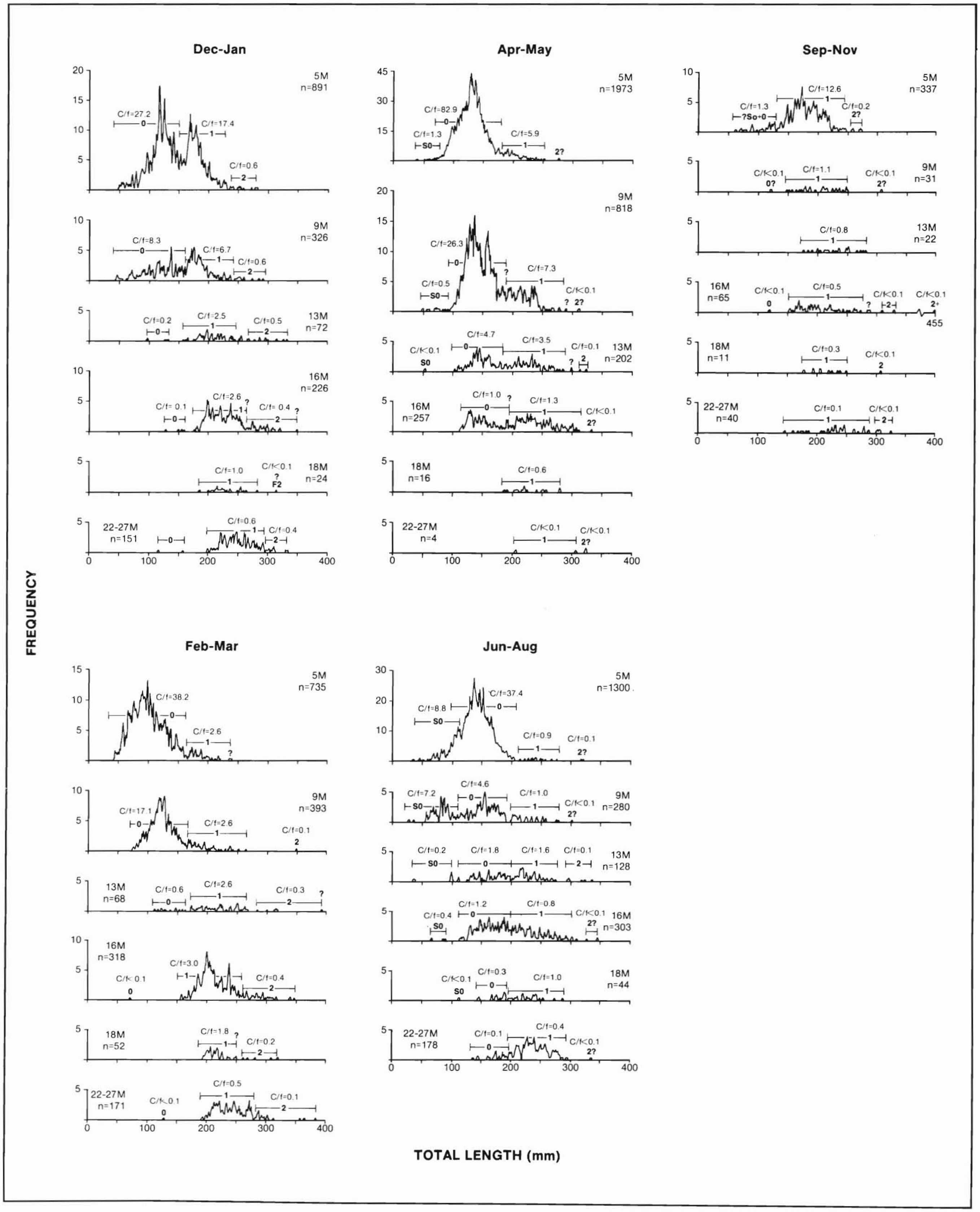


**Figure 9—Length frequencies and catch per unit effort (C/f, expressed as mean number of individuals per 10-min tow) by depth for *Menticirrhus americanus* off Freeport, Texas, October 1977-August 1981. Data were pooled over the 4-year period because length frequencies within listed periods were similar each year. Designated ages are for fall-spawned fish except where noted as spring (S). Age designation for each fall cohort changed after August.**

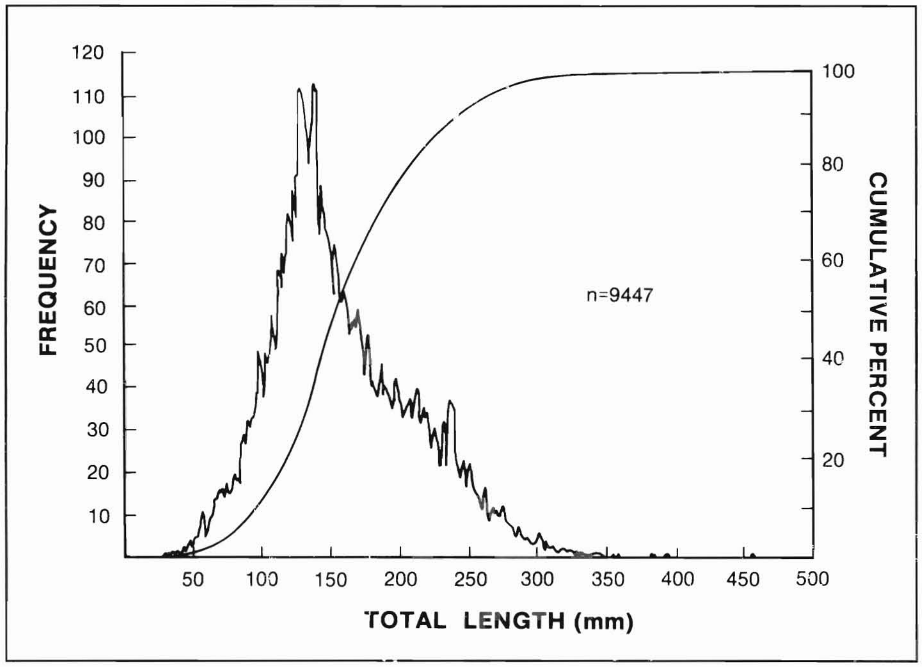


**Figure 10—Length frequencies and cumulative percentage of all *Menticirrhus americanus* collected off Freeport, Texas, October 1977-August 1981.**

**Table 1—Maturity stages assigned to male and female *Menticirrhus americanus*. Gravid, ripe, and spawning/spent stages were difficult to distinguish in males and were pooled.**

| Stage | Description | Stage | Description |
|---|---|---|---|
| | MALES | | FEMALES |
| 1. Immature | Sex undetermined. Testes very small or indistinguishable. | 1. Immature | Sex undetermined. Ovaries very small or indistinguishable. |
| 2. Maturing virgin | Testes translucent-red, occupy less than 10% of body cavity. | 2. Maturing virgin | Sex determined. Ovaries very small, no eggs visible to naked eye. |
| 3. Early developing | Testes opaque to grey, occupy 10-15% of body cavity. | 3. Early developing | Ovaries orange-yellow, occupy up to 25% of body cavity. Eggs opaque, visible to naked eye. |
| 4. Late developing | Testes pale yellow, occupy 15-25% of body cavity. | 4. Late developing | Ovaries orange-yellow, occupy 25-50% of body cavity. All eggs opaque. |
| 5-7. Ripening/Spawning | Stages not readily separated. Testes pale yellow, occupy 25% or more of body cavity. Edges of testes crenulated. | 5. Gravid | Ovaries occupy 50% or more of body cavity. Up to half the eggs translucent. |
| 8. Resting | Testes greyish, reduced in size, occupy less than 10% of body cavity. | 6. Ripe | Ovaries occupy 50% or more of body cavity. Over half the eggs translucent. |
| | | 7. Spawning/Spent | Ovaries pale and flaccid, completely or partially empty. |
| | | 8. Resting | Ovaries small and flaccid, appearing in fish large enough to have already spawned. |

**Table 2**—Growth data by spawned group for *Menticirrhus americanus* from the Gulf off Freeport, Texas. Night and day cruises are indicated by N or D. Observed size ranges correspond to those indicated by horizontal bars in Figure 3 and define group boundaries used in growth calculations. Age is scaled to the hatching date derived from indicated equation numbers corresponding to those in Figure 4 and Table 3.

| Collection date | $n$ | Observed size range (mm) | $\bar{x}$ | $s^2$ | 95% limits on means | 99% limits on observations | Age (days) and hatching date | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | EQUATION | | |
| | | | | | | | 1 | 2 | 3 |
| **Spring 1979** | | | | | | | | | |
| 15 May 79 D | 1 | 79 | 79.0 | 0.0 | — | — | | | |
| 10 Jun 79 N | 3 | 62-73 | 68.0 | 31.0 | 54.2-81.8 | 12.7-123.3 | | | |
| 9 Jul 79 N | 11 | 66-116 | 90.1 | 298.9 | 78.5-101.7 | 35.3-144.9 | | | |
| 22 Aug 79 D | 1 | 73 | 73.0 | 0.0 | — | — | | | |
| 24 Sep 79 N | 4 | 69-116 | 95.8 | 494.9 | 60.4-131.2 | −34.1-225.7 | | | |
| **Spring 1980** | | | | | | | | | |
| 11 Jul 80 N | 1 | 80 | 80.0 | 0.0 | — | — | | | |
| 13 Aug 80 N | 2 | 60-68 | 64.0 | 32.0 | 13.2-114.8 | −296.1-424.1 | | | |
| **Spring 1981** | | | | | | | | | |
| 2 Mar 81 N | 1 | 44 | 44.0 | 0.0 | — | — | 59 | — | — |
| 19 May 81 D | 14 | 38-81 | 56.9 | 102.4 | 51.1-62.7 | 26.4-87.4 | 137 | 72 | 29 |
| 7 Jun 81 N | 109 | 26-103 | 76.4 | 214.2 | 73.6-79.2 | 37.9-114.9 | 156 | 91 | 48 |
| 16 Jun 81 D | 44 | 65-117 | 91.5 | 142.8 | 87.9-95.1 | 59.3-123.7 | 165 | 100 | 57 |
| 1 Jul 81 N | 28 | 96-124 | 108.7 | 56.7 | 105.8-111.6 | 87.8-129.6 | 180 | 115 | 72 |
| 22 Jul 81 D | 8 | 102-138 | 122.9 | 170.4 | 112.0-133.8 | 77.2-168.6 | 201 | 136 | 93 |
| 6 Aug 81 N | 93 | 84-145 | 121.6 | 167.5 | 118.9-124.3 | 87.6-155.6 | 216 | 151 | 108 |
| 18 Aug 81 D | 5 | 98-115 | 104.8 | 71.7 | 94.3-115.3 | 65.8-143.8 | 2 Jan | 8 Mar | 20 Apr |
| **Fall 1976** | | | | | | | | | |
| 8 May 78 D | 1 | 295 | 295.0 | 0.0 | — | — | | | |
| 12 Oct 78 N | 1 | 271 | 271.0 | 0.0 | — | — | | | |
| 30 Nov 78 N | 23 | 237-308 | 264.7 | 410.0 | 255.9-273.5 | 207.6-321.8 | | | |
| 19 Dec 78 D | 10 | 255-348 | 283.1 | 840.8 | 252.4-303.8 | 188.9-377.3 | | | |
| 24 Feb 79 D | 4 | 247-294 | 268.0 | 558.0 | 230.4-305.6 | 130.0-406.0 | | | |
| 14 Mar 79 N | 1 | 291 | 291.0 | 0.0 | — | — | | | |
| **Fall 1977** | | | | | | | | | |
| 14 Apr 78 D | 6 | 111-208 | 154.7 | 1186.7 | 118.5-190.9 | 15.8-293.6 | | | |
| 8 May 78 D | 16 | 133-215 | 178.2 | 498.4 | 166.3-190.1 | 112.4-244.0 | | | |
| 15 Sep 78 D | 1 | 181 | 181.0 | 0.0 | — | — | | | |
| 12 Oct 78 N | 3 | 167-191 | 182.3 | 177.3 | 149.2-215.4 | 50.1-314.5 | | | |
| 30 Nov 78 N | 261 | 146-221 | 178.9 | 229.9 | 177.1-180.7 | 129.0-228.3 | | | |
| 19 Dec 78 D | 132 | 163-225 | 186.0 | 242.0 | 183.3-188.7 | 145.9-226.1 | | | |
| 24 Feb 79 D | 86 | 170-224 | 193.6 | 186.0 | 190.7-196.5 | 157.7-229.5 | | | |
| 14 Mar 79 N | 14 | 200-241 | 213.6 | 106.7 | 207.6-219.6 | 182.5-244.7 | | | |
| 5 Apr 79 N | 82 | 176-278 | 200.2 | 399.6 | 196.8-204.6 | 147.5-252.9 | | | |
| 20 Apr 79 D | 115 | 181-267 | 208.6 | 363.5 | 205.1-212.1 | 158.6-258.6 | | | |
| 15 May 79 N | 98 | 185-281 | 219.8 | 425.4 | 215.7-223.9 | 165.6-274.0 | | | |
| 10 Jun 79 N | 106 | 201-279 | 233.9 | 356.0 | 230.3-237.5 | 184.4-283.4 | | | |
| 24 Jun 79 D | 9 | 212-256 | 235.7 | 192.5 | 225.0-246.4 | 189.2-282.2 | | | |
| 9 Jul 79 N | 8 | 218-274 | 239.0 | 348.0 | 237.7-240.3 | 173.8-304.3 | | | |
| 22 Aug 79 D | 1 | 262 | 262.0 | 0.0 | — | — | | | |
| 24 Sep 79 D | 4 | 262-284 | 276.0 | 92.7 | 260.7-291.3 | 219.8-332.2 | | | |
| 5 Oct 79 N | 4 | 262-287 | 274.0 | 108.7 | 257.4-290.6 | 213.0-334.9 | | | |
| 19 Oct 79 D | 4 | 268-305 | 284.0 | 244.7 | 259.2-308.9 | 192.6-375.4 | | | |
| 6 Nov 79 N | 3 | 271-305 | 285.3 | 310.3 | 241.6-329.0 | 110.5-460.1 | | | |
| 18 Nov 79 D | 2 | 300-308 | 304.0 | 32.0 | 253.2-354.8 | −56.1-664.1 | | | |
| 4 Dec 79 N | 3 | 287-300 | 293.7 | 42.3 | 277.5-309.9 | 229.1-358.3 | | | |
| 14 Dec 79 D | 3 | 282-332 | 304.7 | 641.3 | 241.8-367.6 | 53.4-556.0 | | | |
| 3 Jan 80 N | 5 | 274-300 | 286.2 | 142.2 | 271.4-301.0 | 231.3-341.1 | | | |
| 16 Jan 80 D | 11 | 273-311 | 287.6 | 135.7 | 279.8-295.4 | 250.7-324.5 | | | |
| 4 Feb 80 N | 9 | 266-317 | 283.1 | 345.6 | 268.8-297.4 | 220.7-345.5 | | | |
| 15 Feb 80 D | 5 | 264-349 | 293.4 | 1150.8 | 251.3-335.5 | 137.2-449.6 | | | |
| 8 Mar 80 N | 1 | 311 | 311.0 | 0.0 | — | — | | | |
| 20 Mar 80 D | 1 | 317 | 317.0 | 0.0 | — | — | | | |
| 1 Apr 80 N | 6 | 299-331 | 311.2 | 163.8 | 297.8-324.6 | 259.6-362.8 | | | |
| 16 Apr 80 D | 1 | 323 | 323.0 | 0.0 | — | — | | | |
| 5 May 80 N | 1 | 312 | 312.0 | 0.0 | — | — | | | |
| 2 Jun 80 N | 1 | 318 | 318.0 | 0.0 | — | — | | | |
| 11 Jul 80 N | 11 | 344 | 344.0 | 0.0 | — | — | | | |
| **Fall 1978** | | | | | | | | | |
| | | | | | | | EQUATION | | |
| | | | | | | | 1 | 2 | |
| 30 Nov 78 N | 117 | 45-145 | 107.7 | 631.9 | 103.1-112.3 | 41.8-173.6 | | | |
| 19 Dec 78 D | 162 | 78-158 | 126.8 | 321.4 | 124.0-129.6 | 91.6-161.9 | | | |
| 24 Feb 79 D | 58 | 102-162 | 140.5 | 231.2 | 136.5-144.5 | 100.0-181.0 | | | |
| 5 Apr 79 N | 268 | 67-175 | 129.9 | 378.7 | 127.6-132.3 | 78.8-180.0 | 243 | 95 | |
| 20 Apr 79 D | 341 | 80-180 | 142.8 | 335.7 | 140.5-144.3 | 95.2-189.6 | 258 | 110 | |

**Table 2—(Continued).**

| Collection date | *n* | Observed size range (mm) | $\bar{x}$ | $s^2$ | 95% limits on means | 99% limits on observations | Age (days) and hatching date: EQUATION 1 | Age (days) and hatching date: EQUATION 2 |
|---|---|---|---|---|---|---|---|---|
| **Fall 1978 (Continued)** | | | | | | | | |
| 15 May 79 N | 400 | 92-179 | 138.2 | 348.9 | 136.4-140.0 | 90.1-186.3 | 283 | 135 |
| 10 Jun 79 N | 82 | 131-198 | 167.8 | 227.1 | 164.5-171.1 | 128.1-207.5 | 309 | 161 |
| 24 Jun 79 D | 6 | 160-190 | 173.7 | 108.3 | 162.8-184.6 | 131.7-215.7 | 323 | 175 |
| 9 Jul 79 N | 186 | 125-195 | 156.0 | 162.4 | 154.2-157.8 | 123.2-188.8 | — | 190 |
| 22 Jul 79 D | 13 | 131-192 | 162.8 | 348.5 | 151.5-174.1 | 105.8-219.8 | — | 203 |
| 22 Aug 79 N | 34 | 120-212 | 146.1 | 577.8 | 137.7-154.5 | 80.2-212.0 | — | 234 |
| 24 Sep 79 D | 122 | 144-243 | 186.4 | 466.3 | 182.5-190.3 | 129.8-242.9 | 5 Aug | 31 Dec |
| 5 Oct 79 N | 42 | 125-238 | 192.2 | 808.9 | 183.3-201.1 | 115.4-269.0 | | |
| 19 Oct 79 D | 16 | 144-245 | 212.1 | 961.3 | 195.6-228.6 | 120.7-303.5 | | |
| 6 Nov 79 N | 38 | 151-251 | 210.8 | 1025.2 | 200.3-221.3 | 124.0-297.6 | | |
| 18 Nov 79 D | 9 | 195-258 | 234.0 | 472.0 | 217.3-250.7 | 161.1-306.9 | | |
| 4 Dec 79 N | 17 | 155-255 | 208.1 | 994.2 | 191.9-224.3 | 116.0-300.2 | | |
| 14 Dec 79 D | 20 | 163-251 | 207.1 | 862.7 | 202.6-211.6 | 123.5-290.7 | | |
| 3 Jan 80 N | 58 | 175-266 | 225.0 | 717.5 | 218.0-232.0 | 153.6-296.4 | | |
| 16 Jan 80 D | 68 | 183-265 | 224.9 | 441.8 | 219.8-230.0 | 169.2-280.6 | | |
| 4 Feb 80 N | 67 | 167-264 | 215.9 | 623.2 | 209.8-222.0 | 149.7-282.1 | | |
| 15 Feb 80 D | 56 | 171-247 | 210.7 | 446.6 | 205.0-216.3 | 154.3-267.1 | | |
| 8 Mar 80 N | 56 | 180-287 | 224.2 | 666.3 | 217.3-231.1 | 155.3-293.1 | | |
| 20 Mar 80 D | 23 | 195-292 | 236.7 | 1103.8 | 235.5-237.9 | 143.0-330.4 | | |
| 1 Apr 80 N | 30 | 176-284 | 221.7 | 842.1 | 210.9-232.5 | 141.7-301.7 | | |
| 16 Apr 80 D | 38 | 204-281 | 236.5 | 298.4 | 229.2-243.8 | 175.9-297.1 | | |
| 5 May 80 N | 28 | 193-288 | 228.7 | 573.8 | 219.4-238.0 | 162.3-295.1 | | |
| 19 May 80 D | 16 | 193-300 | 247.6 | 1086.6 | 230.0-265.2 | 150.5-344.7 | | |
| 2 Jun 80 N | 32 | 212-300 | 244.9 | 541.0 | 236.5-253.3 | 181.0-308.8 | | |
| 19 Jun 80 D | 2 | 228-238 | 233.0 | 50.0 | 169.5-296.5 | −217.1-683.1 | | |
| 11 Jul 80 N | 21 | 206-277 | 243.7 | 381.3 | 234.8-252.6 | 188.1-299.3 | | |
| 13 Aug 80 N | 11 | 205-275 | 242.0 | 605.6 | 225.5-258.5 | 164.0-320.0 | | |
| 11 Sep 80 N | 2 | 252-260 | 256.0 | 32.0 | 205.2-306.8 | −104.1-616.1 | | |
| 25 Sep 80 D | 1 | 247 | 247.0 | 0.0 | — | — | | |
| 6 Oct 80 N | 1 | 246 | 246.0 | 0.0 | — | — | | |
| 21 Oct 80 D | 4 | 241-269 | 257.0 | 160.0 | 242.8-271.2 | 183.1-330.9 | | |
| 3 Nov 80 N | 5 | 264-328 | 304.6 | 644.8 | 273.1-336.1 | 187.7-421.5 | | |
| 1 Dec 80 N | 9 | 253-319 | 276.8 | 510.2 | 259.5-294.1 | 201.0-352.6 | | |
| 15 Dec 80 D | 3 | 301-332 | 319.7 | 270.3 | 278.8-360.5 | 156.0-482.9 | | |
| 7 Jan 81 N | 11 | 273-329 | 292.1 | 332.9 | 279.8-304.4 | 234.3-350.6 | | |
| 21 Jan 81 D | 8 | 285-321 | 299.7 | 148.5 | 289.5-309.9 | 257.1-342.3 | | |
| 2 Feb 81 N | 10 | 266-300 | 276.4 | 109.4 | 268.9-283.9 | 242.4-310.4 | | |
| 16 Feb 81 D | 6 | 338-382 | 354.2 | 277.0 | 336.7-371.7 | 287.1-421.3 | | |
| 16 Mar 81 D | 3 | 315-318 | 316.3 | 2.3 | 312.5-320.1 | 301.2-331.4 | | |
| 4 May 81 N | 1 | 322 | 322.0 | 0.0 | — | — | | |
| 16 Jun 81 D | 2 | 318-334 | 326.0 | 128.0 | 224.4-427.6 | −394.2-1046.2 | | |
| 22 Jul 81 D | 1 | 343 | 343.0 | 0.0 | — | — | | |
| **Fall 1979** | | | | | | | | |
| 5 Oct 79 N | 2 | 51-87 | 74.0 | 338.0 | −91.2-239.2 | −1096.3-1244.3 | | |
| 6 Nov 79 N | 7 | 75-121 | 102.1 | 275.8 | 86.7-117.5 | 40.5-163.7 | | |
| 18 Nov 79 D | 2 | 101-145 | 123.0 | 968.0 | −156.5-402.5 | −1857.5-2103.5 | | |
| 4 Dec 79 N | 10 | 56-144 | 120.6 | 616.9 | 102.8-138.4 | 39.9-201.3 | | |
| 14 Dec 79 D | 40 | 54-150 | 118.8 | 397.8 | 112.4-125.2 | 65.5-173.1 | | |
| 3 Jan 80 N | 109 | 48-141 | 110.7 | 424.5 | 106.8-114.6 | 56.6-164.8 | | |
| 16 Jan 80 D | 10 | 94-144 | 125.1 | 192.5 | 115.2-135.0 | 80.0-170.2 | | |
| 4 Feb 80 N | 87 | 42-143 | 82.9 | 896.1 | 76.5-89.3 | 18.5-147.3 | 87 | 232 |
| 15 Feb 80 D | 426 | 49-150 | 103.1 | 425.5 | 101.1-105.1 | 50.0-156.2 | 98 | 243 |
| 8 Mar 80 N | 199 | 61-163 | 101.1 | 439.2 | 98.2-104.0 | 46.6-155.6 | 119 | 264 |
| 20 Mar 80 D | 47 | 66-175 | 123.9 | 689.0 | 116.2-131.6 | 53.6-194.2 | 131 | 276 |
| 1 Apr 80 N | 202 | 68-166 | 120.5 | 344.2 | 117.9-123.1 | 73.0-168.0 | 143 | 288 |
| 16 Apr 80 D | 391 | 77-187 | 137.7 | 296.0 | 136.0-139.4 | 93.4-182.0 | 158 | 303 |
| 5 May 80 N | 187 | 89-174 | 135.5 | 293.1 | 133.5-138.5 | 91.4-179.6 | 177 | 322 |
| 19 May 80 D | 517 | 66-180 | 121.2 | 469.7 | 119.3-123.1 | 65.4-177.0 | 191 | 336 |
| 2 Jun 80 N | 352 | 99-192 | 137.5 | 360.7 | 135.5-139.5 | 88.6-186.4 | 205 | 350 |
| 19 Jun 80 D | 23 | 113-181 | 152.7 | 246.4 | 145.9-159.5 | 108.4-197.0 | 222 | 367 |
| 11 Jul 80 N | 208 | 116-192 | 146.1 | 190.7 | 144.2-148.0 | 110.5-181.7 | 245 | — |
| 24 Jul 80 D | 30 | 123-166 | 141.2 | 148.7 | 136.6-145.8 | 107.7-174.7 | 258 | — |
| 13 Aug 80 N | 254 | 87-191 | 133.0 | 554.0 | 130.1-135.9 | 72.4-193.6 | 278 | — |
| 11 Sep 80 N | 12 | 143-188 | 161.3 | 248.6 | 151.3-171.3 | 112.3-210.3 | 8 Nov | 17 Jun |
| 25 Sep 80 D | 78 | 115-208 | 162.0 | 438.5 | 157.3-166.7 | 106.7-217.3 | | |
| 6 Oct 80 N | 14 | 158-229 | 187.3 | 468.7 | 174.8-199.8 | 122.1-252.5 | | |
| 21 Oct 80 D | 56 | 151-231 | 186.3 | 450.8 | 180.6-192.0 | 129.6-243.0 | | |

**Table 2—(Continued).**

| Collection date | $n$ | Observed size range (mm) | $\bar{x}$ | $s^2$ | 95% limits on means | 99% limits on observations | Age (days) and hatching date: EQUATION 1 | EQUATION 2 | EQUATION 3 | EQUATION 4 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Fall 1979 (Continued)** | | | | | | | | | | |
| 3 Nov 80 N | 38 | 157-225 | 192.9 | 394.7 | 186.4-199.4 | 138.8-247.0 | | | | |
| 18 Nov 80 D | 1 | 211 | 211.0 | 0.0 | — | — | | | | |
| 1 Dec 80 N | 99 | 152-242 | 191.3 | 490.1 | 186.9-195.7 | 133.1-249.5 | | | | |
| 15 Dec 80 D | 77 | 193-284 | 238.5 | 509.8 | 234.2-242.8 | 178.9-298.1 | | | | |
| 7 Jan 81 N | 92 | 165-267 | 215.1 | 789.8 | 209.3-220.9 | 141.2-289.0 | | | | |
| 21 Jan 81 D | 53 | 175-277 | 227.3 | 587.0 | 220.6-234.0 | 162.5-292.1 | | | | |
| 2 Feb 81 N | 55 | 171-252 | 207.2 | 457.2 | 201.4-213.0 | 150.1-264.3 | | | | |
| 16 Feb 81 D | 121 | 176-272 | 226.2 | 744.9 | 221.3-231.1 | 154.8-297.6 | | | | |
| 2 Mar 81 N | 73 | 180-292 | 221.0 | 644.6 | 215.1-226.9 | 153.8-288.2 | | | | |
| 16 Mar 81 D | 48 | 175-267 | 223.6 | 578.8 | 216.7-230.6 | 159.1-288.1 | | | | |
| 7 Apr 81 N | 50 | 189-309 | 238.3 | 1059.1 | 229.1-247.5 | 151.1-325.4 | | | | |
| 20 Apr 81 D | 33 | 186-297 | 222.4 | 698.1 | 213.0-231.8 | 150.1-294.7 | | | | |
| 4 May 81 N | 30 | 207-306 | 243.1 | 758.0 | 232.8-253.4 | 167.2-319.0 | | | | |
| 19 May 81 D | 30 | 202-273 | 233.6 | 426.7 | 225.9-241.3 | 176.7-290.5 | | | | |
| 7 Jun 81 N | 16 | 222-294 | 254.2 | 695.7 | 240.1-268.3 | 176.5-331.9 | | | | |
| 16 Jun 81 D | 40 | 219-300 | 243.8 | 377.0 | 237.6-250.0 | 191.3-296.3 | | | | |
| 1 Jul 81 N | 15 | 247-285 | 264.9 | 125.6 | 258.7-271.1 | 231.5-298.3 | | | | |
| 22 Jul 81 D | 21 | 245-301 | 265.8 | 223.8 | 259.0-272.6 | 223.2-310.4 | | | | |
| 6 Aug 81 N | 7 | 249-287 | 265.7 | 146.6 | 254.5-276.9 | 220.8-310.6 | | | | |
| 18 Aug 81 D | 8 | 259-308 | 278.1 | 262.7 | 264.5-291.7 | 221.4-334.8 | | | | |
| **Fall 1980** | | | | | | | | | | |
| 21 Oct 80 D | 1 | 71 | 71.0 | 0.0 | — | — | | | | |
| 3 Nov 80 N | 5 | 88-118 | 103.8 | 219.2 | 85.4-122.2 | 35.6-172.0 | | | | |
| 18 Nov 80 D | 1 | 78 | 78.0 | 0.0 | — | — | | | | |
| 1 Dec 80 N | 21 | 71-121 | 106.1 | 254.0 | 98.8-113.4 | 60.8-151.4 | | | | |
| 15 Dec 80 D | 1 | 105 | 105.0 | 0.0 | — | — | | | | |
| 7 Jan 81 N | 180 | 50-148 | 111.0 | 593.6 | 107.4-114.6 | 48.2-173.8 | | | | |
| 21 Jan 81 D | 15 | 87-145 | 110.3 | 259.5 | 101.4-119.2 | 62.3-158.3 | | | | |
| 2 Feb 81 N | 131 | 47-157 | 106.7 | 955.4 | 101.4-112.0 | 27.1-186.3 | 175 | — | — | — |
| 16 Feb 81 D | 54 | 61-159 | 124.2 | 593.1 | 117.6-130.8 | 59.1-189.3 | 189 | — | — | — |
| 2 Mar 81 N | 26 | 70-160 | 110.0 | 621.2 | 99.9-120.1 | 40.5-179.5 | 203 | 165 | 150 | — |
| 16 Mar 81 D | 9 | 103-135 | 119.0 | 180.7 | 108.9-129.1 | 73.9-164.1 | 217 | 179 | 164 | — |
| 7 Apr 81 N | 74 | 58-164 | 118.5 | 578.5 | 112.9-124.1 | 54.9-182.1 | 239 | 201 | 186 | 152 |
| 20 Apr 81 D | 25 | 87-172 | 131.7 | 446.5 | 101.3-162.1 | 72.6-190.8 | 252 | 214 | 199 | 165 |
| 4 May 81 N | 153 | 86-174 | 124.1 | 408.3 | 119.3-128.9 | 72.0-176.2 | 266 | 228 | 213 | 179 |
| 19 May 81 D | 93 | 110-195 | 155.3 | 360.7 | 151.4-159.2 | 105.4-205.2 | 281 | 243 | 228 | 194 |
| 7 Jun 81 N | 109 | 130-200 | 162.3 | 318.8 | 158.9-165.7 | 115.4-209.2 | 300 | 262 | 247 | 213 |
| 16 Jun 81 D | 85 | 135-215 | 176.8 | 493.8 | 172.0-181.6 | 118.2-235.4 | 309 | 271 | 256 | 222 |
| 1 Jul 81 N | 40 | 150-236 | 189.7 | 590.1 | 181.9-197.5 | 124.0-255.4 | 324 | 286 | 271 | 237 |
| 22 Jul 81 D | 45 | 164-235 | 204.0 | 444.2 | 197.7-210.3 | 147.3-260.7 | 345 | 307 | 292 | 258 |
| 6 Aug 81 N | 54 | 163-238 | 200.4 | 398.6 | 195.0-205.8 | 146.8-254.0 | 360 | 322 | 307 | 273 |
| 18 Aug 81 D | 54 | 165-248 | 199.1 | 687.9 | 191.9-206.3 | 129.0-269.2 | — | 334 | — | — |
| | | | | | | | 11 Aug | 20 Sep | 3 Oct | 5 Nov |

**Table 3—Summary of iterative process used to calculate hatching dates and set time scales for growth calculations on *Menticirrhus americanus*. Equations describe regressions of observed mean total length on age in days, from Table 2. Initial age values and growth equations were scaled to 1 October and 1 February hatching dates for fall and spring spawned groups. All regressions were significant at $\alpha$ = 0.07 or higher. Equation numbers in parentheses refer to regression lines in Figure 4. No hatching date calculations were made for Fall 76 and Fall 77 cohorts because few of these fish were captured within 12 months of their hatching date.**

| Collection period (equation number) | Initial growth equation | Initial $x$-intercept | Final growth equation | $100r^2$ | Hatching date |
|---|---|---|---|---|---|
| **Spring 1981** | | | | | |
| 2 Mar 81- 6 Aug 81 (1) | TL=0.560 Age+15.9 | −29 | TL=0.560 Age−0.31 | 86.2 | 2 Jan 81 |
| 19 May 81- 6 Aug 81 (2) | TL=0.867 Age−4.39 | 5 | TL=0.867 Age+0.22 | 92.7 | 8 Mar 81 |
| 19 May 81- 6 Aug 81 (3) | TL=−0.009 Age$^2$+3 583 Age−225.9 | 79 | TL=−0.009 Age$^2$+2.137 Age+0.02 | 98.4 | 20 Apr 81 |
| **Fall 1978** | | | | | |
| 24 Feb 79-24 Jun 79 | TL=0.344 Age+76.80 | −223 | TL=0.344 Age+0.07 | 63.0 | 25 Nov 77 |
| 24 Feb 79-22 Aug 79 | TL=0.153 Age+114.5 | −746 | TL=0.153 Age+0.03 | 30.3 | 4 Sep 76 |
| 5 Apr 79-24 Jun 79 (1) | TL=0.532 Age+46.24 | −87 | TL=0.532 Age−0.18 | 86.5 | 5 Aug 78 |
| 5 Apr 79-22 Aug 79 (2) | TL=−0.005 Age$^2$+2.59 Age−145.2 | 65 | TL=−0.005 Age$^2$+1.84 Age−0.60 | 72.5 | 31 Dec 78 |
| **Fall 1979** | | | | | |
| 4 Feb 80-19 Jun 80 (1) | TL=0.408 Age+42.24 | −106 | TL=0.408 Age−0.00 | 78.7 | 17 Jun 79 |
| 4 Feb 80-11 Jul 80 | TL=0.171 Age+93.55 | −548 | TL=0.171 Age+0.03 | 41.6 | 3 Jun 78 |
| 4 Feb 80-24 Jul 80 | TL=0.166 Age+94.15 | −566 | TL=166 Age+0.06 | 45.3 | 15 May 78 |
| 4 Feb 80-13 Aug 80 (2) | TL=−0.003 Age$^2$+1.45 Age−52.3 | 39 | TL=−0.003 Age$^2$+1.24 Age+0.16 | 84.7 | 9 Nov 79 |
| 4 Feb 80-13 Aug 80 (3) | TL=−0.003 Age$^2$+1.70 Age−76.79 | 50 | TL=−0.003 Age$^2$+1.38 Age−0.05 | 92.3 | 20 Nov 79 |
| **Fall 1980** | | | | | |
| 2 Feb 81- 6 Aug 81 (1) | TL=0.557 Age+27.6 | −50 | TL=0.557 Age−0.25 | 89.4 | 11 Aug 80 |
| 2 Mar 81- 6 Aug 81 (3) | TL=0.680 Age−22.7 | 33 | TL=0.681 Age−0.18 | 91.1 | 3 Oct 80 |
| 2 Mar 81-18 Aug 81 (2) | TL=0.630 Age+63.6 | −10 | TL=0.630 Age+0.28 | 93.6 | 20 Sep 80 |
| 7 Apr 81- 6 Aug 81 (4) | TL=0.780 Age−26.7 | 36 | TL=0.780 Age+0.43 | 90.2 | 5 Nov 80 |

**Table 4—Calculations to estimate duration of spawning periods of *Menticirrhus americanus*, during 1978-81. Mean 99% confidence limits were calculated from data in Table 2 for the listed interval of collection dates. Equation numbers used to preduct initial and final sizes for growth increments are those in Figure 4 and Table 3.**

| Interval of Collection dates | Predicted total length | | Mean 99% confidence interval on observations | Growth increment | Time interval (days) | Growth/day (mm) | Spawning duration (days) |
|---|---|---|---|---|---|---|---|
| | Initial | Final | | | | | |
| **Spring 1981** | | | | | | | |
| 1. 19 May- 6 Aug 81 | 76.41 | 120.65 | 67.3 | 44.2 | 76 | 0.56 | 120 |
| 2. 19 May- 6 Aug 81 | 49.50 | 125.18 | 67.3 | 75.7 | 76 | 1.00 | 68 |
| 3. 19 May- 6 Aug 81 | 62.64 | 131.14 | 67.3 | 68.5 | 76 | 0.90 | 75 |
| **Fall 1978** | | | | | | | |
| 1. 24 Feb-15 May 79 | 107.92 | 148.78 | 92.9 | 40.9 | 77 | 0.53 | 174 |
| 2. 24 Feb-15 May 79 | 113.56 | 164.76 | 92.9 | 51.2 | 77 | 0.67 | 139 |
| **Fall 1979** | | | | | | | |
| 1. 4 Feb-19 May 80 | 64.45 | 127.56 | 112.1 | 63.1 | 104 | 0.61 | 184 |
| 2. 4 Feb-19 May 80 | 94.66 | 137.09 | 112.1 | 42.4 | 104 | 0.41 | 275 |
| 3. 4 Feb-19 May 80 | 87.50 | 151.15 | 112.1 | 63.7 | 104 | 0.61 | 183 |
| **Fall 1980** | | | | | | | |
| 1. 2 Feb-19 May 81 | 97.23 | 156.27 | 121.0 | 59.0 | 106 | 0.56 | 217 |
| 2. 2 Feb-19 May 81 | 86.59 | 153.37 | 121.0 | 66.8 | 106 | 0.63 | 192 |
| 3. 2 Feb-19 May 81 | 82.90 | 155 08 | 121.0 | 72.2 | 106 | 0.68 | 178 |
| 4. 2 Feb-19 May 81 | 69.85 | 152.53 | 121.0 | 82.7 | 106 | 0.78 | 155 |

Table 5—Total length (mm) statistics for *Menticirrhus americanus* by maturity stage and sex. Confidence limits are for observations.

| Stage | $n$ | $\bar{X}$ | $S$ | Observed size range | 99% confidence limit |
|---|---|---|---|---|---|
| **Immature** | | | | | |
| | 2,556 | 112 | 21.5 | 31-183 | 56-167 |
| **Male** | | | | | |
| Maturing virgin | 763 | 161 | 26.7 | 109-250 | 92-229 |
| Early developing | 540 | 195 | 31.3 | 130-303 | 114-275 |
| Late developing | 116 | 225 | 26.4 | 140-287 | 156-294 |
| Ripening/Spawning | 2 | 222 | 9.2 | 215-228 | −364-807 |
| Resting | 27 | 238 | 19.6 | 208-271 | 183-292 |
| **Female** | | | | | |
| Maturing virgin | 162 | 162 | 24.2 | 120-241 | 99-224 |
| Early developing | 341 | 233 | 32.1 | 146-343 | 151-316 |
| Late developing | 96 | 258 | 29.6 | 205-345 | 180-336 |
| Gravid | 28 | 262 | 31.0 | 207-339 | 176-348 |
| Ripe | 27 | 265 | 35.1 | 203-333 | 167-362 |
| Spawning/Spent | 14 | 258 | 39.4 | 190-324 | 140-377 |
| Resting | 180 | 248 | 28.6 | 162-325 | 174-321 |

Table 6—Regression statistics of gonad weight (g) on total length (mm) for female *Menticirrhus americanus* captured off Freeport, Texas, October 1977-August 1981. Regressions were significant at $\alpha = 0.06$ or higher and are shown in Figure 5.

| Collection month | $n$ | $r^2$ | Equation |
|---|---|---|---|
| **SEPT.-NOV.** | | | |
| Sep 79 | 24 | 0.678 | 0.0612 TL - 11.87 |
| Oct 79 | 22 | 0.579 | 0.0207 TL - 3.81 |
| Nov 79 | 13 | 0.800 | 0.0690 TL - 14.97 |
| Sep 80 | 23 | 0.734 | 0.0261 TL - 4.47 |
| Oct 80 | 28 | 0.471 | 0.0044 TL - 0.59 |
| Nov 80 | 28 | 0.584 | 0.0511 TL - 10.05 |
| **DEC.-FEB.** | | | |
| Dec 79 | 13 | 0.703 | 0.0198 TL - 3.57 |
| Jan 80 | 44 | 0.577 | 0.0224 TL - 4.20 |
| Feb 80 | 7 | 0.873 | 0.1002 TL - 18.63 |
| Dec 80 | 84 | 0.550 | 0.0170 TL - 3.17 |
| Jan 81 | 87 | 0.727 | 0.0188 TL - 3.59 |
| Feb 81 | 101 | 0.559 | 0.0480 TL - 9.74 |
| **MAR.-MAY** | | | |
| Mar 80 | 26 | 0.769 | 0.2306 TL - 46.70 |
| Apr 80 | 49 | 0.700 | 0.1981 TL - 37.94 |
| May 80 | 24 | 0.715 | 0.1092 TL - 20.51 |
| Mar 81 | 65 | 0.602 | 0.1689 TL - 34.34 |
| Apr 81 | 40 | 0.831 | 0.1140 TL - 21.61 |
| May 81 | 24 | 0.792 | 0.1216 TL - 25.24 |
| **JUNE-AUG.** | | | |
| Jun 80 | 16 | 0.829 | 0.0740 TL - 14.93 |
| Jul 80 | 8 | 0.815 | 0.1087 TL - 24.51 |
| Aug 80 | 6 | 0.619 | 0.0545 TL - 11.27 |
| Jun 81 | 61 | 0.640 | 0.0567 TL - 10.85 |
| Jul 81 | 44 | 0.823 | 0.0805 TL - 16.01 |
| Aug 81 | 33 | 0.764 | 0.0681 TL - 13.33 |

Table 7—Observed mean total length (mm) at 6 months, Ages I and II, for fall-spawned cohorts of *Menticirrhus americanus* off Freeport, Texas. Mean sizes and confidence limits at Ages I and II were calculated from mean size statistics (Table 2) for the period September-November and assume a September-November hatching date; collections from August were substituted in 1981 when fall cruises were not made. Mean size statistics at 6 months were calculated from data (Table 2) for the period March-May, and 99% confidence limits for observations were calculated as means of upper and lower limits given in Table 2.

| Cohort | 6 months | | | Age I | | | Age II | | |
|---|---|---|---|---|---|---|---|---|---|
| | No. of means in calc. of $\bar{X}$ | $\bar{X}$ | 99% limits on observ. | No. of means in calc. of $\bar{X}$ | $\bar{X}$ | 99% limits on observ. | No. of means in calc. of $\bar{X}$ | $\bar{X}$ | 99% limits on observ. |
| 1976 | — | — | — | — | — | — | 2 | 267.9 | 208-322 |
| 1977 | 2 | 166.5 | 64-269 | 3 | 180.7 | 90-372 | 5 | 284.7 | 184-376 |
| 1978 | 3 | 137.0 | 88-185 | 5 | 207.1 | 128-317 | 5 | 262.1 | 185-376 |
| 1979 | 6 | 123.3 | 89-199 | 6 | 183.5 | 122-134 | 1 | 278.1 | 221-335 |
| 1980 | 6 | 126.4 | 70-183 | 2 | 199.8 | 138-262 | — | — | — |
| Pooled mean | 4 | 138.3 | 78-209 | 4 | 192.8 | 119-271 | 4 | 272 | 200-352 |

Table 8—Regressions of weight-length, girth-length, and length-length for *Menticirrhus americanus*, with supporting statistics. Regressions were significant at $\alpha = 0.05$. The symbol $v$ is from Ricker's (1973) GM regression. Measures are grams and millimeters.

| | Equation | $n$ | TL range | $100r^2$ | Mean square error | Corrected total $SS_X$ | Corrected total $SS_Y$ | $\bar{X}$ | $\bar{Y}$ | $v$ |
|---|---|---|---|---|---|---|---|---|---|---|
| Immatures | $\log_{10} TW = -5.61 + 3.24 \log_{10} TL$ | 2,556 | 31-183 | 96.2 | 0.004 | 23.4 | 255.1 | 2.04 | 0.99 | 3.30 |
| Males | $\log_{10} TW = -5.95 + 3.40 \log_{10} TL$ | 1,448 | 109-303 | 97.6 | 0.002 | 11.0 | 130.0 | 2.25 | 1.69 | 3.44 |
| Females | $\log_{10} TW = -5.94 + 3.39 \log_{10} TL$ | 1,697 | 120-345 | 98.6 | 0.002 | 20.0 | 232.4 | 2.28 | 1.79 | 3.41 |
| Males + females + immatures | $\log_{10} TW = -5.79 + 3.33 \log_{10} TL$ | 5,701 | 31-345 | 98.8 | 0.003 | 128.4 | 1,438.2 | 2.17 | 1.42 | 3.35 |
| Males + females | $\log_{10} TW = -5.93 + 3.39 \log_{10} TL$ | 3,145 | 109-345 | 98.3 | 0.002 | 31.7 | 369.9 | 2.26 | 1.74 | 3.42 |
| | $TL = 7.40 + 1.18\ SL$ | 5,701 | 31-345 | 99.8 | 5.06 | 11,522,762 | 16,072,558 | 125.0 | 155.1 | 1.18 |
| | $SL = -6.19 + 0.85\ TL$ | 5,701 | 31-345 | 99.8 | 3.63 | 16,072,558 | 11,522,762 | 155.1 | 125.0 | 0.85 |
| | $G = -11.53 + 0.61\ TL$ | 5,701 | 31-345 | 98.0 | 21.14 | 16,072,558 | 6,144,025 | 155.1 | 83.4 | 0.62 |
| | $TL = 21.60 + 1.60\ G$ | 5,701 | 31.345 | 98.0 | 55.30 | 6,144,025 | 16,072,558 | 83.4 | 155.1 | 1.62 |