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REPRODUCTIVE BIOLOGY OF BLUE RUNNER (*Caranx crysos*) FROM THE EASTERN GULF OF MEXICO

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ABSTRACT: Blue runner were obtained from commercial fisheries in south Florida, northwest Florida, and the Mississippi Delta. Monthly mean gonadosomatic indices indicated that peak spawning occurred in June, July, and August for all areas with a secondary peak in October for northwest Florida. The spawning season was confirmed for the south Florida collection by histological examination of gonads. Probit analysis of 185 northwest Florida blue runner captured during peak spawning months indicated a length-at-maturity of 267 mm. Fecundity varied from 41,000 ova in a 243-mm-FL, 288-gram fish to 1,546,000 ova in a 385-mm-FL, 1,076-gram fish. Sex ratios were 1.15F:1M for Mississippi Delta, 1.66F:1M for northwest Florida and 1.91F:1M for south Florida.

The blue runner, *Caranx crysos*, is a coastal pelagic species of the western north Atlantic, ranging from Nova Scotia to Brazil (McKenney *et al.*, 1958). It is abundant along the southeast coast of the United States, through the West Indies faunal region and, seasonally, the northeast Gulf of Mexico (Berry, 1959; Ginsburg, 1952). Blue runner are present in Bermuda water but are less abundant there than elsewhere (Nichols, 1939).

Blue runner occur singly or in schools and are captured by sport and commercial fishermen for bait, food, and sport. About 307 t of blue runner were taken commercially off the west coast of Florida during 1978 (Anonymous, 1981). More recently large numbers of fish are now being caught together with red drum, *Sciaenops ocellatus*, by purse seiners off the Mississippi Delta (Overstreet, 1983). Blue runner are also taken by charter boats off the Atlantic and gulf coasts and by pier and jetty anglers.

Seasonal occurrence of young blue runner in collections made by various researchers has provided a basis of estimating spawning cycles. Berry (1959) noted from larval sizes that spawning extended from early April to early September off the southeastern Atlantic coast of the United States. Juveniles (<100 mm SL) were found by Dooley (1972) in peak abundance during June and July off southeast Florida where they have a close affinity with the sargassum community and the Gulf Steam. McKenney *et al.* (1958) and Fahay (1975) stated that spawning occurred year-round; however 75% of the post-larvae collected by McKenney *et al.* (1958) were taken from April through August. Montolio (1976) noted two separate spawning peaks based on his larval collections from the south-central Gulf of Mexico, one in April-May, and the other in August-September. A summary of the reproductive biology of blue runner is also given by Johnson (1978).

Other aspects of the biology of blue runner are less well known. Munro (1974) provided a length-weight equation of $W = .0065\ TL^{3.302}$, where W = weight in g and TL = total length in mm, and estimates of 620 mm TL for maximum length and 5,400 g for maximum weight from the Caribbean Sea. Berry (1979) noted a maximum record fork length (FL) of 711 mm and an estimated maximum weight of 2,724 g and he estimated length-at-maturity occurred at 225-250 mm SL. Reintjes (1959) stated that no data were available on age-size relationship, growth rates, age-at-first spawning, life expectancy, mortality rates, and sex ratios. The purpose of this investigation was to expand further our knowledge of blue runner reproductive biology by determining spawning season, fecundity, length-at-maturity, and sex ratios from the eastern Gulf of Mexico.

METHODS

We examined gonads from 1179 blue runner (447 males and 732 females that were obtained during 1980 and 1981 from three geographic areas. Fish from northwest Florida were purchased fresh from local fish houses. Mississippi Delta fish were taken by stratified sub-sampling techniques of Ketchen (1950) from drum seine catches made in Louisiana coastal waters west of the Mississippi River. These fish had been held on ice for 2-5 days prior to landing. Blue runner from south Florida were obtained fresh from commercial fishermen from Marathon, Florida, and were then frozen for shipment to Panama City, Florida. All fish were weighed for total body weight to the nearest g and measured for fork length to the nearest mm.

Gonads were preserved initially in 10% Formalin and then placed in Bouin's fixative for storage. Later gonads were weighed to the nearest 0.1 g for calculation of gonadosomatic index (GSI) according to the formula: gonad weight/whole body weight x 100. The spawning season for each area was inferred by examining the mean GSI according to month of capture. Blue runner taken only from south Florida from April 1980 through April 1981 were used to verify the spawning season by histological examination of gonadal tissue. Five to ten gonads from each month were selected. Tissue samples were randomly taken from each gonad, then dehydrated, embedded in paraplast and sectioned at 7-10 μ. All samples were stained with a modification of Mallory's triple stain. Two-hundred ova from each ovarian section were classified as follows: stage I, immature/resting; stage II, maturing; stage III, mature; stage IV, ripe; stage V, spent. These ova stages were similar to those reported by Baglin (1982) for his whole ovarian development. Sex ratios were determined for each of the three study areas and were examined for deviation from the expected ratio of 1:1 by chi-square analyses (Snedecor and Cochran, 1967).

Length-at-maturity was estimated by probit analysis from the lengths of 185 northwest Florida female blue runner taken from May to August. Sub-samples of ovarian tissue from each fish were placed in watch glasses, teased apart, and the ova examined at 50X magnification for their state of maturation. Classification of individuals as mature or immature was made on the basis of the presence or absence of vitellogenic ova greater than 200 μ in diameter. Fish were grouped into 10-mm FL intervals, and the percentage of mature individuals was determined for each interval. Percentages were converted to probits and plotted against fork length by the

methods of Natrella (1973) to determine the size at which 50% of individuals may be expected to become mature.

Maturing or mature ovaries of 25 blue runner taken from all three study areas during peak spawning months were used to estimate fecundity. Fish were selected from several fork length intervals to allow correlation of fecundity with length. Three wedge-shaped samples of ovarian tissue extending from the outer tunic to the central lumen and weighing approximately 0.1 g each were removed from each gonad at sites selected according to a random numbers table. The samples were weighed to the nearest 0.01 g, teased apart, and counts made of total number of ova exceeding 200 μ in diameter. Data from the three samples were combined and used to estimate fecundity by the formula: $F = NxW/w$, where F is fecundity, N is the combined ovum count from the three samples, W is the total gonad weight, and w is the combined weight of the three samples. This technique for determining fecundity was similar to that used by Finucane and Collins (1984).

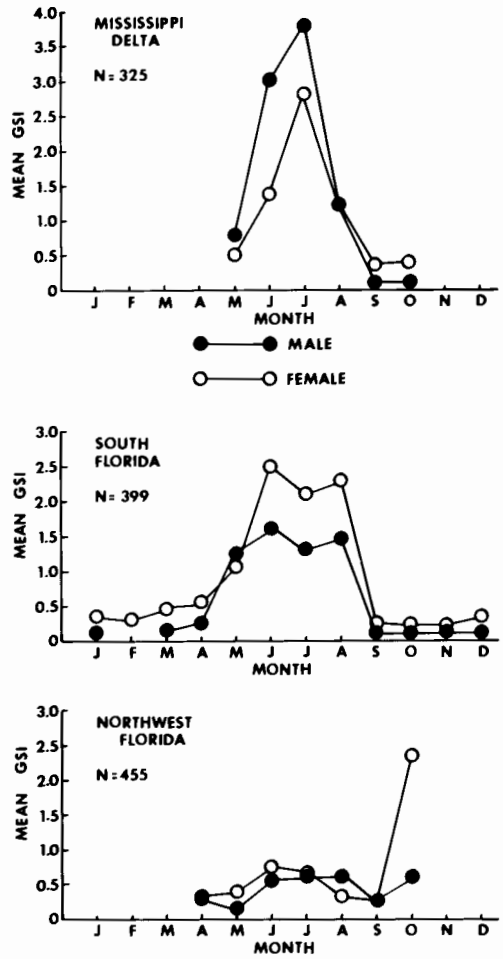

Figure 1. Seasonal variation in mean gonadosomatic index for male and female blue runner collected from three study areas during 1980 and 1981.

RESULTS

Monthly mean GSIs for males and females from the Mississippi Delta and south Florida indicated that June, July, and August were peak spawning months (Fig. 1). Analysis of south Florida samples showed that gonads, as indicated by GSI, returned to resting stage levels during September and remained at these levels throughout the winter and underwent recrudescence in April and May. Blue runner were not available from northwest Florida and the Mississippi Delta during winter months and therefore determinations of spawning cycles are incomplete for these two areas. Fish were obtained only from May through October from the Mississippi Delta and from April through October in northwest Florida. A spawning pattern was observed for these two areas similar to that seen in south Florida. GSIs increased in the spring, peaked in the summer, and decreased in the fall. A significant increase was noted in GSIs for females captured during October off northwest Florida (Fig. 1). Fish contributing to this peak in 1980 and 1981 were quite small (200-250 mm FL) which suggests that some blue runner may have two spawning peaks in the Gulf of Mexico.

Plotting percentages of ova in each

developmental stage versus month of capture for the south Florida samples that were examined histologically (Fig. 2) yielded results that agree with the spawning cycles determined from GSIs. Vitellogenic ova first appeared in blue runner collected in April, became more numerous during may, and were most abundant from June through August. Ovaries returned to resting stages in September. No ripe (stage IV) ova were observed in any of the ovaries examined

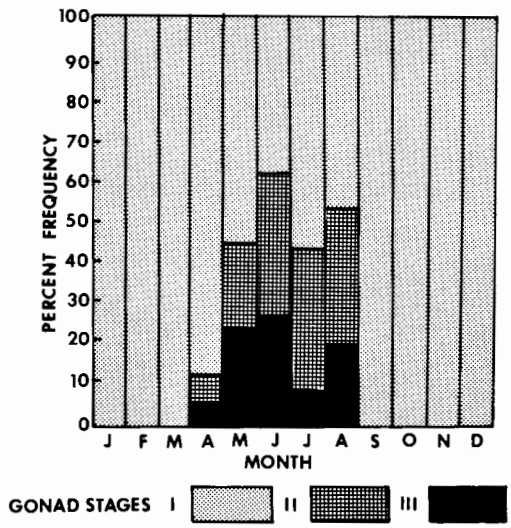

Figure 2. Monthly distribution of ovarian stages for blue runner from south Florida as determined by histological examination of ovaries. Percentages of ova found in each of 3 stages (stage I — immature/resting; stage II — maturing; stage III — mature) are shown. No ripe (stage IV) or spent (stage V) ovaries were found.

histologically and no postovulatory follicles, which might indicate recent spawning, were observed.

Fitting of a probit line by least squares indicated that the length at which 50% of the females would be expected to become sexually mature was 267 mm FL (Fig. 3). The correlation coefficient (r) for this regression was .64 which is significant at the .05 level.

Fecundity varied from 41,000 ova in a 288 g. fish to 1,546,000 ova in a 1,076 g fish (Table 1). Regression of fecundity on fork length (mm) was best fit by the curvilinear equation: Fecundity = .0000989 $FL^{4.22}$ (r = .80, P = .01, df = 9), while regression of fecundity on weight (g) was best fit by the linear equation: Fecundity = −152,000 + 986W (r = .81, P = .01, df = 15).

Females outnumbered males in all three areas. The ratio for the Mississippi Delta area (1.15:1 n = 331) did not differ significantly (P <0.25) from the expected ratio of 1:1. The ratio for northwest Florida (1.66:1 n = 465) and the ratio of south Florida (1.91:1 n = 408) were both highly significant (P <0.005). They deviated from the expected ratio of 1:1 with chi-square values of 28.4 and 40.2, respectively.

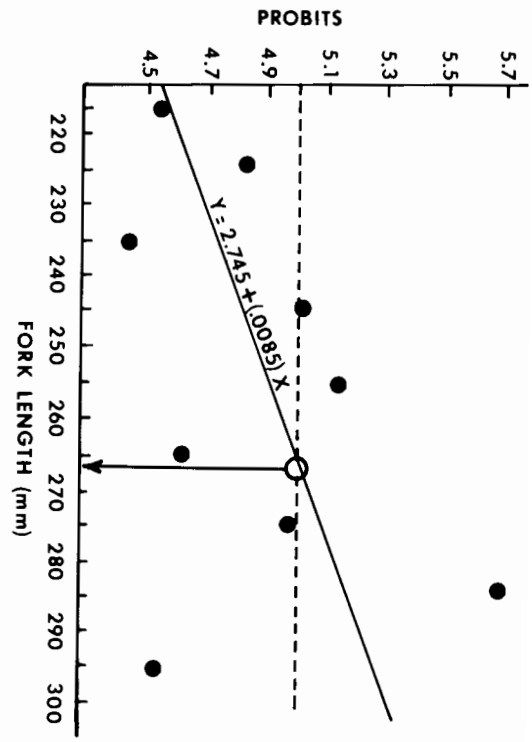

Figure 3. Probit analysis of length at maturity for female blue runner from northwest Florida. The intersection of the regression line with the 5.0 probit line, when projected onto the X-axis, yields fork length at which 50% of individuals may be expected to become mature.

Table 1. Lengths, weights, and gonadal data from all three study areas for late-maturing female blue runner collected during May, June, and July 1980 and 1981.

Area	Collection date	FL (mm)	Weight (g)	GSI	Fecundity
South Florida	15 June 1980	270	340	4.65	392,000
	30 June 1980	278	295	1.91	163,000
	11 June 1980	288	395	4.54	378,000
	24 May 1980	299	508	3.35	365,000
	24 May 1980	300	508	1.87	195,000
	24 May 1980	303	568	1.88	223,000
	11 June 1980	315	568	1.68	173,000
	13 June 1980	319	595	1.32	137,000
	13 June 1980	320	568	3.35	500,000
	30 June 1980	322	735	7.06	1,256,000
	11 June 1980	335	622	2.52	324,000
	30 June 1980	336	735	4.13	561,000
	30 June 1980	371	962	2.14	396,000
	11 June 1980	385	1,076	5.59	1,546,000
	30 June 1980	388	1,076	3.33	945,000
	9 July 1980	460	1,816	3.79	1,334,000
Northwest Florida	2 July 1980	242	307	2.35	146,000
	12 June 1980	243	288	1.53	41,000
	1 July 1980	254	311	2.00	246,000
	1 July 1980	272	475	2.56	198,000
Mississippi Delta	17 July 1981	304	505	1.72	162,000
	17 July 1981	351	785	4.36	829,000
	29 June 1980	382	908	2.67	566,000
	17 July 1981	404	1,025	4.37	1,089,000
	19 June 1980	420	1,362	4.57	1,223,000

DISCUSSION

The spawning seasons for blue runner as inferred from maturation data are similar throughout the eastern Gulf of Mexico. The relatively short duration of the spawning season is somewhat surprising as blue runner larvae have been collected from the southern Gulf of Mexico, the Florida Straits, and the

southeast Florida coast in every month of the year (McKenney *et al.*, 1958; Fahay, 1975; Dooley, 1972; Montolio, 1976). Although the summer peaks of larval abundance noted by these workers coincide with the spawning season determined in this study, it is clear that some spawning must occur throughout the year, as presence of larvae is proof of spawning. Berry (1959) theorized that larvae collected from the Florida Current are probably spawned in offshore southerly waters and are carried northward by prevailing currents. An extended spawning season in the Caribbean Sea combined with transport of larvae by currents could explain the apparent discrepancy but other possibilities must also be considered.

Blue runner captured for this study were taken from coastal waters of three rather limited geographic areas. If spawning populations of blue runner were present in oceanic waters or in coastal waters of areas not sampled for this study, it is possible that they might have extended spawning seasons that could account for the year-round occurrence of larvae in south Florida waters. No ripe fish were found from any area during this study. Berry (1959) and Nichols (1939), on the basis of larval collections, indicated that spawning occurs in oceanic water seaward of 100 fathoms. Migration of pre-spawning fish to these areas would effectively remove them from the fishery and could account for the absence of ripe fish in the collections made for this study.

The pronounced increase in GSIs for female blue runner (200-250 mm FL) captured in October of 1980 and 1981 from northwest Florida was unexpected and inconsistent with the pattern seen in the other two study area. In April, when adult blue runner were beginning to mature, the October-maturing fish would have been immature juveniles. However, in October with water temperature and photo-period similar to that occuring in April, these smaller fish may begin gonadal recrudescence. Whether or not these fish continue to develop and spawn in late fall or winter was not determined, but some of the GSIs recorded in October were among the highest observed in blue runner from northwest Florida. A general secondary spawning season for blue runner may occur in the northern Gulf of Mexico, but, this is unlikely as larger blue runner (200-400 mm FL) captured in October from the Mississippi Delta show no evidence of gonadal development. No large blue runner were taken at this time of year from northwest Florida.

The results of the probit analysis for length-at-maturity presented in this study agree well with the only other published estimate of 225-250 mm SL (Berry, 1959). We believe blue runner probably become mature at lengths slightly below the calculated value of 267 mm FL. Future estimates based on more extensive sampling of small fish and histological examination of gonads throughout the year would help to confirm their size at maturity.

No comparative information on fecundity of blue runner was available from the literature but their values appear similar to those determined for some other coastal pelagic species. For example, bluefish collected off northwest Florida produced 164,000 ova from a 270 mm FL fish and 1,266,000 ova from a 458 mm FL as compared to 392,000 and 1,334,000 ova for a 270 mm FL and 460 mm FL blue runner. (J.H. Finucane, unpubl. manuscr.). Manooch (1979) noted the advantages of high fecundities to pelagic species whose ova and larvae may be subject to a variety of unpredictable environmental hazards.

Numerical dominance of females may be an artifact of sampling methods. Schooling by sex or segregation of habitats or habits by sex could cause artificailly skewed sex ratios. The variation of sex ratios between areas follows no discernible pattern and, due to the use of different capture gear in different areas, does not readily lend itself to analysis.

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