PRODUCTION OF GULF KILLIFISH IN BRACKISH-WATER PONDS[a]

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Abstract: Production of gulf killifish (*Fundulus grandis*) was investigated from 17 November 1977 to 10 July 1978 in 0.08 ha, brackish-water, earthen ponds at the Claude Peteet Mariculture Center. Gulf killifish averaging 30.7 g and stocked at 12,500 fish/ha deposited eggs on Spanish moss spawning mats from 21 March through 16 May 1978. Fifty mats with eggs were transferred to a hatching pond which yielded 82,500 juvenile killifish averaging 0.1 g at harvest on 16 May. Stocked at 250,000 fish/ha in 3 grow-out ponds on 19 May and fed a commercial minnow feed, the juveniles averaged 2.0 g (marketable size) on 10 July 1978 with mean survival of 82%, feed conversion of 1.9, and production of 427 kg/ha.

Proc. Ann. Conf. S.E. Assoc. Fish & Wildl. Agencies 32: 502-508

The gulf killifish, locally called the "bull minnow," is in great demand as a live bait for several of the Gulf Coast's most popular sports fisheries, including flounder (*Paralichthys* spp.), spotted seatrout (*Cynoscion nebulosus*), and red drum (*Sciaenops ocellata*). Demand for the baitfish, however, usually far exceeds the supply sporadically collected with traps and seines.

Recently, the potential of increasing supplies of gulf killifish to bait dealers and sports fishermen was accomplished in brackish-water ponds in Alabama, when wild gulf killifish were spawned in "hatching ponds" and the offspring were reared to marketable size in "grow-out ponds" (Tatum and Helton 1977). The encouraging results, especially when compared to culture of gulf killifish in closed systems (McIlwain 1977), stimulated further pond research. Therefore, from 17 November 1977 through 10 July 1978, additional studies were conducted on holding, spawning, hatching, and grow out of gulf killifish in earthen, brackish-water ponds.

General assistance was provided by D. M. Kelley and S. A. Styron. Diagnostic services were provided by J. P. Hawke and staff of the Southeastern Cooperative Fish Disease Laboratory, Auburn University. Appreciation is expressed for enthusiastic support from Youth Adult Conservation Corps personnel, including S. K. Boyington, R. E. Johnson, A. J. Jones, S. B. Kinsey, J. L. Lambeth, B. M. Lay, R. Love, and P. K. Wilsey. Figures were prepared by K. T. Trimble, and B. L. Whatley typed the manuscript.

MATERIALS AND METHODS

All ponds for holding, spawning, hatching, and grow-out studies were located at the Claude Peteet Mariculture Center (CPMC) and were 0.08 ha with mean depths of 1 m. Pond bottoms were sandy clay loam, and the deep ends contained catch basins and pivotal standpipes to facilitate harvesting. The ponds were initially filled and periodically replenished with brackish water pumped from the Gulf Intracoastal Waterway and filtered through nylon webbing (Domestic Lace Mfg., Inc., Style 8845230). Salinities

[a]This paper is the result of research sponsored by the U. S. Department of Commerce/NOAA/NMFS under Public Law 88-309 (Project 2-263-R) and the State of Alabama. References to trade names in this paper do not imply endorsement by NOAA or the State of Alabama.

were measured periodically with an induction salinometer (Beckman Instruments, Inc., Model RS5-3) or refractometer (American Optical Co., Model 10419). A maximum-minimum thermometer (Taylor, Model 5458) placed on the bottom of the deep end of a pond was read at 3-day intervals. Spawning, hatching, and grow-out ponds were occasionally fertilized (chicken manure, 284 kg/ha) and oiled (2.5 l motor oil SAE 30 and 20 l diesel oil/surface ha) to promote natural productivity and to control predacious insects, respectively. Feeding rings (1.2 m^2) covered with 1.3 cm hardware cloth were used in the ponds to contain floating feed. Throughout the study, weights for feed and fish were obtained with an electric balance (Mettler, P-1000).

Holding Phase

Approximately 5,000 adult gulf killifish were overwintered in one holding pond from 17 November 1977 through 20 February 1978. These fish were randomly selected from both wild stock captured in coastal Alabama during 1975 and first and second filial generations produced at the CPMC. A commercial floating fish feed (Purina Trout Chow, 40% Protein; large fingerling or developer size) was administered to the pond at a rate of 28.4 kg/ha/day (2.27 kg/pond/day) in 2 equal portions on weekdays or once daily on weekends.

Spawning Phase

On 21 February 1978, adult fish from the holding pond were randomly selected as brood stock and stocked at a density of 12,500 fish/ha in each of 2 spawning ponds. Prior to stocking, sexing of 500 adult fish indicated a 1:1 sex ratio. Individual weights for 100 fish of each sex indicated average weights of 37.3 g (range: 61. - 104.1 g) and 24.0 g (range: 6.9 - 69.3 g) for males and females, respectively.

Between 21 March and 25 April, sets of 3 to 8 spawning mats were periodically placed on the bottom of each spawning pond at a depth of 0.5 m. All mats were rectangular (80 cm x 40 cm x 5 cm) and constructed of dried Spanish moss (*Tilliadsia usneoides*) enclosed in vinyl-coated, welded wire (5 x 7.5 cm mesh). To obtain estimates of deposited eggs, mats were initially checked twice daily (21 March through 27 March), then once daily (28 March through 4 April) or periodically (5 April to early May). After eggs accumulated heavily on the mats, the mats were transferred from spawning ponds to hatching ponds to reduce predation by adult gulf killifish on eggs and offspring. Exposure of *F. grandis* eggs to air for even extended periods is not harmful (Gurley 1974); consequently, the mats were hand carried between ponds.

Feeding followed methods used for the holding-pond study, except that for each pond feeding rate of floating fish feed was reduced to 11.5 kg/ha/day, and an additional sinking, meal-type fish feed (Bama Fish and Minnow Food; 32% protein; Alabama Feed Mills) was administered at 5.6 kg/ha/day beginning on 24 April 1978.

On 16 May both spawning ponds were drained, and adult minnows were counted. Population estimates were calculated for offspring by dividing total biomass of juveniles by the average weight of 8 groups of 250 fish.

Hatching Phase

Twenty-two spawning mats were transferred to the hatching pond on 29-30 March 1978, approximtely 8 days after being placed in the spawning ponds. An additional 28 mats were periodically transferred to the hatching pond during April. Mats were observed several times weekly to determine when hatching occurred. Beginning on 21 April, the sinking fish feed was administered to the hatching pond according to quantities and methods used for the spawning ponds. The hatching pond was drained on 16 May, and population estimates for juveniles were obtained according to identical methods used for the spawning pond. Offspring from spawning and hatching ponds were then combined and randomly distributed to grow-out ponds.

Grow-out Phase

Three grow-out ponds were stocked with the offspring on 19 May 1978 at a density of 250,000 fish/ha. The juvenile gulf killifish had grown slightly between 16 and 19 May and averaged 0.2 g at stocking. Weekly, 50 fish were collected with a seine (2 mm mesh) and weighed. The sinking fish feed was administered at 10% body weight assuming 100% survival and adjusted at sampling intervals. Grow-out ponds were harvested on 10 July 1978 to obtain estimates for survivals, yields, and feed conservions. At harvest 200 fish from each pond were individually weighed and measured for total length. Juvenile gulf killifish were examined for parasites and diseases on 29 May, 20 June, and at harvest.

RESULTS

Holding Phase

The holding pond's low water levels due to pump failures for 28 of the 96 days of the holding phase allowed heavy predation on the brood stock by gulls and necessitated reduction of feeding rates periodically. Subsequently, meaningful data for feed conversion and changes in total biomass of brood stock was nullified for the holding phase. Nevertheless, survival of adult brood fish was 76% at harvest. Feed administered totaled 179.9 kg.

During the holding phase, temperatures ranged from 2-19.5 C, and salinities varied from 2-15 ppt (Fig. 1). Schooling of brood stock was noted when water temperatures were less than about 15 C. Feeding activity also decreased at lower temperatures.

Spawning Phase

F. grandis deposited eggs (yellow, 1.0-1.5 mm dia.) on the spawning mats throughout the spawning phse. Approximately 5 eggs/mat were observed on 22 March. Eggs were allowed to accumulate on the mats, and by 27 March an average of 40 eggs (range: 30-50) was observed on each mat. Estimates from 22-27 March indicated that more often eggs were deposited on the mats between 1630 and 0800 h (evenings) than between 0800 and 1630 h (days). Deposition of eggs increased rapidly after 27 March, and the cumulative average of eggs/mat was 100 on 29 March for 1 pond and 540 on 30 March for the other pond. After 30 March, estimates indicated that about 130 eggs/day were deposited on each mat. Usually eggs were deposited in clusters about 2 cm deep in the mat.

During the spawning phase, temperatures ranged from 4 - 33 C, and salinities varied from 5 - 10 ppt (Fig. 1). Minimum and maximum temperatures were 16 C and 23 C, respectively, on March 27 (day 130) when spawning activity increased, and maximum temperatures had ranged between 23-24 C for the previous 15 days (Fig. 1). Spawning continued throughout the spawning phase, even when temperatures surpassed 28 C.

Survival rates for brood stock were 82% and 90% when the 2 spawning ponds were drained. Juvenile *F. grandis* collected from the spawning ponds totaled 1,400 in 1 pond and 3,650 in the other pond. Mean weight of the juveniles was 0.1 g.

Feed was administered regularly, and 75.0 kg of floating feed and 8.2 kg of sinking feed were dispensed to each spawning pond.

Hatching Phase

At harvest on 16May the hatching pond produced 82,500 juvenile fish averaging 0.1 g (103.1 kg/ha). During the hatching phase, temperatures ranged from 12.5 - 33 C, and salinity decreased from 10 to 5 ppt (Fig. 1). A total of 8.2 kg of sinking feed was administered to the hatching pond.

F. grandis eggs hatched 2-4 weeks after transfer from spawning ponds to the hatching pond. Similar periods of embryonic development for gulf killifish were reported by Ernst et al. (1977) and observed at the National Marine Fisheries Service's Galveston Laboratory by M. J. Duronslet (personal communication).

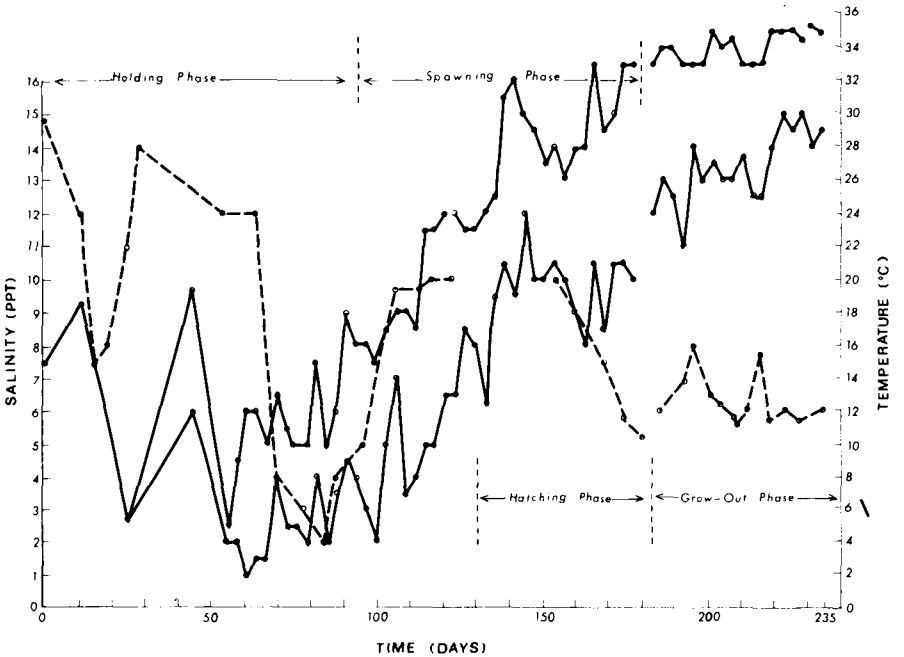

Fig. 1. Salinity (---) and temperature (×) in brackish-water ponds at the CPMC, 17 November 1977 (day 0) - 10 July 1978 (day 235). Minimum and maximum temperatures at 3-day intervals were obtained from day 26 to 235.

Grow-out Phase

Gulf killifish reached marketable size 52 days after they were stocked in grow-out ponds (Fig. 2). At harvest their mean weight and total length were 2.0 g (range: 0.8-7.2 g) and 56 mm (range: 40-84 mm), respectively (Table 1). Mean total lengths of fish from the 3 ponds differed significantly ($P < 0.01$, one-way analysis of variance) with larger fish being produced in pond A-2 (Table 2).

Production data for the grow-out phase are summarized in Table 1. Yield of marketable-size gulf killifish averaged 426.8 kg/ha (range: 354.7-505.1 kg/ha), and survival rates averaged 82% (range: 76-88%). Mean feed conversion was 1.9 (range: 1.6 - 2.3); the feed was eagerly accepted by the fish.

During the grow-out phase, temperature ranged from 22 - 35.5 C, and salinity varied from 11 - 16 ppt. No pathogens were observed on gulf killifish during parasitological and microbiological examinatins.

DISCUSSION

Spawning mats, which greatly contributed to the development of the freshwater baitfish industry (Prather et al. 1953), offer a management technique for separating predacious brood stock from their offspring. For example, 95% of the juvenile *F. grandis* recovered from hatching and spawning ponds were harvested from the former, which contained spawning mats.

Table 1. Summary of pond study on grow out of *Fundulus grandis* stocked at 250,000/ha at the Claude Peteet Mariculture Center, 1978.

	Stocking data			*Harvest data*						
				Weight of fish (g)		*Total length of fish (mm)*				
Pond No.	*Date stocked*	*Mean weight (g)*	*Production days*	*Mean*	*Range*	*Mean*	*Range*	*Kg/ha*	*Survival (%)*	*Feed conversion*
A-1	19 May	0.2	53	2.1	1.3-4.6	56	49-73	505.1	88	1.6
A-2	19 May	0.2	52	2.2	1.1-7.2	58	48-84	420.5	76	1.9
C-4	19 May	0.2	52	1.6	0.8-4.2	53	40-70	354.7	81	2.3
	TOTALS	0.2	52	2.0	0.8-7.2	56	40-84	426.8	82	1.9

Table 2. Percentages of *Fundulus grandis* in intervals of total length for 3 ponds harvested on 10-11 July 1978 at the Claude Peteet Mariculture Center.

Intervals (mm)	*Percentages of fish in intervals for 3 ponds*		
	A-1	A-2	C-4
40-44	---	---	2.0
45-49	0.5	1.5	22.0
50-54	39.0	32.0	46.0
55-59	39.5	44.0	16.5
60-64	15.5	11.0	7.5
65-69	4.5	4.0	4.0
70-74	1.0	3.5	2.0
75-79	---	2.5	---
80-84	---	1.5	---

Since each female brooder had potential of producing about 1200 mature eggs (May 1977) and yield was only 88 juveniles per female, potential may exist for greater production in hatching ponds. Deposition of eggs by the brood stock may have decreased as early as 16 April when water temperatures were 28 C or higher, temperatures which reportedly slow reproductive development of gulf killifish (Fivizzani 1977, Spieler et al. 1978). Other factors, including stocking densities, sex ratio of brood fish, diet, quantity of mats, cannabilism and predation, could have reduced the yield and should be investigated in future research. On the other hand, survival of brood stock and their offspring probably was not affected by either temperature (range: 2 - 33 C) or salinity (range: 2 - 15 ppt). Gulf killifish were captured and maintained at temperatures above 33 C (Strawn and Dunn 1967, Christmas and Waller 1973), and a lethal low temperature of -1.5 C was reported by Umminger (1971). Griffith's (1974) review of the literature on salinity tolerances for gulf killifish at Gulf Coast sites indicates a range of 0.05 - 58.6 ppt, and Swingle (1971) collected gulf killifish near the CPMC at salinities ranging from undetectable concentrations to 24.9 ppt.

Gulf killifish reared in the grow-out phase were large enough (5.0 - 7.5 cm total length) for bait sales; however, a larger fish (8.0 - 10.0 cm) may be preferred by Gulf Coast sports fishermen. Further marketing analysis is under investigation (personal communication, Michael H. Smith, Auburn University).

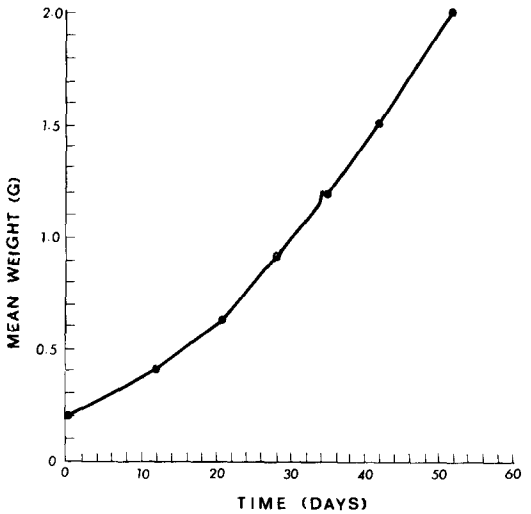

Fig. 2. Mean growth rate of gulf killifish reared in brackish-water ponds at the CPMC, 19 May - 10 July 1978.

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