LABORATORY SPAWNING AND LARVAL REARING OF RED DRUM AND SOUTHERN FLOUNDER

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Abstract: Laboratory spawning and larval rearing studies were conducted with red drum (*Scianenops ocellata*) and southern flounder (*Paralichthys lethostigma*) from 1974 through 1977. Adult fish were placed in 29.92 kl spawning tanks equipped with biological filters and subjected to photoperiods and temperatures regulated to simulate seasonal variations. Red drum spawned 52 times producing 6.0 X 10^7 eggs. Southern flounder spawned 13 times producing 1.2 X 10^6 eggs. Eggs were collected and incubated, and larvae were reared to fingerling size. This paper describes techniques used to produce fingerling red drum and southern flounder.

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Increasing fishing pressure and deterioration of the natural environment in the Texas Gulf coast area have resulted in decreased stocks of sport fishes. Species life histories, including spawning and larval development, must be understood to manage these sport fishes. Cooperative studies by the National Marine Fisheries Service (NMFS) and the Texas Parks and Wildlife Department (Inland Fisheries) were conducted to develop laboratory techniques needed to spawn and culture important marine sport fishes. This study was designed to develop laboratory spawning and culturing techniques for red drum and southern flounder. This research was supported by Federal Aid Restoration Funds under Dingell-Johnson F-31-R.

MATERIALS AND METHODS

Four adult red drum (weight range 9-15 kg) were collected with beach seine (305 m) and hook and line in September and November 1974 from the surf near Port Aransas, Texas. Two more red drum of similar size were taken from 9.9 ha ponds at the Texas Parks and Wildlife Department Coastal Fisheries Research Station, Palacios, TX in late September. Six pairs of adult southern flounder (weight range 1-3 kg) were caught with hook and line on 13 August 1976 from the Corpus Christi Ship Channel near Port Aransas.

Red drum were moved in aerated hauling tanks (1 fish/520 l of water) from collection sites to laboratory holding tanks (20 kl) at the NMFS Laboratory, Port Aransas, TX. Fishes were moved from hauling tanks with wet cloth stretchers. Southern flounder were carried to laboratory holding tanks (1.5 kl) in 90 l Styrofoam ice chests. Brood fishes were given 1 to 5 min treatments of a 25 ppm solution of malachite green-formalin to prevent infections and remove ectoparasites. The solution mixture was 14 g malachite green per 4 l 40 percent formalin. One week after collection the 3 pairs of red drum and 6 pairs of southern flounder were introduced into 29.92 kl spawning tanks equipped with biological filtration as described by Arnold et al. (1976). A second filter was added to the red drum tank 6 months later to improve water quality.

Adult red drum fed within 14 days after capture and thereafter were fed on alternate days with freshly thawed mullet (*Mugil* spp.) and shrimp (*Penaeus* spp.). Mullet was discontinued as a food since this food source is known to harbor a Canteni bacteria (D. H. Lewis, College Station, TX, Pers. Comm., 1976). Southern flounder were fed only live shrimp as other foods were rejected. Tanks were cleaned weekly to remove excess food materials and organic wastes. But, cleaning was discontinued in flounder tanks during spawning due to adult excitability.

Fish in the spawning tanks were subjected to photoperiods and temperatures regulated to simulate seasonal variations (Tables 1 and 2). Nine light fixtures, each with 4 fluorescent bulbs, were arranged in 3 rows, 5 m apart and 1.5 m above the tank. Each row was controlled by a 24 hr, noncorrosive electric timer. The timers were set so rows of

Table 1. Photoperiod and temperature regimes used to induce spawning of red drum in a 29.92 kl spawning tank, October 1974 through October 1975.

Month	Photoperiod (hrs) Light	Dark	Mean Temperature (C)	Temperature Range (C)	Laboratory Season
October	12	12	23.0	22.5-25.0	summer
November	9	15	20.0	19.0-21.0	fall
December	9	15	18.0	16.0-20.0	fall-winter
January	9	15	18.4	16.0-20.0	fall-winter
February	12	12	19.3	17.0-20.0	spring
March	15	9	23.6	23.0-25.0	summer
April	15	9	24.6	24.0-26.0	summer
May	12	12	26.0	25.0-27.0	late summer
June[a]	12	12	26.0	24.0-27.0	late summer
July	9	15	24.0	23.0-25.0	fall-winter
August[b]	9	15	22.0	21.0-24.0	fall-winter
September	9	15	23.3	22.5-25.5	fall-winter
October[c]	9	15	23.0	23.0-23.5	fall-winter

[a]First spawning behavior noted 6/25/77.
[b]First spawn 8/13/75.
[c]Last spawn 10/27/75.

Table 2. Photoperiod and temperature regimes used to induce spawning of southern flounder in a 29.92 kl spawning tank. August 1976 through January 1977.

Month	Photoperiod (hours) Light	Dark	Mean Temperature (C)	Temperature Range (C)	Laboratory Season
August	15	9	26.5	26.0-27.0	spring
September	12	12	26.5	25.5-27.5	summer
October	12	12	22.8	20.7-25.0	late summer
November	9	15	17.7	16.0-19.5	fall
December[a]	9	15	17.0	16.5-17.5	fall
January[b]	9	15	17.0	16.5-17.5	fall

[a]First spawn 12/21/76.
[b]Last spawn 1/3/77.

lights turned on in 5 min intervals each morning and off in 5 min intervals each evening to simulate dawn and dusk. Two electric air conditioners controlled room temperature and consequently water temperature.

Spawning was observed through a 30 cm X 50 cm window in one end of the spawning tank. Percentage fertilization and hatch were determined after spawns by placing eggs in 100 ml beakers filled with water from the spawning tank.

Procedures for handling buoyant eggs were described by Arnold et al. (1976). Eggs were removed the morning after each spawn and placed into 187 l fiberglass hatching tanks filled with water from spawning tanks. Hatching containers were stocked with 100-200 red drum eggs/l or 5-10 southern flounder eggs/l. Five 57 l aquaria were each stocked with 70 fertile southern flounder eggs. Temperatures and salinities in hatching containers were maintained at 24 C and 28 o/oo for red drum and 17 C and 28 o/oo for southern flounder.

After hatching, larvae were moved immediately to 57-74 l rearing containers. These containers were prepared and stocked using methods described by Arnold et al. (1976). Red drum and southern flounder were stocked at 1-7 fish/l. Rotifers (*Brachionis placatilis*) were fed to red drum at 3 days post-hatch and to southern flounder at 6 days post-hatch. Newly hatched brine shrimp nauplii (*Artemia* spp.) were fed to red drum and southern flounder at 6 and 14 days post-hatch, respectively. Culture and feeding methods for these 2 food organisms were described by Arnold et al. (1976). Chopped shrimp were given to red drum and southern flounder at 15 and 35 days post-hatch, respectively. Red drum fry were kept in rearing containers at the laboratory and others were stocked into rearing ponds at the Palacios Research Station (Colura et al. 1976) to compare rearing methods to 60 days of age. Twelve fingerling red drum (44 mm TL) were put into a 15 kl tank equipped with biological filtration and reared for 19 mo. Southern flounder were kept in rearing containers for 60-80 days.

RESULTS AND DISCUSSION

Red Drum

Red drum in the spawning tank during December 1974 failed to spawn, even though the water temperature and photoperiod simulated spawning conditions. Handling stress, initial tank acclimation, or water quality in holding tanks may have caused gonadal resorption in gravid fish. On 25 July 1975, after the red drum had been subjected to a 7 mo recycling through the 4 annual seasons (Table 1), drumming noises were heard and males began butting females. This behavior continued until 14 August when the first spawn occurred, producing 2.0 X 10^6 eggs. Spawning continued until 3 November 1975. During these 76 days an estimated 6.0 X 10^7 fertilized eggs were produced by 3 females in 52 spawns.

Red drum spawns were predictable, as chasing and butting with associated drumming started 3-4 hr before each spawn. Male coloration changed as courting intensified. Males became dark red to bluish-gray on the dorsum above the lateral line and pale white on the ventrum. Spawning occurred just before or after laboratory simulated dusk. When spawning occurred the tank became cloudy with milt released by several males attending 1 female. Eggs were released at mid-depth in the tank, and 10-20 min later buoyant, fertilized eggs entered the filter box through the overflow drain. Fertilization was more than 99 percent.

Eggs placed in hatching tanks had hatch rates of 94-99 percent in 19-20 hr. Stocking of 1-2 larval fish/l resulted in survival rates of 3-30 percent after 30 days. The major cause of death seemed to be insufficient amount of food during the first 6 days. Larval red drum stocked in aquaria reached 34 mm mean TL (range 25-44 mm) in 22-24 days. This growth was similar to that achieved in brackish water ponds containing natural foods; however, survival in the ponds was higher (12-65%) after 30 days (Colura et al. 1976).

The 12 fingerling red drum (44 mm TL) stocked into 15 kl rearing tanks grew to a mean weight of 190 g and 250 mm mean TL in 6 mo; at 19 mo they had grown to a mean weight of 1,840 g and 523 mm mean TL.

Southern Flounder

Males began attending gravid females 3 weeks before spawning. ,This attendance increased in intensity until spawning started. Males would follow a female, and when they came to rest males would position their heads 2-3 cm from the female's vent. At spawning the female swam to the surface and released eggs which were immediately fertilized by an attending male. All spawns occurred at laboratory midday. It appeared only the 3 largest females ($>$ 2 kg) spawned, and each spawned more than 3 times.

The first spawn occurred on 21 December 1976 (Table 2); 12 more spawns followed on consecutive days, producing a total of 1.2 X 10^5 eggs. Fertilization was 30-50 percent. These hatched in 61-76 hr, with 6-35 percent hatching success.

Larvae stocked into aquaria were used to document the growth and structure development of southern flounder; therefore, a detailed record of larval survival was not maintained. However, from the 350 fertilized eggs stocked in 5 aquaria, 105 fish were recovered after 90 days. These fish began metamorphosis at 40-46 days (8-11 mm TL) and 50-51 days this structural change was complete. After this period, southern flounder fingerlings became completely demersal.

CONCLUSIONS

Adult red drum and southern flounder can be maintained in laboratory tanks equipped with biological filtration.

Laboratory spawning of red drum and southern flounder can be induced by regulating photoperiods and temperatures to simulate seasonal variations.

Red drum and southern flounder eggs can be hatched and fry raised to fingerling size in the laboratory.

LITERATURE CITED

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