STATUS OF MARINE FISH INTRODUCTIONS INTO THE FRESH WATERS OF TEXAS

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Abstract: Techniques have been developed for spawning adult southern flounder (*Paralichthys lethostigma*), spotted seatrout (*Lynoscion nebulosus*), and red drum (*Sciaenops ocellata*) and rearing their larvae for freshwater acclimation and introduction into heated freshwater reservoirs in Texas. Egg production, percentage egg fertilization, percentage hatch, percentage return of larvae stocked into laboratory aquaria and hatchery ponds, and potential for fingerling survival in fresh water were compared for the 3 species. Red drum was found to be the most suitable for culture and introduction into fresh water. A diagram and estimated construction cost of a laboratory facility for holding and spawning marine fishes is presented.

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Most of the 41 heated reservoirs in Texas support large populations of rough fish which are underutilized by native predators. Sport fishing in these lakes often suffers because of the domination of fish populations by rough fishes. Bennett (1944) and Odum (1971) indicated that sport fishing in freshwater reservoirs may be improved by introducing large predator fishes to aid in controlling problematic forage and rough fishes. To better utilize the rough fish resource and improve fishing, 3 marine fish species, southern flounder, spotted seatrout and red drum, were selected for experimental stocking into heated lakes in Texas. These fishes were selected because they grow to large sizes (southern flounder—9 kg, spotted seatrout—8 kg, and red drum—34 kg), are predaceous, appeal to anglers, and often encounter almost fresh waters in their native habitats.

These fishes were stocked into several Texas reservoirs in the 1950's and 1960's (letter, E. G. Simmons, Rockport, TX). Stocking rates were low because fingerlings were difficult to collect. However, the success of many of these introductions prompted further research.

In 1972, Texas Parks and Wildlife Department personnel initiated a program to propagate the 3 species plus other predatory marine fish species to obtain large numbers of these fishes for freshwater introductions. Spawning and rearing studies in 1972 and 1973 were conducted at the State Fish Hatchery at Olmito, Texas. These studies were moved to the National Marine Fisheries Service Laboratory at Port Aransas in 1974, under a cooperative agreement between the NMFS and the Texas Parks and Wildlife Department, Inland Fisheries Function. Further rearing studies were conducted at the Texas Parks and Wildlife Coastal Fisheries Research Station at Palacios TX from 1974 to 1977.

This is a report on the status of marine fish propagation and the outlook for the future of marine fish introductions into fresh waters of Texas. Financial and technical support for this cooperative study were provided by the Federal Aid in Fish Restoration Act under Project F-31-R of the Texas Parks and Wildlife Department; U.S. Department of Commerce, NOAA, National Marine Fisheries Service; and the Texas Parks and Wildlife Department Coastal Fisheries Function under PL 88-309 (Project 2-252-R). Appreciation is expressed to the editorial staff of the Texas Parks and Wildlife Department, Inland Fisheries Function for their review of the manuscript.

MAINTENANCE AND SPAWNING OF BROOD FISHES

Brood fishes were collected near Port Aransas and held at the National Marine Fisheries Service laboratory at natural temperatures (15-26 C) in indoor 29,920 liter (6.1 x 2.7 x 1.5 m) fiberglass tanks. Tanks were equipped with biological filters as described by Arnold et al (1976). Fishes began feeding after 2-21 days and were fed live and freshly thawed penaeid shrimp and smaller amounts of mullet (*Mugil* spp.) and pinfish (*Lagodon rhomboides*) at 3 to 4 percent of their body weight. Spotted seatrout and red drum ate live or dead food but southern flounder required live food. Tanks were vacuumed weekly to remove solid wastes.

Fishes were subjected to photoperiod and temperatures regulated to simulate seasonal variations as described by Arnold et al. (1976).

FECUNDITY, PERCENTAGE FERTILIZATION AND PERCENTAGE HATCH

Southern Flounder

Six southern flounder females used in controlled spawning experiments weighed an average of 2.0 kg (range of 1.0-3.0 kg). Three females spawned and produced approximately 40,000 eggs each. However, percentage fertilization and percentage hatch were low, averaging only 26 and 50 percent for each, respectively. Only 5,000 larvae were obtained from each of the 3 females.

No reasons for these apparently low fertilization and hatch rates were determined, although possibly low fertilization and hatching rates are normal for southern flounder. Flounder spawning was observed several times and each spawning act involved 1 male and 1 female. In each observation, the male released a small amount of sperm which may have been insufficient to fertilize all the eggs released by the female.

Spotted Seatrout

Eight spotted seatrout females and 7 males used in controlled spawning experiments weighed an average of 1.8 kg (range of 1.0-3.2 kg). Fish spawned during each of 13 consecutive months for a total of 82 spawns, producing approximately 3.0 million eggs. Approximately 36,000 eggs were produced each spawn. Ninety-nine percent of the eggs were fertilized and hatch ranged from 70-85 percent. The fact that several males participated in the spawning act probably enhanced fertilization. Males released so much sperm at the time of spawning that it clouded the water for a short period of time.

Red Drum

The 3 red drum females and 3 males used in controlled spawning weighed an average of 13.5 kg (range of 10.9-15.9 kg). Fish spawned during each of 3 consecutive months for a total of 52 spawns, producing approximately 60.0 million eggs (1.2 million eggs/spawn). Ninety-nine percent of the eggs were fertilized and hatch ranged from 94-99 percent.

Red drum spawning was observed several times and all males participated in the spawning act with each female. When spawning occurred, the water became so cloudy with sperm that the fish could not be seen for 10 to 15 min.

LARVAL REARING

POND CULTURE

Southern Flounder

Five thousand newly hatched southern flounder larvae were stocked into a saltwater pond at the Palacios research station. Water temperatures dropped to 9.0 C the week following larval stocking. The pond was drained after 32 days and no fish were recovered. This was probably because of the low water temperatures which occurred just after stocking.

Spotted Seatrout

Pond rearing studies were conducted during the summers of 1975 and 1976 at the Palacios research station. Colura et al. (1976) reported a poor return of fingerlings (average 3%) from ponds and attributed this to cannibalism, high pond temperatures, and low oxygen levels in the ponds during rearing.

Red Drum

In the fall of 1975, the Palacios station reported a 20 percent return of red drum fingerlings from hatchery ponds (Colura et al. 1976). Returns of fingerlings from ponds where newly hatched larvae were stocked ranged from 2-10 percent, but returns from ponds where 2-day-old larvae were stocked ranged from 12-65 percent. The more developed 2-day-old larvae were apparently better able to escape predaceous insects and copepods.

Fingerling red drum (approximately 40 mm TL) were stocked in saltwater ponds at the Palacios facility and freshwater ponds at the Olmito State Fish Hatchery. Fishes reared at both facilities were fed commercially prepared catfish feed during the study. Fingerlings averaged 125 mm TL when the ponds were drained and returns from the salt and freshwater ponds were 82 and 50 percent, respectively (Colura et al. 1976).

LABORATORY CULTURE

Southern Flounder

Southern flounder larvae reared in 57 l glass aquaria survived and grew well. Three hundred and fifty fertilized eggs stocked into aquaria produced 105 metamorphosed fish (30% return) in 60 days. Flounder were expected to be cannibalistic even before metamorphosis; however, no cannibalism was noted and fish readily fed on rotifers (*Branchionus plicatilis*) and brine shrimp nauplii (*Artemia* sp.).

Spotted Seatrout

A return of 30 percent was realized in the laboratory by feeding only rotifers and "alga-fed" brine shrimp (nauplii and adults). Thirty-day-old fish produced by this method were 30 to 40 mm TL. Feeding newly hatched brine shrimp nauplii provided a return of less than 3 percent of the larvae stocked and high losses from cannibalism were observed. The time, expense, and the uncertainty of the brine shrimp egg supply make feeding alga-fed brine shrimp impractical for mass production of fingerling spotted seatrout.

Red Drum

Larval red drum reared in aquaria readily fed on rotifers and brine shrimp (nauplii and adults); however, losses to cannibalism were extremely high. After 30 days, an average of less than 10 percent (range 3-30%) of the fish (approximately 40 mm TL) remained.

FRESH WATER ACCLIMATION

Southern Flounder

Newly metamorphosed southern flounder were easily acclimated from seawater (28 to 32 ppt) to fresh water ($<$ 1 ppt) within 3 hr with 100 percent survival. Fish appeared stressed for a short period of time after freshwater acclimation and remained motionless on the tank bottom for 10 to 20 min.

Spotted Seatrout

Although spotted seatrout could be acclimated to fresh water at 40 mm TL, survival was questionable, particularly if the fish were introduced into an established freshwater fish population. Fish were stressed for several hours after acclimation (3 hr acclimation time) and would have been easy prey for freshwater predators. From 15-60 percent of spotted seatrout acclimated to fresh water and held in aquaria died within 3 wks after acclimation. No larger spotted seatrout were available for freshwater acclimation experiments; possibly larger fish would acclimate to fresh water more readily.

Red Drum

Red drum fingerlings as small as 40 mm TL could be acclimated to fresh water in 3 hr; however, fishes showed considerable stress. Larger fingerlings (125 to 140 mm TL) acclimated to fresh water (3 hr) showed little or no stress.

SUCCESS OF MARINE FISH INTRODUCTIONS INTO FRESH WATER

Southern flounder, spotted seatrout, and red drum were introduced into impounded fresh and saline waters in Texas long before this study began. Results of some of these introductions were poor. Spotted seatrout did not survive transport and/or freshwater acclimation (letter, E. G. Simmons, Rockport TX). There have been no reported recoveries of red drum that were stocked in Lakes Kemp and O. R. Mitchell in 1953 and 1954. However, red drum introduced into Red Bluff and Imperial Reservoirs not only survived but grew approximately 2.0 kg/yr. Red drum up to 10.0 kg were taken by anglers from these reservoirs (Henderson 1972). Southern flounder introduced into Lake Casa Blanca and into ponds at the Olmito State Fish Hatchery also grew rapidly; approximately 1.5 kg/yr (Campbell 1964; letter, E. M. C. Dietz, Rockport TX).

Since the marine fish propagation study has been in progress, hatchery reared marine fish predators have been introduced into 9 reservoirs in Texas (Table 1). Fishermen have shown considerable interest in this program, prompted by their catches from some of these reservoirs. Southern flounder up to 2.0 kg (14-mo-old) have been caught from Long Lake. Stomach analyses of these fish showed they fed primarily upon small sunfishes which are problem fishes in some Texas reservoirs. Red drum have grown rapidly in Victor Braunig Lake; the largest reported was an 18-mo-old, 3.0 kg fish. Stomach analyses of red drum from Victor Braunig Lake showed the fish fed primarily upon

threadfin shad (*Dorosoma petenense*) and *Tilapia* sp. Red drum catches up to 0.5 kg (9-mo-old) have also been reported from Lake Creek Reservoir.

Table 1. Stocking records of marine fish fingerlings introduced into freshwater reservoirs of Texas, 1974-1977.

Fish Species	*Reservoir*	*Date*	*Number*	*Average size (mm)*
Southern flounder				
	Alcoa	3/77	4,500	35
Spotted seatrout				
	Long	6,8,9/75	6,072	55
Red drum				
	Victor Braunig	4/76	2,065	130
	Lake Creek	9/75	13,409	38
	Long	9/75	33,120	38
	Striker	10/75	18,435	38
	Town	11/75	100	30
	Tradinghouse Creek	9/75	53,161	38
	White River	10/75	14,415	32
	White Rock	4/76	2,200	86

CONCLUSIONS AND RECOMMENDATIONS

The marine fish propragation study was originally designed to determine techniques for spawning, rearing, hauling, and acclimating (to fresh water) selected marine fish species. The success of the program provided fisheries biologists with thousands of marine fish predators for introduction into freshwater reservoirs. It was determined that the 3 species studied could be acclimated to fresh water at 30 to 40 mm TL, but nothing was known about their potential for survival in reservoirs with established fish populations. Southern flounder, since they are bottom fishes, should not readily attract freshwater predators and their chances of survival, even at 30 to 40 mm, should be great. However, small (30 to 40 mm) spotted seatrout and red drum apparently succumb to osmotic stress or are susceptible to predation, since very few of the 140,000 introduced into freshwater reservoirs have been caught. Larger red drum (125 to 140 mm TL) stocked into Victor Braunig Lake apparently survived in large numbers since more than 25 of the 2,100 fish stocked have been reported caught by fishermen.

The value of marine fish introductions in controlling problem fishes and in supplying recreation to fishermen must be determined before further expenditures by the Texas Parks and Wildlife, Inland Fisheries Function could be justified. A candidate reservoir should be selected, marine fishes introduced, and the effects of their introduction evaluated. Introductions should be restricted to those species which have shown to be suitable for mass culture and which have survived well in fresh water. Red drum appear to be the most suitable for this type of study since they have proven relatively easy to culture in ponds and apparently do well in fresh water when stocked as advanced fingerlings ($<$ 125 mm TL). Southern flounder should not be considered for mass culture since fecundity, percentage fertilization and percentage hatch are apparently low. However, spawning and rearing experiments with this species should be repeated to verify results obtained in this study. Spotted seatrout, although easy to spawn, are apparently too difficult to rear for freshwater introductions.

Should marine fish introductions prove beneficial in freshwater fisheries management, a facility must be constructed (if economically feasible) to supply fingerlings for stocking. A laboratory building which could be used for holding and spawning brood fishes has been designed by Texas Parks and Wildlife Department biologists (Fig. 1). The building would house 8 29,920 l tanks (2 tanks/room) where brood fishes could be held for photoperiod-temperature and/or hormone spawning. The facility would have a minimum of 100 ha of saltwater ponds and a constant, unpolluted seawater supply within a salinity range of 28-32 ppt. An unpolluted freshwater supply would also be available for fresh-

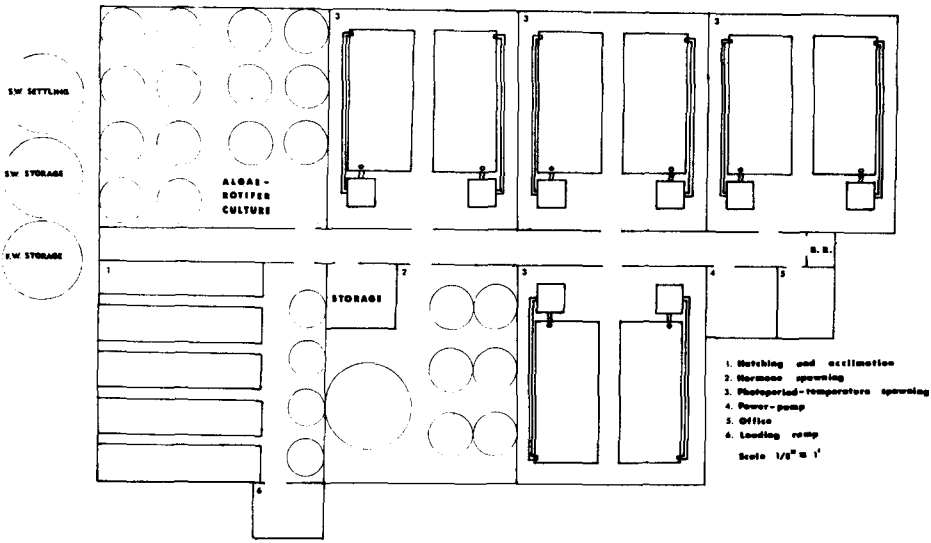

Fig. 1. Proposed laboratory facility designed by Texas Parks and Wildlife Department biologists for use in holding marine brood fishes for hormone or photoperiod-temperature induced spawning and for acclimating fingerlings of these marine species to fresh water for introduction into freshwater heated reservoirs in Texas.

water acclimation of fingerlings. Department engineers have estimated the building construction cost at $570,000 and land for pond space and cost of pond construction would add another $500,000. Even if it is not economically feasible for the Texas Parks and Wildlife Department to construct this facility, its construction by another agency would probably be justified in developing culture techniques which could be used to produce fishes for sport and commercial purposes.

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