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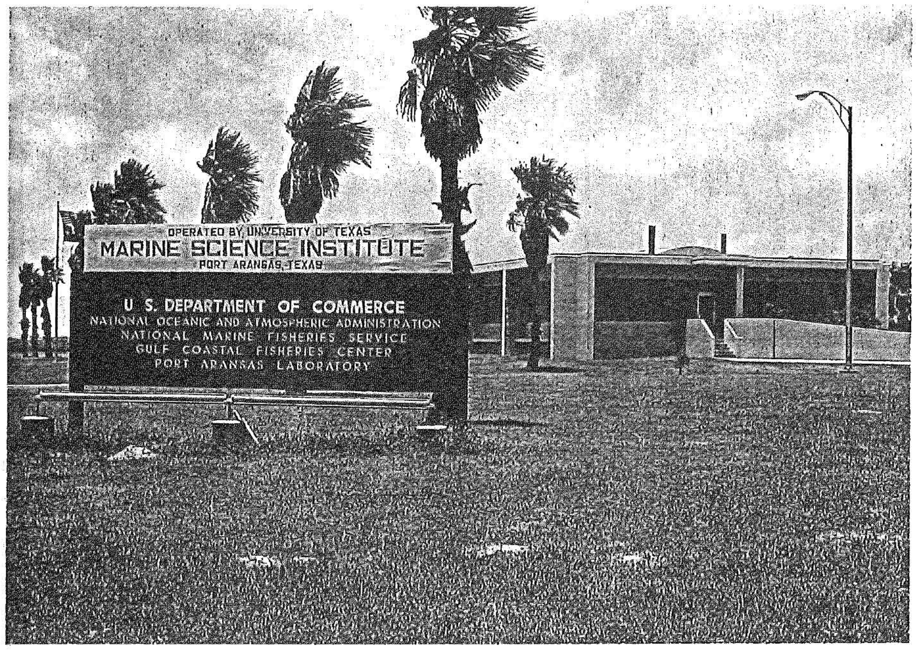
U.T.'s Marine Fish Research Program

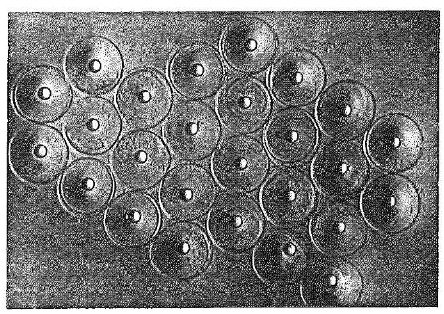
By Dr. C.R. "Connie" Arnold



THE MARICULTURE RESEARCH PROGRAM at the University of Texas, Port Aransas Marine Lab has only been in existence for a few years but has already dealt with some of the most difficult aspects of finfish mariculture. Ours is a unique team approach to marine fish culture based on first determining the underlying biological processes which control reproduction, survival, and growth, and secondly applying these facts to culture and eventually to mass production. Thus the knowledge gained from basic research on the ecology, physiology and biochemistry of a species such as redfish will provide the technical background necessary for development of reliable techniques for culture.

Broad-based support from the private sector, the federal government and the state of Texas assures the continuation of this mariculture research and is indicative of the widespread interest in such an integrated approach. The program is composed of a team of scientists conducting research in the areas of maturation and spawning, reproductive and stress physiology, nutrition, physiological-ecology and bioenergetics of eggs and larvae, natural habitat evaluation and grow out.

One of the major assets of the program is the ability to consistently spawn marine fish in captivity. Over the past several years we have successfully spawned redfish, spotted seatrout, flounder, croaker and red snapper, the first natural spawning in captivity for all of these species. This natural spawning



Newly spawned eggs. Studies of larvae and eggs such as these provides new insights into the needs of juvenile redfish.

was induced using the photoperiod-temperature techniques developed for marine fish at the Port Aransas lab. We can induce redfish and spotted seatrout to spawn routinely, but further research will be required before we can achieve a similar success in spawning red snapper.

A major achievement was increasing the length of time redfish spawn so that eggs are available year-round. Redfish naturally spawn over a short period from August through October or November. Experiments in our lab show that spawning ceases when the water temperature drops below 68°F. Collaborative studies revealed newly hatched larval fish could not survive temperatures below 68°F, therefore we conclude that natural spawning is limited by low water temperature in late fall. By manipulating temperature, captive redfish can be induced to continue spawning. We have a group of redfish that have spawned from one to eight times per month for a record 38 consecutive months (and as of this writing are still spawning). This success has proven invaluable to our research program and has great potential for the mariculture industry since the young redfish are now available year-round instead of for just a few months in the fall.

In April 1983, the egg-to-egg cycle for redfish was completed in our laboratory. Eggs that were spawned and hatched in the lab in July, 1980 were reared to maturity. Spawning by these lab-reared fish at the age of 44 months was the breakthrough which will enable us to begin selective breeding studies.

Historically, efforts to induce marine fish to spawn in captivity have been hampered by a lack of knowledge of marine fish reproductive physiology. The sources and identities of the hormones controlling each stage of sexual maturation and spawning in marine fish are largely unknown. Such knowledge is essential for the development of reliable procedures to artificially induce the maturation and spawning of marine fish in captivity.

Blood and gonad samples (ovaries and testes) have been collected from wild populations of spotted seatrout over two spawning seasons. The seasonal cycle of hormonal fluctuations in the blood will be correlated with the stage of gonadal development to determine which hormones are involved in each maturation stage. We have discovered that the final stages of egg development and sperm production in spotted seatrout and redfish are not controlled by the steroid hormones which regulate these processes in other fish such as salmon. The identity of the hormones which perform these functions in redfish and spotted seatrout is still unknown, but analysis which will identify these hormones is continuing.

Examination of the ovaries revealed that female spotted seatrout had two

Photo period temperature techniques developed at the Port Aransas Marine lab have induced many fish to spawn in captivity for the first time. These include redfish, speckled trout, flounder, croaker and even red snapper.

peaks of spawning activity in Redfish Bay in 1982 and one peak in 1983. The increase in water temperature above 74°F in the spring appears to be the cue which initiates spawning. Spawning ceases when water temperatures drop below 76°F in October. Speckled trout spawn over shallow grassy flats in Redfish Bay soon after dusk. The rapid recovery in ovary weight within a day after spawning suggests that these fish can spawn frequently. The presence of eggs at different stages of maturity in the ovary also indicates that spotted seatrout are multiple spawners although the number of times an individual is capable of spawning is uncertain.

Techniques to artificially induce maturation and spawning by hormone implants are also being tested. Currently we are testing whether an implant of LHRH, a brain hormone which induces gonadal maturation in mammals, can stimulate the sexual maturation and spawning of redfish. This preparation has already been shown to stimulate ovarian growth in carp.

A series of experiments were performed to determine the degree of stress associated with various procedures commonly used in the culture of finfish. Analysis of samples is incomplete but preliminary data suggest the redfish recover rapidly from the stress of capture, transport and transfer to a new holding tank. One hour after transfer plasma glucose concentrations (an indicator of stress) were five to six times control levels, but by 24 hours had returned to basal levels.

Anesthetics may be useful to limit the effects of stress caused by handling and other procedures. Several different fish anesthetics will be tested for their ability to prevent biochemical stress responses in captive fish. Another experiment demonstrated that one pound redfish could be kept at densities of up to 35 fish per 50 gallon tank without causing undue stress (as shown by plasma glucose levels).

Egg and larval fish studies are providing considerable insight into the physical, chemical, and biological needs of young redfish. We have shown that temperature is extremely important in regulating growth at all stages. Results of growth characterization studies, beginning with newly fertilized eggs to 15-day-old larvae, demonstrate the presence of two growth periods. One extends from hatching through depletion of the yolk-sac and the other beginning at the onset of active feeding. Increase in length during the first stage is slow but positive compared with a much faster increase during the second stage.

The pattern of growth in body weight differs from that of length. For the first five days after hatching, larval fish actually decrease in weight. This coincides with the period when larvae are dependent on internal food reserves in the yolk. After they begin active feeding, the young fish increase in weight very quickly, growing at almost twice the rate at 82°F as they do at 75°F. In fact young redfish increase in size at an enormous rate, growing to 15,000 times the hatching size in three months.

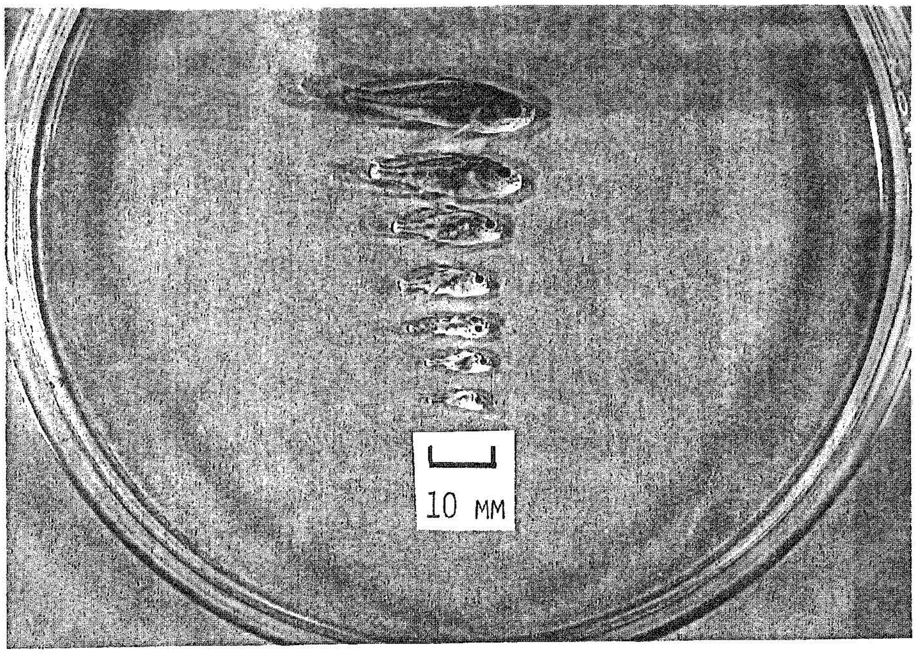
How can young redfish grow at such a phenomenal rate? In the lab we have discovered that this growth is dependent not only on feeding prodigious quantities of food but on providing increasing size of food as the fish grow. Small redfish, eating for the first time, eat very small zooplankton, but in a day or two quickly begin taking larger sizes. Eight to 10 day old fish, feeding on brine shrimp nauplii, can eat up to 100% of their body weight in a day. In nature this very tiny hatching size coupled with an enormous growth rate means the larval redfish must find food quickly or risk starving to death. Unlike adults, fish larvae die quickly when starved and a lack of food at some stage during the first few weeks would be fatal. Identifying feeding requirements has allowed us to successfully raise large numbers of redfish larvae in enclosed, 20 ft. diameter tanks.

During numerous studies we have noted an obvious and persistent size variation in redfish of the same age. There is a strong tendency for fish of the same age, grown under similar environmental conditions to vary greatly in both size and developmental stage. Newly hatched fish do not have fully formed fins, as adult fish do, but as they grow the fins develop in a predictable sequence. The fins enable the fish to maneuver and swim more strongly as they increase in size. Smaller fish are always in an earlier developmental stage than are larger fish of the same age, even though they are grown under similar conditions. If this type of growth and development has a genetic basis then it will have an important application to mariculture and poses some intriguing questions for field ecologists. It may be possible to use this natural variation to select only fast growing fish for mass culture. But the questions remain whether variation occurs in nature and if so, why?

To answer these and many other questions we are conducting field studies of the natural habitat of young red drum. Two basic objectives of this work are to (1) determine spawning time and spawning area for redfish through the collection of eggs and larvae and (2) study the distribution of larval redfish in seagrass meadows (their primary nursery habitat) to learn what influences the survival of young redfish.

Information on how redfish live in nature can aid in designing facilities and experiments in the lab and conversely, lab experiments help field ecologists look for variations (such as temperature or food supply) which might affect survival and growth of natural populations.

Although there has been much speculation over the years about where and when redfish spawn, definitive data were lacking, mainly because red drum eggs and larvae had not been described and could not be identified in field samples. The description of redfish eggs and up to 14-day-old larvae was published in 1981 based on eggs spawned and reared in our lab. We previously published descriptions of speckled trout and red snapper eggs and larvae. The availability of this reference material and the larval fish rearing facilities at our lab was the catalyst to pursue the location of red drum spawning sites.



Young redfish grow 15,000 times the hatching size in three months. Data gleaned from growth studies show redfish of the same age may vary widely in size.

The results of initial investigations verify that redfish spawn over a relatively short period of time. In 1982, no redfish eggs were found until September 15 and none after October 10. Although redfish spawning appeared to be confined to September and October in 1982, environmental conditions (especially water temperature) might cause spawning to occur slightly earlier or later in other years.

Laboratory and field data indicate spawning takes place near dusk, and in 81-86°F water the eggs hatch in about 18 hours. All egg samples were taken between 9:00 and 10:30 in the morning or about 12 hours after spawning. Given an average long shore current speed of 1/4 to 1/2 knot, it is probable that the eggs we captured were spawned within three to five miles of the pass. Findings, however, do not rule out redfish spawning at distances greater than five miles from the pass. More extensive egg sampling will be necessary to determine the total area over which redfish spawn.

Redfish larvae grow at a rate of about 0.5 mm per day and remain in the plankton for eight to ten days, during which time they are transported by tidal currents into the bay. There their habitat requirements change and they switch from living in the water column to living on the bay bottom. We have found that very small redfish (less than 3/4 inches) live almost exclusively in seagrass meadows where they find abundant food (small crustaceans) and protection from predators. Our long term monitoring of larval redfish abundance in the seagrass meadows has shown there are substantial variations in relative abundance from year to year. In 1980 and '81 the maximum abundance of redfish larvae in the seagrass meadows was about eight to ten fish per 10 square meters (m^2) whereas in 1982 maximum abundance reached 32-34 fish per 10 m^2. The causes for this variation in year class strength are unknown. Research on other fishes, especially cod and herring, have shown that a lack of adequate food at critical times, or tidal transport of larvae into unfavorable areas can cause significant year-to-year variation in abundance. Other possibilities, such as unfavorable weather conditions or predation, could periodically reduce the survival of the young recruits. The answer to this and other significant questions await further field and laboratory research.

Dr. C.R. "Connie" Arnold has pioneered research on the artificial propogation of redfish. His research formula is being used at the John Wilson Redfish Hatchery which is currently producing some 10-20 million redfish yearly for stocking in Texas bays—Ed.