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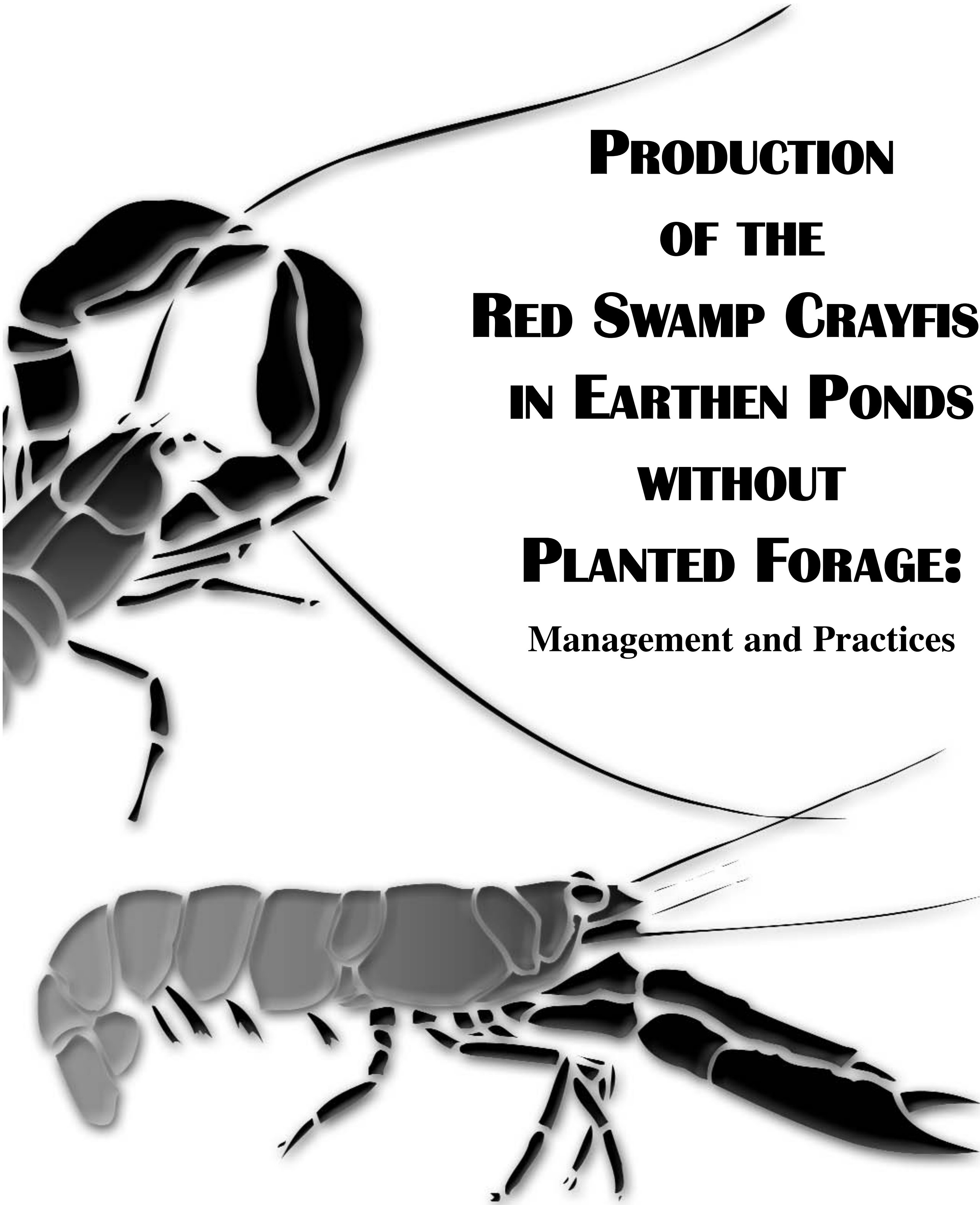
Production of the Red Swamp Crayfish in Earthen Ponds without Planted Forage:

Management and Practices



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Production of the Red Swamp Crayfish in Earthen Ponds without Planted Forage: Management Practices and Economics

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INTRODUCTION

Crayfish farming has been an integral part of the culture of the southeastern United States, particularly in Louisiana. Crayfish farming arose because increases in product demand could not be satisfied by the traditional capture fisheries centered in the Atchafalaya River basin. Thus, the annual crayfish harvest in Louisiana is currently derived from both capture and culture fisheries. The culture fisheries use shallow ponds that are annually drained and refilled. Volunteer, naturally occurring vegetation — or a planted agronomic crop, most often rice — is used as an indirect nutrient resource. After the planting of an agronomic crop, the pond is eventually flooded in preparation for future harvest by trap. This practice takes advantage of the annual cycle of flooding and drying that is characteristic of the natural habitat of crayfish. In the absence of open water, the crayfish burrow on the bottom or along the perimeter of the pond to a depth where water is available to maintain sufficiently moist gills for adequate transfer of oxygen. Under these conditions, crayfish can survive for extended periods of time.

Characteristics of Traditional Culture

Traditional pond culture of crayfish consists of the planting and growth of an agronomic crop, commonly rice, followed by a gradual addition of water (flooding) to a depth between 18 and 24 inches (0.45 and 0.60 meters). After flooding, crayfish emerge from their burrows. The farmer may choose either to harvest the rice (double cropping; i.e., a crop of both rice and crayfish) or to let it stand (set aside; i.e., a crop of crayfish only). After the rice is harvested, regrowth, called ratoon, occurs. After harvest and as air temperatures decrease to freezing, either the ratoon or the unharvested rice dies, and decomposition of the plant matter begins. During decomposition, the plant material serves as a substrate for bacteria and attached algae that are consumed by organisms that, in turn, are food for the crayfish. Crayfish are generally harvested with traps from as early as November, but they are generally harvested January through May. The suspension of harvest, followed by draining, may occur before May, generally in response to a highly successful capture harvest or the need to plant an agronomic crop. When the capture fisheries contribute to a large proportion of the supply of crayfish, then prices often fall below the level at which the culture fisheries can achieve a profit.

Limitations of the Traditional Forage-Based Culture in Earthen Ponds

The success of forage-based culture fisheries has helped to satisfy the increasing consumer demand for crayfish and also to prolong the duration of the season when product is available. However, this approach to crayfish farming has several inherent shortcomings that limit production potential and product availability. The shallow water depth required for the planting of rice or other forage creates potential problems for maintenance of good water quality. The decay of the agronomic crop can produce critically low dissolved oxygen concentrations, particularly at high water temperatures. Dissolved oxygen is rapidly consumed and the amount of oxygen that can be maintained in a particular volume of water decreases as water temperature increases. Another significant problem symptomatic of forage-based systems of crayfish farming is the eventual depletion of the source of food resources, sometimes by March or early April. A combination of depletion of forage and high densities of resident populations of crayfish creates a food shortage. In response to the lack of sufficient food resources or high population densities, crayfish cease to grow — a response called stunting. This results in a crayfish population composed of a large proportion of individuals below market size.

The shallow pond depth associated with a forage-based culture system also limits harvest to a trap or passive method of capture. The presence of the vegetation and shallow water depth preclude any active harvest approach by seining. Seining could provide a rapid and efficient removal (thinning) of excessively dense populations and thus quickly remove the threat of stunting.

Use of planted forage also limits the duration of the growth and harvest period. The pond must be drained and the planted forage crop allowed to grow before the pond can be reflooded. Forage-based systems can also restrict the time of the year when flooding can occur. If flooding occurs during warm water temperatures, accelerated rates of decay will cause the dissolved oxygen in the water to decrease to levels that are stressful and even lethal. Cool water temperatures are less likely to create problems in the management of water quality, but they are not conducive to optimum growth of the red swamp crayfish (*Procambarus clarkii*).

The Alternative — No Planted Forage

A management strategy that does not include the planting of forage offers two significant advantages over the traditional form of crayfish farming. The duration of the harvest and growing season is increased, providing a live crop for a significantly greater period of time when products from the capture and traditional culture fisheries are either not available or available in small quantities. Also, the ability to exercise control over the input of nutrients/food minimizes the incidence of low levels of dissolved oxygen, thus maintaining a high growth rate.

Strategies for Pond Culture Without Planted Forage

Pond Design

Ponds should have an average depth of approximately 4 feet, range in size from 1 to 5 surface acres of water, and have a 3:1 slope from the top of the levee to the pond bottom. A rectangular, raceway design is more amenable to distribution of a formulated diet over the entire surface area of the pond. Such a design also creates a greater perimeter area to volume ratio, a characteristic that is considered beneficial because greater surface area is available for burrowing. This design also increases the area of shallow water that presumably serves as a nursery or sanctuary for juveniles. Juveniles have been observed to congregate in these shallow edges during the evening, possibly to feed or seek refuge from cannibalism.

Initial Stocking and Restocking

Farming begins with the stocking of broodstock that are generally obtained from commercial sources and are assumed to consist of an equal number of males and females (1:1 ratio). Care should be exercised in the selection of broodstock for stocking. Only crayfish that have been harvested within the previous 24 hours should be stocked to reduce the probability of stocking stressed crayfish that may result in significant post-stocking mortality. Broodstock can be stocked from May to July at 75 to 100 pounds per acre (84 to 112 kilograms per hectare [kg/ha]). If sound management practices are followed, then no annual restocking of broodstock is necessary. Young produced from matings within the unharvested population remaining in the pond — i.e., natural recruitment — are sufficient to sustain consistent levels of production from year to year.

Restocking should be conducted if production in a pond is significantly lower than that of all other ponds. Gradual decreases in production over time (25-30% decrease) should also be addressed with a restocking procedure. Unless there is knowledge of extensive mortality, restocking should not occur at initial rates, but rather at a rate directly related to the magnitude of the decrease in production.

Feeds and Feeding Strategies

In the absence of food sources arising from the decomposition of planted forage, a formulated feed, or some combination of organic fertilization and feed, is required. After the initial stocking of broodstock in an established pond, a source of food is not required because the natural foods already in the pond should be sufficient to sustain the population until the first young of the year are produced in mid-fall. If newly constructed ponds are to be used, an organic fertilization procedure (15 pounds per acre, twice per week, of alfalfa hay, corn, or some other inexpensive source of carbon) should commence after filling and continue after stocking to ensure the availability of sufficient natural food. Otherwise, feeding in a newly stocked pond should begin in October.

A pelleted 32% sinking catfish feed or an extruded 30% crude protein, sinking diet of comparable price is recommended. Some portion of the feed stimulates the production of natural foods by serving as a source of nutrition for microorganisms that in turn are food for organisms that crayfish consume. Some feed may also be directly consumed. The greater water stability of extruded diets would presumably afford a greater probability of their being directly consumed. Feeding of crayfish is generally based on an estimate of the biomass (total weight) of the pond population and water temperature. Consumption of food by crayfish increases with increasing temperature and ceases at extremely low temperatures — less than 50°F (10°C) — within its range of tolerance.

Table 1. Recommended daily and monthly feeding rates and percent of total feed fed for each month.

Month	Rate per day	Rate per month	Percent
	lb/A	*lb/A*	
January	0.0	0	0.0
February	0.0	0	0.0
March	12.9	400	7.1
April	25.0	750	13.4
May	31.5	975	17.4
June	30.8	925	16.5
July	22.6	700	12.5
August	14.5	450	8.1
September	13.3	400	7.1
October	14.5	450	8.1
November	12.5	375	6.7
December	5.7	175	3.1
Total		**5,600**	**100.0**

The recommended feeding rates for each month are presented in Table 1. These amounts translate into daily feeding rates that range from 5.6 to 31.5 pounds per acre (6.3 to 35.3 kg/ha). Generally, the best time of day to feed is during the late afternoon in anticipation of increased foraging activity that occurs after sunset. Whether a daily feeding is necessary has yet to be determined. If the number of days per week when feeding occurs is reduced without a change in the total amount fed per week, then labor costs would be reduced. However, this management practice must be approached cautiously because trapping success or water quality may be adversely affected.

The recommended feeding schedule combined with a routine harvest strategy (see harvest section) should result in feed conversion ratios that range from 2.0 to 2.5. However, feed conversion ratios must be interpreted cautiously because a proportion of the nutrients for growth is derived from natural food in the pond. Moreover, some of the diet is consumed by crayfish not harvested during a season. These unharvested crayfish will eventually become mature broodstock and will produce a new crop of juveniles that will be harvested during the following season. Generally, restocking will not be needed if recommended rates of feeding are followed to ensure successful recruitment — production of young crayfish.

Commercially manufactured feed can be supplemented with an organic fertilizer such as cracked corn grain or cottonseed meal based on price considerations. Organic fertilization practices can be beneficial but need to be approached with caution, particularly when pond water temperatures are high. Otherwise, dramatic reductions in dissolved oxygen can occur, leading to conditions that negatively affect growth and may even cause mortality. Soybeans are consumed by red swamp crayfish and are considered to be a good alternative source of a variety of nutrients.

Water Quality

Red swamp crayfish are very tolerant of adverse water-quality conditions. For example, they tolerate levels of dissolved oxygen as low as 0.5 milligrams per liter (mg/L). However, chronically low levels of dissolved oxygen are not conducive to maximum growth. Plans for emergency aeration when levels fall below, or are anticipated to fall below 3 mg/L should be included as part of routine pond management. Most problems with low levels of dissolved oxygen occur from May through August. During this period, saturation levels of oxygen are lower due to higher water temperatures, and the biomass of crayfish using oxygen is the highest. An oxygen meter or some type of analytical test to monitor dissolved oxygen at least once daily is highly recommended. A good time to monitor dissolved oxygen levels is in the early morning just before sunrise. Generally, this is the time when levels are lowest during a 24-hour period. Levels that are chronically low require more frequent monitoring to avoid lethal levels from occurring. Red swamp crayfish usually congregate around the perimeter of the pond when low levels of dissolved oxygen create stressful conditions. Crayfish may react to adverse water-quality conditions in ponds by emigrating to search for better conditions. Low levels of dissolved oxygen can be alleviated through water aeration procedures using PTO-driven paddlewheels or floating electrical aerators that provide 1.0-1.5 horsepower per acre.

A pH range of 7 to 9 should be maintained. Soil of a pond bottom should be treated with lime according to recommended application rates when the pH is below 7. High levels of pH for the water can be reduced through application of either gypsum ($Ca\ SO_4$) or alum ($AlSO_4$). Quantity and use of these compounds will be determined by the desired level and rate of reduction of pH.

Harvest

After the initial stocking of broodstock, harvest can begin in late March or early April of the following year. Generally, harvest is conducted by trap, but seining has also been used. Pyramidal-type traps with a 3/4-inch mesh and three openings are used and can be purchased from commercial suppliers. These traps are similar in design to those used in ponds with planted forage (Figure 1) except that the neck (upper portion) is extended to reach above the surface in the greater depth of water. The top portion of the neck is equipped with a PVC collar to prevent the escape of trapped crayfish. A trap density of 20–25 per acre (49–62 per hectare) is recommended. Formulated bait for use in traps is commercially available and designed to be water-stable. Generally, it is in the form of a cylinder, 3.1 inches (79.6 millimeters) in length, 1.4 inches (35 mm) in diameter, and weighing approximately 4 ounces (115 grams). Generally, each trap is baited with one piece. Dissolution of the bait is temperature-dependent, but it generally persists for at least 48 hours. These baits are not effective at temperatures below 63°F (17°C). Below this water temperature, individual or total weight of crayfish harvested from traps, whether baited or unbaited, is not significantly different. Trap harvest is most effective when the crayfish are most active, generally at temperatures between 63° and 86° F (17° and 30° C).

Baiting and harvest strategies are based on pond water temperature. At temperatures below 63°F, traps are set without any bait and harvested once a week. This

Table 2. Estimated harvest days per month, daily and monthly harvest yields, and the monthly harvest yields expressed as a percent of the total annual yield.

Month	Harvest days per month	Daily yield	Monthly yield	Percent
		lb/A	*lb/A*	
January	1	20.0	20	0.9
February	1	25.0	25	1.1
March	4	26.25	105	4.8
April	10	31.5	315	14.3
May	14	41.1	575	26.1
June	13	38.5	500	22.7
July	13	26.2	340	15.5
August	7	10.0	70	3.2
September	7	12.9	90	4.1
October	5	20.0	100	4.6
November	4	15.0	60	2.7
December	0	0.0	0	0.0
Total	**79**		**2,200**	**100.0**

catch is presumably the result of crayfish seeking refuge provided by the traps. When water temperatures exceed 63°F, traps are baited and harvested three times per week. Soak time, the interval of time between baiting and subsequent harvest, is 24-72 hours. No trapping should be conducted when water temperature falls below 55°F. Trap harvest should be suspended for at least 1 week when the average weekly catch per trap per day — i.e., catch per unit effort (CPUE) — falls below 0.5 pound. In addition, trap harvest should be suspended from August 15 to September 15 when the highest frequency of mating and spawning activity occurs. This time period may vary depending on the latitudinal location of the production ponds. Collectively, this temperature-dependent, trap-harvest strategy generally results in 75 to 90 days of harvest per year. These recommended harvest practices optimize CPUE by reducing labor costs associated with harvesting and baiting, as well as increasing the average individual size (weight) of harvested crayfish.

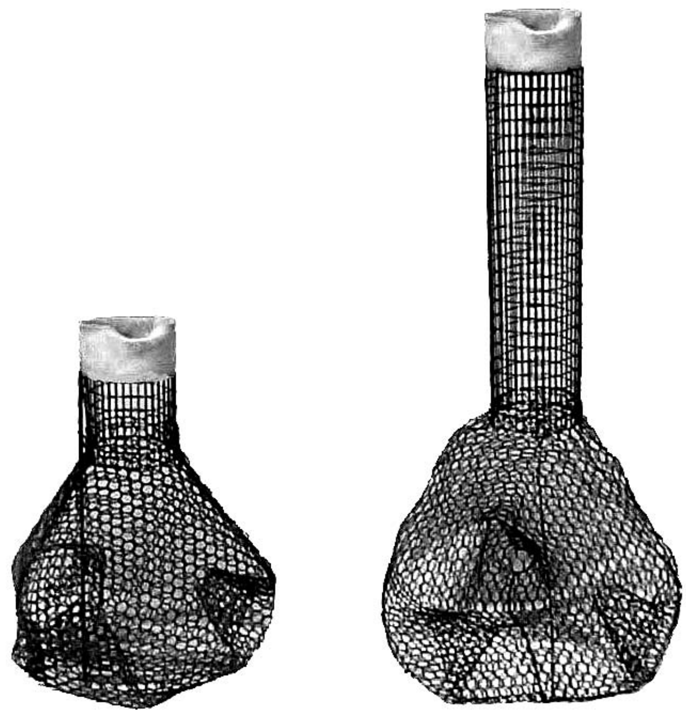

Figure 1. Pyramid traps with three funnel openings used to harvest crayfish. Traps are positioned vertically on the bottom of the pond. Approximately one third of the upper portion of the trap extends beyond the surface of the water. To accommodate the greater mean depth of production ponds without planted forage, the height of the neck portion is increased, as shown in the trap on the right. The trap on the right is designed for use in ponds 3 to 4 feet (0.9 to 1.2 meters) deep.

An examination of the monthly distribution of trap days (Table 2) indicates that approximately 70% of the total trapping days occurs in April through August, inclusive. Monthly yields are the sum of the catch for the number of individual trap days per month. Daily harvest yield is highest during the months of March through July, ranging from approximately 25 to 40 pounds per acre per day (28 to 45 kg/ha per day). From August through February, when conditions are favorable for harvest, the daily yield decreases by approximately 50%, ranging from 10 to 25 pounds per acre per day (11 to 28 kg/ha per day). Higher daily yields for the latter months, when pond water temperatures are generally less than 63°F (17°C), could possibly be achieved through a convenient and effective "cold-water" formulated bait that results in a CPUE significantly higher than that achieved with unbaited traps. Fish have proved to be effective cold-water bait in traditional forage-based farming. However, fish present potential problems related to labor, availability, storage, and the introduction of disease.

Seining is an alternative harvest strategy when pond water temperatures are below 63°F (17°C). However, when this active form of harvest is conducted once a week, the yield relative to what is harvested using unbaited traps is not significantly different. The ability to seine in deeper ponds without planted forage introduces the option of thinning high-density populations as a preventative measure, if needed, to avoid the possible occurrence of small, stunted crayfish due to crowding. Seine harvest will capture recently molted or soft-shell crayfish that do not enter traps. These soft-shell animals are recognized as a value-added product that generally commands a much higher selling price. Soft-shell crayfish can be separated from the other harvested crayfish but are often damaged by seine harvest and must be rapidly processed to preserve the soft-shell condition. The presence of vertical substrate (see substrate section) within the water column of production ponds will preclude seine harvest in that area of the pond.

Expected Annual Yields

Expected annual yield ranges from 1,800 to 2,300 pounds per acre (2,017 to 2,578 kg/ha). The monthly proportional distribution of annual yield is presented in Table 2. A large proportion, approximately 42%, of the annual production is harvested during mid-June through November/December, when crayfish are not available from either the traditional capture (wild populations) or culture fisheries. At this time, the land is either dry or harvestable populations have yet to develop in the newly flooded ponds. Table 3 presents a comparison of mean monthly yields for production ponds with planted forage in southwest and north Louisiana (Boucher and Gillespie 2000) and ponds without planted forage. Individual harvest weight is highest from September through April, ranging from approximately 1 ounce (28 g), or 16 count, to 0.8 ounce (22.4 g), or 20 count. From May through mid-August, when the number of crayfish in the pond is generally the highest, harvest weight decreases and varies slightly around 0.67 ounce (18.8 g), or 24 count.

Table 3. Mean monthly yields of production ponds with planted forage in Louisiana compared with yields in experimental ponds without planted forage.

Month	Southwest LA	North LA	No planted forage
	lb/A	*lb/A*	*lb/A*
January	120	x	20
February	180	x	25
March	240	60	105
April	360	210	315
May	240	240	575
June	x	90	500
July	x	x	340
August	x	x	70
September	x	x	90
October	x	x	100
November	x	x	60
December	x	x	x
Total	**1,140**	**600**	**2,200**

PROCESSING

Harvested crayfish are generally packed into open-mesh vegetable sacks for refrigerated storage and transportation. The crayfish are kept moist during the storage period. In some cases, harvested crayfish are held in tanks filled with water for 24-48 hours to allow "purging" of partially digested food from the intestinal tract before storage. This procedure has a dual effect of increasing the attractiveness of the product to the consumer while also increasing quality for storage and transport. During the purging procedure, some mortality occurs and generally is compensated by an increase in price due to increase in quality.

Crayfish products are marketed either as whole or peeled tails. Whole crayfish are sold either live or frozen. In the past, crayfish were frozen whole in a brine for export. Whole crayfish also have been frozen in fast-freezing systems, and shelf life is between 4 and 6 months for this method of processing. Crayfish must be kept alive before they are processed. Otherwise, the quality of the meat deteriorates due to the release of proteolytic enzymes from the digestive gland. Generally, transfer of live specimens to a country where they are not native is prohibited. Sensory evaluation panels (personal communication, Dr. Juan Silva, Department of Food Science and Technology, Mississippi State University) have been conducted in association with analytical tests of shell rigidity and muscle shear. No significant changes in quality based on harvest time have been detected, except for an increase in shell hardness during mid- to late July and early August. However, this seasonal property of the shell is not considered to be a marketing concern.

The practice of size grading was introduced during the last decade in an attempt to increase net returns by increasing price with increasing size. Generally there are three grades: (1) peeler, less than 21 count, 0.75 ounce (21 g); (2) restaurant, between 21 and 15.5 count, 1.04 ounces (29 g); and (3) export, more than 15.5 count, corresponding to the preferred destination of each of the categories. From April though August, the smallest grade predominates, consisting of 58-73% of the total number harvested. From September through March, the percentage of the smallest grade decreases to 40-50% of those harvested, with 25% being export grade.

Other Management Considerations

Invasion of Production Ponds by Fish

The presence of fish populations in crayfish production ponds will adversely affect production, and the magnitude of the problem is directly related to the number of fish in the pond. Fish detrimentally affect production by competing with crayfish for feed and natural food organisms. Additionally, green sunfish or bullheads of sufficient size will consume crayfish. Application of management practices that prevent or minimize the invasion of fish is therefore necessary to achieve maximum annual production. Small fish caught in crayfish traps or fish observed along the perimeter of the pond are good indicators that a serious problem exists. If large populations of fish are established, then the ponds should be drained for removal of fish. Generally, large fish populations arise from not using an appropriate-sized screen to prevent the introduction of fish and fish eggs if surface water is used to fill the pond. Also, fish may enter through the pond drain during overflows. Pond size can also reduce the potential problem of fish invasion. Ponds of 5 acres or less are less likely to become a depository for fish or fish eggs introduced by birds. Smaller ponds are also easier to manage if a fish invasion does occur.

From mid-August to mid-September, when harvest from production ponds is generally suspended due to low CPUE, ponds can be drained to remove any fish that might have entered. Ponds should be drained approximately 1 foot, followed by a week of no draining, then another reduction of 1 foot, and so on, until the pond is completely drained. This procedure will provide sufficient time for the crayfish to find a place to burrow temporarily into the pond bottom. After removal of fish, the pond should be reflooded immediately. If large populations of fish are present, ponds should be drained to a shallow depth and seined to remove most of the fish. Thereafter, complete draining can occur to remove any remaining fish.

Wildlife Depredation

Bird depredation can contribute to significant losses in traditional shallow ponds with planted forage. However, the actual impact has yet to be documented. Nonetheless, the recommended pond depth and slope for ponds without planted forage should minimize access of wading birds. If vertical substrate (see next section) is used, then access by diving birds, such as pelicans and cormorants, will be impeded. If, despite these practices, bird populations begin to increase around crayfish production ponds, then some procedure to effect dispersal of birds will be necessary.

Mammalian sources of depredation include raccoons, otters, beavers, and muskrats. Management must include careful monitoring for the presence of these animals and a corresponding effort to minimize their impact.

Substrate

The addition of vertically oriented substrate, like plastic mesh fencing, to the water column of ponds can increase annual production by approximately 30%, to 2,200 and 3,000 pounds per acre (2,466 to 3,362 kg/ha). The area of substrate used (mesh included) is equivalent to 50% of the bottom surface area of the pond. Given the presumed life of the substrate and the current cost, incorporating this management practice can be cost-effective. Other, less expensive forms of substrate material could achieve the same results, and design that allows the rapid placement and retrieval is advisable. Substrate can be positioned so that the option to seine can be exercised.

The increase in annual production achieved through the addition of substrate is the result of increases in survival and average individual harvest weight. The substrate apparently is a place for additional food to grow, and it helps to distribute the pond population of crayfish in three, rather than two, dimensions within the pond. The wider distribution of crayfish achieved by the substrate may also reduce the incidence of aggressive encounters, thereby reducing mortality in addition to saving more energy to channel to growth.

ECONOMICS

Economic analyses have incorporated the production results from experimental ponds and estimated operational and fixed costs into different scenarios for production ponds with and without substrate. Prospective crayfish farmers represent a variety of backgrounds and occupations, such as row crop farming, animal husbandry, catfish culture, or very little agricultural background. Therefore, several economic net return scenarios were developed to include a broad range of levels of investment in crayfish farming. The estimated net returns are based on enterprise budgets being developed for a 131.6-water-acre (176-land-acre) crayfish farm consisting of 28 ponds, each 4.7 water acres (6 land acres). Appendix tables provide information on four different required levels of investment (described in this section), equipment requirements, and depreciation and interest estimates. Also included is a sample enterprise budget based on a crayfish selling price of $1.50 per pound.

Table 4 presents the results of a sensitivity analysis of these findings for different crayfish selling prices. Scenario I is based on a situation in which land must be purchased, ponds must be constructed, and all machinery and equipment must be purchased (see appendix tables for specific levels of investment). Net returns for crayfish production ponds containing substrate ranged from -$701 to $121 per acre when all investment for land, equipment, and pond construction were included at crayfish selling prices of $1 or $1.50 per pound. When these investments were included for production ponds without substrate, all net returns were negative.

Scenario II represents a situation in which land is already owned, but ponds must be constructed and all machinery and equipment must be purchased. Net returns for production ponds containing substrate ranged from -$641 to $182 per acre for crayfish selling prices of $1 to $1.50 per pound. For production ponds without

Table 4. Expected per-acre net returns at different levels of investment and crayfish prices for four different scenarios (I-IV).

Selling price	I Purchase of land, machinery	II Purchase of all machinery, no land	III Purchase of some machinery, no land	IV Purchase of no land or machinery, use of existing ponds
$/lb	*$/A*	*$/A*	*$/A*	*$/A*
With substrate				
1.00	-701	-641	-512	-43
1.25	-290	-229	-101	**368**
1.50	**121**	**182**	**310**	**779**
Without substrate				
1.00	-728	-667	-539	-83
1.25	-390	-330	-201	**254**
1.50	-53	**8**	**136**	**592**

substrate, net returns were lower and negative, except for a net return of $8 per acre achieved at the $1.50 selling price.

Scenario III represents a situation in which a farm already exists, land is already owned, and only aquaculture-related equipment and pond construction require additional investment. For this scenario, much of the farm machinery, such as tractors and trucks, are already owned and can be used in the crayfish operation. At this reduced level of investment, net returns for production ponds containing the substrate ranged from -$512 to $310 per acre for selling prices of $1 to $1.50 per pound. At this same range of selling prices, net returns for ponds without substrate ranged from -$539 to $136 per acre.

Scenario IV represents an existing aquaculture operation that devotes some existing water acreage to crayfish production. All land, ponds, machinery and equipment are already owned. Purchase of traps, harvesting equipment, and crayfish for the initial stocking of ponds is necessary. Net returns for production ponds containing substrate ranged from -$43 to $779 per acre for selling prices of $1 to $1.50 per pound. At this investment level, net returns for production ponds without substrate ranged from -$83 to $592 per acre for the same selling prices.

Greater net returns were always realized in production ponds with substrate compared with those without substrate. A selling price of $1.50 always yielded positive net returns for production ponds with substrate. Lower selling prices resulted in negative net returns for at least one of the four investment scenarios considered. The three major operating expenses that comprise 76% of all costs of the crayfish farming enterprise are ranked as feed, labor, and bait. If practices can successfully reduce the costs of any of these three expenses, or greater production can be achieved, then more positive net returns can be realized, even at a price less than $1.50 per pound of crayfish. Selling prices that exceed $1.50 per pound are possible and are influenced by season, size, and market location.

Recommendations

- Pond size should range from 3 to 5 acres (1.2 to 2 hectares), with an average depth of 3.5 feet (1.07 meters), and be rectangular in shape with a length:width ratio of 5:1.

- Initial stocking of 75 to 100 pounds per acre (84 to 112 kg/ha) of mature crayfish can occur from May through July; there is no need to restock each year.

- Feed a pelleted sinking 28% to 30% crude protein catfish feed, possibly in combination with an organic fertilization procedure.

- Do not feed when the water temperature is less than 50°F (less than 10°C).

- Add substrate to the pond in a vertical orientation throughout the water column at a level equivalent to 50% of the bottom surface area of the pond.

- Trap density should be 20 to 25 per acre (50 to 62 per hectare). A pyramid-style, three-funnel trap with an elongated neck is recommended.

- Trap three times each week when water temperature is at least 63°F (17°C); trap once a week when water temperature is less than 63°F but more than 55°F (13°C); trap set should not exceed 72 hours.

- Suspend trapping from August 15 through September 15 and drain ponds, if necessary, to control fish invasion.

- Suspend trap harvest for 1 week when the weekly average catch per trap is less than 0.5 pound per day (0.23 kg per day); i.e., 10 to 12.5 pounds per acre per day (12.1 to 14 kg/ha per day).

APPENDIX

Appendix Table 1. Enterprise budgets for crayfish production scenarios with and without substrate for 131.6-water-acre farm, Mississippi Delta, 2000.

Item	With substrate		No substrate	
	Entire farm	Per acre	Entire farm	Per acre
GROSS RECEIPTS				
Crayfish yield (lb)	289,520	2,200	237,600	1,805
Crawfish sales ($1.50/lb)	434,280	2,468	356,400	2,025
VARIABLE COSTS				
BAIT (for traps) ($)	36,075	205	36,075	205
FEED ($)	78,894	448	78,894	448
LABOR				
Operations management ($)	27,500	156	27,500	156
Hired labor ($)	26,729	152	26,729	152
Crayfish harvesting ($)	12,127	69	12,127	69
SACKS ($)	1,974	11	1,974	11
FUEL				
Mowing ($)	143	1	143	1
Water quality ($)	123	1	123	1
Feeding ($)	196	1	196	1
Electric floating paddlewheels ($)	7,870	45	7,870	45
PTO-driven paddlewheel ($)	1,361	8	1,361	8
Pumping ($)	3,200	18	3,200	18
Transportation ($)	1,007	6	1,007	6
Trap harvesting ($)	492	3	492	3
REPAIRS AND MAINTENANCE				
Vegetative cover ($)	1,120	6	1,120	6
Water supply (well, pump, motor, and outlet pipe) ($)	1,888	11	1,888	11
Feeding (truck, feeder with electronic scales and storage) ($)	1,448	8	1,448	8
Water quality equipment ($)	141	1	141	1
Harvesting equipment ($)				
Boat, motor, and trailer ($)	732	4	732	4
Traps ($)	521	3	521	3
Substrate ($)	1,467	8	0	0
Electrical (starter panels, service stand, meters, and cables) ($)	104	1	104	1
Miscellaneous equipment ($)	12,280	70	12,280	70
LIABILITY INSURANCE ($)	5,400	31	5,400	31
HAULING CRAYFISH ($)	2,895	16	2,895	16
INTEREST ON OPERATING COSTS[1] ($)	11,284	64	11,211	64
SUBTOTAL OF VARIABLE COSTS ($)	**236,972**	**1,346**	**235,431**	**1,338**
INCOME ABOVE VARIABLE COSTS ($)	**197,308**	**1,121**	**120,969**	**687**
FIXED COSTS (land, pond construction, and all machinery)				
DEPRECIATION ($)	81,993	466	60,077	341
INTEREST ON INVESTMENT ($)	89,752	510	65,951	375
TAXES AND INSURANCE ($)	4,214	24	4,214	24
SUBTOTAL Of FIXED EXPENSES ($)	**175,959**	**1,000**	**130,241**	**740**
TOTAL COSTS ($)	**412,931**	**2,346**	**365,672**	**2,078**
NET RETURN ABOVE ALL SPECIFIED EXPENSES ($)	**21,349**	**121**	**-9,272**	**-53**

[1]Interest charged for 6 months at 10% per year.

Appendix Table 2A. Estimated investment requirement for crayfish production with substrate addition and different levels of investment for a 131.6-water-acre farm.

Item	Investment requirement for scenario			
	I Pond construction all machinery all land	II Pond construction all machinery no land	III Pond construction some machinery no land	IV Existing ponds no machinery no land
	$	*$*	*$*	*$*
LAND[1]	**140,800**	**0**	**0**	**0**
POND CONSTRUCTION				
Earth moving	274,050	274,050	274,050	0
Piping and Fixtures	15,750	15,750	15,750	0
Gravel	69,315	69,315	69,315	0
Vegetative cover	1,403	1,403	1,403	0
Total pond construction	**360,518**	**360,518**	**360,518**	**0**
SUBSTRATE				
Plastic mesh fencing, plastic twine, and rebar	**328,752**	**328,752**	**328,752**	**328,752**
WATER SUPPLY				
Well, pump, motor, and outlet pipe	**109,848**	**109,848**	**109,848**	**0**
FEEDING EQUIPMENT				
Used truck (3/4 ton, 4x4, feeding)	5,250	5,250	0	0
2,000-lb truck-mounted feeder	7,100	7,100	7,100	0
Electronic scales/printer	4,000	4,000	4,000	0
Bulk storage	1,800	1,800	1,800	0
Total feeding equipment	**18,150**	**18,150**	**12,900**	**0**
MISCELLANEOUS EQUIPMENT[2]	**177,222**	**177,222**	**70,272**	**0**
HARVESTING EQUIPMENT				
Traps	15,792	15,792	15,792	15,792
Boat (14-ft, 42-in bottom)	3,200	3,200	3,200	3,200
Outboard motors (15 hp, 4-cycle)	3,730	3,730	3,730	3,730
Boat trailers (14-in wheels)	1,300	1,300	1,300	1,300
Total harvesting equipment	**24,022**	**24,022**	**24,022**	**24,022**
STOCK[3]	**31,584**	**31,584**	**31,584**	**31,584**
ELECTRICAL				
Starter panel, service stand, meter, and cable	**15,630**	**15,630**	**15,630**	**0**
TOTAL INVESTMENT	**1,206,526**	**1,065,726**	**953,526**	**384,358**
INVESTMENT PER WATER SURFACE ACRE	**9,168**	**8,098**	**7,246**	**2,921**
INVESTMENT PER LAND ACRE	**6,855**	**6,055**	**5,418**	**2,184**

[1]Valued at $800 per acre.
[2]A detailed description of miscellaneous equipment is presented in Appendix Table 3.
[3]100 lb/acre.

Appendix Table 2B. Estimated investment requirement for crayfish production with no substrate and different levels of investment for a 131.6-water-acre farm.

Item	Investment requirement for scenario			
	I Pond construction all machinery all land	II Pond construction all machinery no land	III Pond construction some machinery no land	IV Existing ponds no machinery no land
	$	*$*	*$*	*$*
LAND[1]	**140,800**	**0**	**0**	**0**
POND CONSTRUCTION				
Earth moving	274,050	274,050	274,050	0
Piping and fixtures	15,750	15,750	15,750	0
Gravel	69,315	69,315	69,315	0
Vegetative cover	1,403	1,403	1,403	0
Total pond construction	**360,518**	**360,518**	**360,518**	**0**
SUBSTRATE				
Plastic mesh fencing, plastic twine, and rebar	**0**	**0**	**0**	**0**
WATER SUPPLY				
Well, pump, motor, and outlet pipe	**109,848**	**109,848**	**109,848**	**0**
FEEDING EQUIPMENT				
Used truck (3/4 ton, 4x4, feeding)	5,250	5,250	0	0
2,000-lb truck-mounted feeder	7,100	7,100	7,100	0
Electronic scales/printer	4,000	4,000	4,000	0
Bulk storage	1,800	1,800	1,800	0
Total feeding equipment	**18,150**	**18,150**	**12,900**	**0**
MISCELLANEOUS EQUIPMENT[2]	**177,222**	**177,222**	**70,272**	**0**
HARVESTING EQUIPMENT				
Traps	15,792	15,792	15,792	15,792
Boats (14-ft, 42-in bottom)	3,200	3,200	3,200	3,200
Outboard motors (15 hp, 4-cycle)	3,730	3,730	3,730	3,730
Boat trailers (14-in wheels)	1,300	1,300	1,300	1,300
Total harvesting equipment	**24,022**	**24,022**	**24,022**	**24,022**
STOCK[3]	**31,584**	**31,584**	**31,584**	**31,584**
ELECTRICAL				
Starter panel, service stand, meter, and cable	**15,630**	**15,630**	**15,630**	**0**
TOTAL INVESTMENT	**877,774**	**736,974**	**624,774**	**55,606**
INVESTMENT PER WATER SURFACE ACRE	**6,670**	**5,600**	**4,748**	**423**
INVESTMENT PER LAND ACRE	**4,987**	**4,187**	**3,550**	**316**

[1]Valued at $800 per acre.
[2]A detailed description of miscellaneous equipment is presented in Appendix Table 3.
[3]100 lb/acre.

Appendix Table 3. Estimated miscellaneous equipment investment requirements for a crayfish production system without planted forage, Mississippi Delta, 2001.

Miscellaneous equipment	Farm and aquaculture machinery	Aquaculture only machinery	Depreciation for all equip.	Depreciation for all aquaculture equip. only
	$	$	$	$
Tractor (56-80 hp new)	25,000	0	3,571	0
Tractor (56-80 hp used)	12,500	0	1,786	0
Truck (1/2 ton new, 4x4)	20,000	0	2,857	0
Truck (1/2 ton used, 4x4)	10,000	0	1,429	0
Service building with office and bath (20 ft x 40 ft)	27,000	0	1,350	0
Office equipment	1,000	0	200	0
Computer with printer	1,000	0	200	0
Telephone	50	0	10	0
Farm/shop equipment	6,000	0	857	0
Oxygen meter[1]	2,036	2,036	407	407
Oxygen meter membrane and KCL kit	36	36	12	12
pH meter[2]	320	320	64	64
pH meter buffer solution	24	24	8	8
Paddlewheels				
Electric floating (3 hp/4.7 water acres)	59,416	59,416	8,488	8,488
Portable PTO-Driven (10-in)	7,900	7,900	1,129	1,129
6-foot side-mount mower	4,400		880	
Waders	440	440	147	147
Hip boots	100	100	33	33
TOTAL	**177,222**	**70,272**	**23,428**	**10,288**

[1]Includes meter, 25 feet of cable, and probe.
[2]Includes meter, 13 feet of cable, and probe.

Appendix Table 4A. Estimated annual ownership costs (depreciation, interest, taxes, and insurance) for crayfish production with substrate.

Item	Investment requirement for scenario (with substrate)			
	I Pond construction all machinery all land	II Pond construction all machinery no land	III Pond construction some machinery no land	IV Existing ponds no machinery no land
	$	*$*	*$*	*$*
DEPRECIATION [1]				
Ponds	18,026	18,026	18,026	0
Water supply (wells, pumps, motors, and outlet pipes)	5,492	5,492	5,492	0
Feeding (truck, feeder with electronic scales, and storage)	3,630	3,630	2,580	0
Harvesting equipment (boat, motor, trailer, and traps)	2,402	2,402	2,402	0
Substrate	21,917	21,917	21,917	21,917
Stock	6,317	6,317	6,317	6,317
Electrical (starter panels, service stand, meters, and cables)	782	782	782	0
Miscellaneous equipment	23,428	23,428	10,288	0
Subtotal	**81,993**	**81,993**	**67,803**	**28,234**
INTEREST ON INVESTMENT [2]				
Land	10,641	0	0	0
Pond construction	27,246	27,246	27,246	0
Water supply (wells, pumps, motors, and outlet pipes)	8,302	8,302	8,302	0
Feeding (truck, feeder with electronic scales, and storage)	1,281	1,281	910	0
Harvesting equipment (boat, motor, trailer, and traps)	1,677	1,677	1,677	1,677
Substrate	23,801	23,801	23,801	23,801
Stock	2,229	2,229	2,229	2,229
Electrical (starter panels, service stand, meters, and cables)	1,181	1,181	1,181	0
Miscellaneous equipment	13,394	13,394	5,311	0
Subtotal	**89,752**	**79,111**	**70,658**	**27,707**
TAXES AND INSURANCE	**4,214**	**4,214**	**4,214**	**4,214**
TOTAL	**175,959**	**165,318**	**142,675**	**60,154**

[1]Computed by the straight line method with zero salvage value.
[2]Average interest on investment was computed using an 11% interest rate over the life of the loan divided by the length of the loan life.

Appendix Table 4B. Estimated annual ownership costs (depreciation, interest, taxes, and insurance) for crayfish production without substrate.

Item	Investment requirement for scenario (without substrate)			
	I Pond construction all machinery all land	II Pond construction all machinery no land	III Pond construction some machinery no land	IV Existing ponds no machinery no land
	$	*$*	*$*	*$*
DEPRECIATION [1]				
Ponds	18,026	18,026	18,026	0
Water supply (wells, pumps, motors, and outlet pipes)	5,492	5,492	5,492	0
Feeding (truck, feeder with electronic scales, and storage)	3,630	3,630	2,580	0
Harvesting equipment (boat, motor, trailer, and traps)	2,402	2,402	2,402	2,402
Substrate	0	0	0	0
Stock	6,317	6,317	6,317	6,317
Electrical (starter panels, service stand, meters, and cables)	782	782	782	0
Miscellaneous equipment	23,428	23,428	10,288	0
Subtotal	**60,077**	**60,077**	**45,887**	**8,719**
INTEREST ON INVESTMENT [2]				
Land	10,641	0	0	0
Pond construction	27,246	27,246	27,246	0
Water supply (wells, pumps, motors, and outlet pipes)	8,302	8,302	8,302	0
Feeding (truck, feeder with electronic scales, and storage)	1,281	1,281	910	0
Harvesting equipment (boat, motor, trailer, and traps)	1,677	1,677	1,677	1,677
Substrate	0	0	0	0
Stock	2,229	2,229	2,229	2,229
Electrical (starter panels, service stand, meters, and cables)	1,181	1,181	1,181	0
Miscellaneous equipment	13,394	13,394	5,311	0
Subtotal	**65,951**	**55,310**	**46,856**	**3,906**
TAXES AND INSURANCE	**4,214**	**4,214**	**4,214**	**4,214**
TOTAL	**130,241**	**119,600**	**96,957**	**16,839**

[1]Computed by the straight line method with zero salvage value.
[2]Average interest on investment was computed using an 11% interest rate over the life of the loan divided by the length of the loan life.

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