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DE84 000435

USE OF SOLAR ENERGY IN THE
PRODUCTION OF CHANNEL CATFISH

Final Report

K-64

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Research project funded by the U.S. Department of Energy under the Appropriate
Technology Small Grants Program. Grant No. DE-FG4480R410313.000.

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Summary

No catfish are grown commercially in eastern Kentucky due primarily to a growing season approximately three weeks too short to provide the minimum 180 day feeding season. This research project was designed to test the feasibility of using solar energy to heat pond water enough to lengthen the feeding season the required number of days. The procedure involved the heating of a small starter pond by covering it with a solar swimming pool cover. Fingerling catfish were stocked in the small pond in early April and transferred to a larger rearing pond in May when water temperatures in the larger pond reached 65° F.

Oxygen levels were maintained at acceptable levels in the covered pond by frequent aeration. Water quality resulting from a prolonged spring drought and run-off from a pasture fertilized by chicken manure seriously affected the project.

Other significant problems encountered included algae build-up and the accumulation ammonia and carbon dioxide in the water. Losses to fungus infection was the most serious problem encountered. Approximately 30 percent of the fingerlings died from this cause while in the small covered pond.

After the fish were transferred to the large rearing pond, no further unanticipated problems were encountered. From the time the fish were transferred to the large pond they were handled in a typical open pond operation. At the end of the growing season in October, the fish had an average weight of 1.4 pounds.

Introduction

During the 1960's and 1970's commercial catfish farming developed into a significant industry in the upper Mississippi delta, and a number of other places in Southeastern United States. Commercial production in Kentucky has been successful only in a few southwestern counties and in those counties most operation have been marginal and tenuous.

Channel Catfish (*ictalurus punctatus*) are indigeneous to the larger streams and reservoirs throughout the state and are generally regarded highly as food fish by many of the residents. They are also a popular item in pay lakes throughout the state. Most of the Channel Catfish sold in the markets or used to stock pay lakes are transported from farms in Arkansas and Mississippi at considerable expenditure of energy.

In the Appalachian portion of Kentucky no channel catfish are grown commercially. Although hundreds of farm ponds are stocked with the fish none are produced as a farm coop. The few attempts at commercial production have been economic failures.

Three environmental problems combine to make commercial production of fish by open pond or raceway methods uneconomical. These include inadequate water supplies, few good pond sites, and a growing season too short to consistently produce a marketable fish in a single growing season. The most significant of these is the short growing season.

Research and experience have shown that 180 feeding days is the approximate minimum time required to produce a marketable channel catfish from average size fingerlings (4 to 6 inches). Channel catfish convert food efficiently when water temperatures are above 60° fahrenheit. It has been well documented that a growing season of approximately 210 days is necessary in order to have the minimum number of feeding days.

In eastern Kentucky, water temperatures in open ponds normally reach optimum feeding temperatures about the first week in May and fall below 60° about October 5. This period is approximately 3 weeks short of the minimum growing season for a commercial operation.

Although water supplies and water quality are less than optimal, thousands of private ponds and small lakes in eastern Kentucky could be modified for fish production if the growing season were long enough. This project was designed to test the feasibility of using solar energy to increase the length of the feeding season.

Solar covers are used successfully to extend the effective swimming season by warming the water in the pond. A floating solar cover warms a pond in two ways: (1) by reducing evaporation from the surface and retarding night-time heat loss, and (2) by absorbing and retaining some of the solar radiation that strikes the surface. This research effort was designed to test the feasibility of using a similar cover to warm water in a catfish pond sufficiently to start fingerling catfish feeding approximately three weeks before temperatures are sufficiently warm in an open pond. Since it was deemed impractical to cover enough of the surface of a large rearing pond to significantly alter the temperature, this research plan was to construct two ponds in close proximity -- a large rearing pond and much smaller starting pond that was to be warmed by a solar cover. (See Figure 1). The fingerling catfish were to be stocked in the small covered pond and fed for approximately three weeks until temperatures in the large rearing pond reached 60° fahrenheit. At that time the fish were to be transferred to the larger pond and managed in a traditional open pond culture until the end of the growing season.

Figure 1.

It was anticipated that problems of oxygen deficiency and ammonia and/or CO² build-up might be encountered since the solar cover would hinder normal exchange of gasses between the water and the atmosphere. To take care of this possibility an aeration system was planned. (See Figure 2).

Procedures Followed

In an effort to duplicate conditions that would be encountered on a typical hill-country farm, the decision was made at the beginning of the project to use an existing pond supplied only with run-off water as the main rearing pond. A stock-watering pond was "borrowed" from Morehead State University. Renovation of the pond was necessary to make it suitable for use in the project.

At this point the local office of the U.S. Soil Conservation Service was enlisted to help in the design of the ponds. Due to unusually wet, cold weather in November, 1981, work on the ponds was delayed beyond the planned starting date. During the first week in December the existing pond was drained and the small pond was dug. Because of a deep accumulation of sludge, further work on the large pond was delayed until the bottom dried out sufficiently to permit a bull dozer to operate in the pond. In late March, work on the large pond was completed.

Three unexpected problems developed at this point which were to have a negative impact on the project. The subsoil under the small pond contained enough gravel to cause a serious seepage problem. This was partially solved by lining the bottom and sides with plastic. The second problem was totally unanticipated and constituted a more serious problem. During the early spring, the pasture land upslope from the two ponds was heavily fertilized by chicken manure from the university's broiler operation. Since the only source of water available to the project was run-off water from the pasture, poor water quality plagued the project from that point onward.

Figure 2.

The third problem, an unusually dry period in late winter and spring, compounded the difficulties presented by the first two. No significant precipitation occurred during March and early April. At the time when the large pond should have been full of water, it had almost no water at all. Since the original plan had been to keep the small pond filled by pumping water from the large pond, a new source of water had to be found. A deep sump was dug adjacent to the small pond and water from this was used to fill the small pond. However, this water was contaminated by chicken manure from the pasture and resulted in rapid algae growth.

During the last week of March, the small pond was pumped dry, the bottom was lined with four mil plastic, and the pond was refilled with fresh water.

On April 3rd the solar cover was installed and the aereator was put in place. The solar cover used in the project was a standard floating swimming pool cover made of translucent bubble plastic. This type of cover can be purchased at any outlet selling swimming pools and supplies. The spring of 1981, was unusually warm for eastern Kentucky. At the time the solar cover was installed, the surface water temperatures was 54° F, several degrees above normal temperature for that date.

On April 4th, 366 large fingerling catfish (6") were stocked in the small pond. The fingerlings had been transported from Dumas, Arkansas, by tank truck. Many of them had injuries from handling and hauling in close confinement. Injuries ranged from minor scrapes and scratches to serious puncture wounds. Before stocking in the pond, the fingerlings were treated in a solution of salt and methylene blue to ensure that they were free of fungi and ich and to facilitate healing of injuries sustained in transit.

Water temperatures in the small pond increased rapidly, reaching 60° Fahrenheit on the afternoon of April 6. Weather conditions during the second week in April were unusually hot and humid with afternoon readings reaching

the low 80's and night temperatures of about 60°. Water temperature in the covered pond reached 72° F on April 8. On April 12, the night temperature fell to 33°F and at 7:00 a.m. on April 13, the temperature in the covered pond had dropped to 58°F. This was the only time during April that the temperature under the solar cover dropped below 60°F. Water temperatures were checked twice daily throughout the study period. During the four weeks the fingerling catfish were kept in the small pond with the cover in place the temperature of the water averaged 4°F higher than the temperature in open ponds nearby. The greatest difference was in the morning readings indicating that the cover was more effective in retaining heat at night than it was in the actual heating of the water during the day.

A factor that hindered the heating of the small pond was the loss of water from seepage. To maintain water at a constant level in the pond, approximately 50 cubic feet of water had to be added each day. The additional water was always at least four degrees fahrenheit cooler than the pond water and sometimes as much as seven degrees cooler. Frequent aeration of the pond to maintain oxygen content at safe levels contributed to water loss and also to cooling the pond due to increased evaporation.

As previously noted the fish were carefully inspected for injury and diseases before stocking. As a precaution, all the fingerlings were treated in a solution of sodium chloride and methylene blue before being released in the small pond. During the four weeks the fish were kept under the solar cover, the pond was carefully checked to insure that a suitable environment was maintained. Dead fish were promptly removed, temperature and oxygen content were checked at least twice daily, and the pond was aerated when necessary.

At the end of the first week a heavy algae build-up was evident. It could not be determined if this was a result of nutrient enrichment from

fish food and excrement from the fish or from the chicken manure that was fertilizing the water supply. Most likely it was a combination of both factors. To control the algae, one-half pound of algaecide was added to the water at the beginning of the second and fourth weeks.

Since 90% of the pond surface was covered by a floating cover, very little exchange with the atmosphere was possible. In order to maintain oxygen at acceptable levels and reduce the build-up of nitrogen and carbon dioxide in the water, it was necessary to aerate the pond frequently. Aeration was accomplished by lifting water from the pond with a gasoline powered pump, spraying it against a baffle and allowing it to fall back into the pond from a height of six feet. The pump delivered 55 gallons of water per minute. Water was drawn from one end of the pond and returned at the other end. At six hour intervals around the clock, the pond was aerated for two hours. Approximately 12,000 gallons of water were pumped each time the pond was aerated.

Only once during the four weeks were the fish under stress because of oxygen deficiency. On the seventeenth day of the experiment, pump failure resulted in a twenty-four hour period without aeration. During this period the cover was removed from the surface, but oxygen levels dropped to dangerous levels. Although no fish died directly as a result of this, the oxygen content was reduced to the point that many of the fingerlings were surfacing to obtain oxygen from the water surface. This is an indication that oxygen levels are becoming critical.

The fish were fed each day at 5:00 p.m. A high protein, floating catfish made by Ralston-Purina Company was used throughout the life of the project. Floating food was used in order to determine the amount of food being consumed and to prevent the accumulation of uneaten food in the pond which could have

contributed to the problem of nutrient build-up in the heavily stocked small pond.

At the beginning of the project one of the questions that needed to be answered was whether or not a healthy fish population could be maintained in a densely populated pond in which most of the surface was covered with a floating solar cover.

Everything went as planned during the first week except for the rapid growth of algae. Only three fingerlings died and these were seriously injured. On April 14, the tenth day of the project, the first indication of a serious health problem in the fish population became evident. Four fingerlings were observed on the surface with patches of fungi on their fins and backs. These were removed and inspected carefully. All were fish that had been injured in shipment and their injuries had become infected. From that point until the fish were transferred to the large rearing pond on May 9, fingerlings died each day apparently with the same ailment. Losses ranged from two to nine per day. Total counted losses amounted to 97 or almost 27% of the initial population.

It was impossible to determine the exact cause of this rather heavy loss of fish. Although every effort was made to maintain optimum conditions in the pond, poor water quality was a major problem throughout this phase of the project. Through the entire month of April, a severe drought contributed to a continuing decline in the quality of water pumped into the small covered pond. This was an uncontrollable variable since no other water was available. The solar cover was removed from the pond on May 2.

A major rain occurred during the first week in May and provided enough runoff to fill the larger rearing pond. On May 9, the surviving healthy fingerlings were transferred to the larger pond to be reared by conventional open pond culture methods. Approximately 260 young catfish were stocked in the larger pond.

From May 9, to October 4, the fish were fed daily at approximately 6:00 p.m., and the shoreline was carefully checked each morning and afternoon for diseased or dead fish. Attrition was normal during this five month period. Twenty-three additional fish were found dead, most of them during the first two weeks after the transfer from the small pond. No further fungi were observed on the fish living or dead.

Chicken manure from the runoff area continued to cause problems with water quality. Twice during the summer in late June and in mid-August, the rearing pond had to be treated with an algaecide to reduce a heavy algae bloom.

As water temperatures declined in late September, feeding activity fell off and all but stopped by October 4, when the surface temperature fell to 56°F. Feeding was terminated at this point.

On September 28, the pond was seined to obtain a sample for weighing. Thirty-seven fish were trapped, weighed and released. They ranged in size from just over 3/4 lb. to 2 1/4 lbs. with an average weight of 1.4 lbs. Most of them were well within marketable weights.

Problems Encountered

Seven significant problems developed that had an impact on the outcome of the project. Three of these have been previously mentioned but are repeated for emphasis.

1. Water Quality. The most serious problem involved water quality.

Since the only source of water was surface runoff, some difficulty was anticipated. However, the problem created by a heavy application of chicken manure to the drainage area seriously jeopardized the project and probably contributed substantially to the unacceptably high loss of fish (approximately 1/3 of the total population died). Since the ponds were on "borrowed" land, we had no control over this problem.

3. Difficulty in obtaining Fingerlings. Originally the plan had been to purchase fingerlings from a fish farmer in Shelbyville, Kentucky. Due to death of the owner, the farm ceased operations in the autumn of 1980. Locating an alternate supply proved difficult and expensive. A severe drought in the Delta during the fall and winter of 1980 combined with a severely cold winter drastically reduced the supply of fingerlings in the spring of 1981. Fingerlings were purchased in Dumas, Arkansas, and transported by truck to Morehead, Kentucky. Because of the shortage of fingerlings it was necessary to accept fingerlings that were somewhat larger than planned. The long truck haul resulted in numerous injuries to the young fish. These injuries afforded places where infections could begin and probably contributed to the heavy loss of fingerlings in the small solar pond.
4. Inadequate Water Supply. Not only was the water quality below optimum level due to drought and contamination, but the amount of water available during late spring presented a serious challenge to the continuation of the experiment. Only by digging a deep sump near the small pond could enough water be obtained to keep the solar pond filled during the most crucial period.
5. Depletion of Oxygen. The solar cover prevented a normal exchange of gases between atmosphere and the pond surface. Frequent aeration was necessary to add oxygen to the water and to help reduce the build-up of carbon dioxide and ammonia in the water and under the cover. The heavy algae growth that resulted from fecal matter from the fish, unconsumed food, and nutrients in the run-off water used to fill the pond necessitated the use of an algacide to kill off the algae bloom. This also contributed to the need for aeration. A bio-filter built into the system would probably have reduced some of these difficulties.

6. Fungi Infection. Although precautions were taken to insure that the fingerlings stocked in the solar pond were free of diseases and infections, the growth of fungi on the fish became a serious problem that destroyed almost one-third of the fingerlings in the pond. The most susceptible fingerlings were those with scrapes or abrasions on their skin or damage to tails, fins, or spines.
7. Water Seepage. Loss of water from the small pond due to seepage required the daily replacement of approximately fifty cubic feet of water. This decreased the efficiency of the solar cover by the frequent addition of cooler water.

Conclusions

The results of this project present a mixed and somewhat inconclusive picture. However, several conclusions can be drawn that may prove useful or instructive to researchers and/or fish farmers.

1. A solar cover is capable of raising water temperatures in a small, shallow pond sufficiently to lengthen the feeding season by approximately two weeks at the beginning of the season.
2. An adequate and reliable water supply is the first requirement of any successful fish farming operation. This must be from a perennial spring, stream, or well. Run-off water is too unreliable both in amount and quality.
3. Continuous aeration is essential to maintain optimum or even minimum oxygen levels in a covered pond stocked heavily enough with fingerlings to make the project worthwhile.
4. A source of electricity at the site is necessary. Only electric powered aerators are reliable enough and economical enough to be used. A gasoline powered pump is too expensive and time consuming and too prone to failure to be used.

5. A biofilter is probably an absolute requirement to maintain the health of a dense population of fingerlings in a covered, heated pond environment. A closed loop or modified raceway system could be the answer.
6. Run-off water enriched by chicken manure is an excellent mixture for growing blue-green algae and fungi but is unsatisfactory for maintaining a healthy fish population.
7. It is possible using this method to produce a channel catfish of marketable size in a single growing season in the Appalachian portion of Kentucky, but probably not profitably due to losses and the necessarily small scale of such an operation.
8. Further experimentation is necessary to determine if the problem of fish dying from fungus infections was a result of the contaminants in the run-off water used in the project or from the build-up of waste in the water resulting from uneaten food and fecal matter.
9. It appears unlikely that this experimental method of fish production can successfully compete with the open pond culture of catfish in the Delta and other areas of long growing seasons and abundant water supplies.

Recommendations

1. Further experimentation is necessary before this method should be attempted on a commercial scale.
2. No commercial venture in fish farming should be attempted unless a dependable supply of high quality water is available.
3. A bio-filter should be used when a large density of fish is maintained in a small volume of water.

4. An air space between a solar cover and the pond surface would probably be useful. Raising fingerlings in a greenhouse environment should be tried as an alternative.
5. This is a high risk technique and no one should invest money in it that he/she cannot afford to lose.
6. For any farmer in eastern Kentucky interested in producing channel catfish, the following procedure could be used: two ponds, one small, and one large should be used. The first year the small pond should be stocked with a large population of catfish fry or small fingerlings and fed a balanced fish food. At the end of the growing season when they are approximately six inches in length, they should be transferred to the larger pond and stocked at a density of 2,000 per surface acre. The second year they could be intensively fed and grown to marketable size. A marketable fish could be produced annually without the risk and expense of a solar cover. Small pond size and limited water supplies limit this to a hobby or at best a sideline operation.

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