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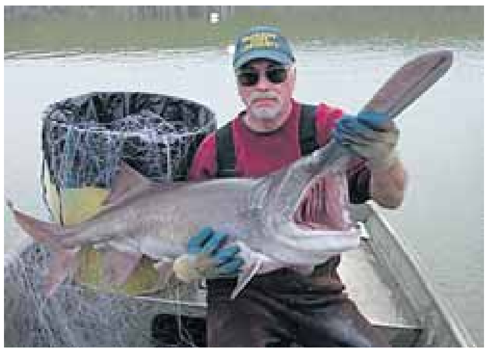

Rick Onders with a mature, wild-caught paddlefish.

Culturing Paddlefish Fingerlings at Kentucky Wastewater Treatment Plant

BY STEVEN MIMS, RICHARD J. ONDERS AND TIMOTHY PARROTT

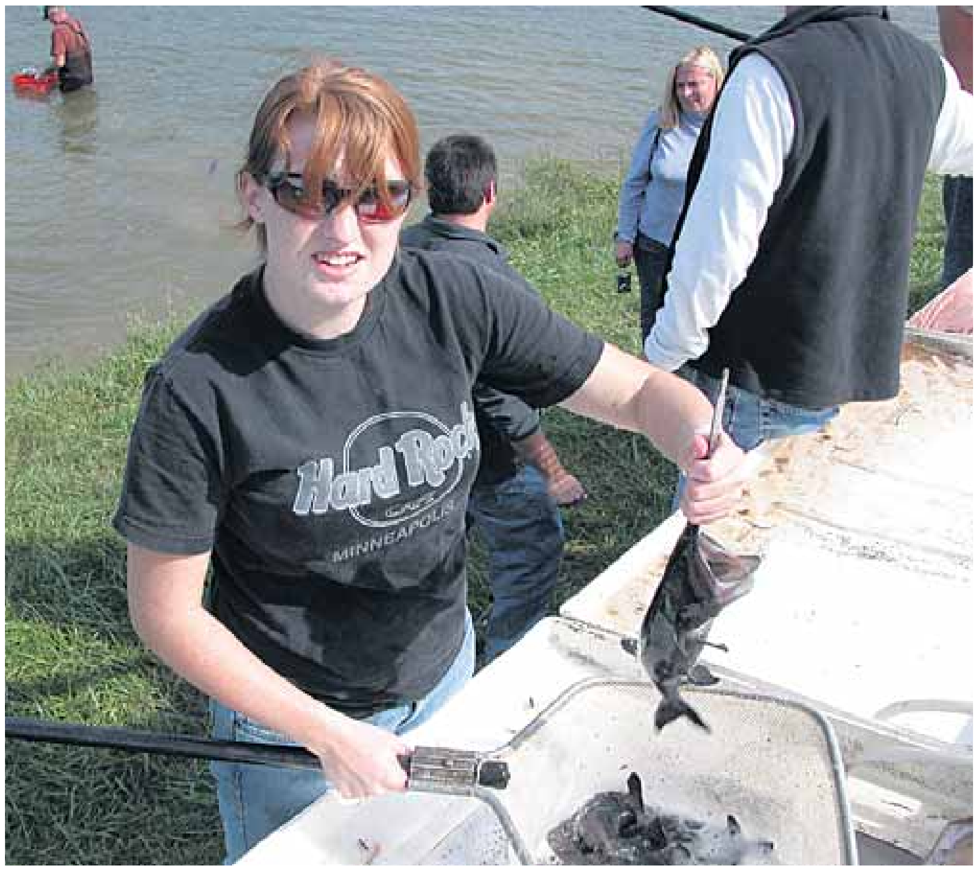
Aquaculture is "the world's fastest growing food producing sector" according to the United Nation's Food and Agriculture Organization, and nearly half of the food fish consumed in the world are now grown rather than captured in the wild. This trend will likely continue since it is predicted that by 2030, an additional 40 million metric tons of aquatic food will be required just to maintain current consumption levels. The only option is aquaculture.

However, some potential bottlenecks to large scale production include the high cost of capital investment compounded with a lack of interest by investors, shortage of land and freshwater, increasing demand and competition for price and availability of fish meal (a limited resource), rising energy costs, and environmental impacts. Recognizing these concerns, the aquaculture industry must seek alternative species and production strategies consistent with goals for sustainable development.

One such species suitable for US growers is the paddlefish *Polyodon spathula*, because of its filter feeding capabilities that enable it to grow in existing water bodies.

Paddlefish are valued for their white boneless meat and highly prized black roe (caviar). They are native only to the Mississippi River basin and adjacent Gulf drainages of the United States. Paddlefish grow rapidly especially under lake conditions where zooplankton is plentiful. (See *Hatchery International*, Vol. 2/1, January, 2001; Vol. 5-4, July 2004)

Two production strategies, polyculture with channel catfish, and reservoir ranching, rely on stocking phase II fingerlings that are 35 cm long and weigh 150-250 g (see www.sare.org/publications/factsheet/0705.htm for more information.) Stocking paddlefish with channel catfish is a suitable method for producing meat without incurring additional feed costs. Reservoir ranching is suitable for producing both meat and caviar. Paddlefish filter out natural foods and grow until reaching sexual maturity in 8-12 years. The main bottleneck for both systems is a reliable supply of phase II fish.


Stocking paddlefish juveniles.

Traditionally, in tank culture larval fish diets are used during the first 30-40 days after hatching, until the fish reach about 7.5 cm, or phase I. At this size they can be trained to take a 1.5 mm floating pellet, and are usually stocked into ponds for further grow out over the next 90 days to phase II. Unfortunately, currently available diets are not species-specific for larval paddlefish and are not economical, mostly due to low survival rates of 10 to 20%. Live *Daphnia* (water fleas) are known to be the first food of choice for larval paddlefish, but obtaining a large supply is difficult. Hence, the benefits of using a waste-water facility for aquaculture generally and for paddlefish specifically.

Why Use Wastewater?

Wastewater treatment plants are today integral parts of any urban community. However, at the beginning of the 20th century, only a few US cities and industries had sewage treatment facilities. During the 1950s and 1960s, the U.S. government provided funds for constructing municipal waste-treatment plants, technical training and assistance, and water-pollution research. However, in spite of these efforts, expanding population and industrial and economic growth caused both pollution and public health issues to increase. In response, the National Environmental Policy Act (NEPA) was enacted, and the Environmental Protection Agency (EPA) created to oversee pollution-control programs. The Water Pollution Control Act Amendments of 1972 expanded the federal government's role in water pollution control and significantly increased funding for waste-treatment works.

With better methods for processing wastewater now available, many municipalities are now building new, larger facilities, and decommissioning the old ones, many of which include sedimentation ponds and tanks that could easily and economically be converted for fish culture. Many are being needlessly demolished, when recycling them as fish hatcheries could avoid demolition costs, create new jobs, and generate revenue. Most of the new facilities are being built adjacent to the old, and would conveniently allow processed wastewater to be used in the hatchery, provided it meets EPA water quality criteria safe for humans, wildlife and aquatic life. Which brings us to experiments ongoing in Kentucky.

Pilot Study

Staff at the municipal sewage treatment plant located in Frankfort, the Capital City of Kentucky, in collaboration with Kentucky State University Aquaculture Research Center, began evaluating the growing of paddlefish fingerlings using three, on-site, sustainable resources:

1) Tanks —two circular 1125 m^3 digester tanks and a 135 m^3 circular sludge

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thickener tank) that were no longer used in daily operations,

2) Ozone-disinfected wastewater that is otherwise released into the Kentucky river, and

3) *Daphnia* (commonly called water fleas), a food source for larval paddlefish, that grow naturally in four 1500 m^3 clarifier tanks.

The plant processes on the average 22,500 m^3/day of wastewater that is disinfected with ozone before it is released into the Kentucky River. By using the plant's pumping infrastructure, processed water can be delivered to the fish tanks then returned to the head of the plant once more for treatment. This source of water is potentially very valuable since only limited ground water is available in many parts of Kentucky. Furthermore, the water is saturated with oxygen, pH is 7.0-7.2, total ammonia nitrogen is below 1.0 mg/l, nitrite is below 0.1 mg/l, and chloride levels are 6-10 mg/l.

Daphnia, optimum food for phase I larvae, are available in large numbers. In other circumstances, *Daphnia* can be a nuisance because in large numbers their swimming movements disrupt the sludge blanket in clarifier tanks, causing total suspended solids to increase and often causing discharge permit violations. Since chemicals may not be used at this stage in processing, mechanical removal is the only option for solving this problem. Feeding them to paddlefish turns waste into a new resource.

In mid- April, 2006, 15,000 paddlefish fry were stocked into the 135 m^3 circular sludge tank supplied with processed wastewater at a flow rate of 100 l/min. They were bred, incubated and hatched at KSU Aquaculture Research Center then stocked at the waste water plant 6 days after hatching, when they were ready to start feeding.

Live *Daphnia* collected daily from the clarifier tanks with hand-pulled plankton nets were fed to the paddlefish. Fish grew to phase I size in about 4 weeks. Thereafter, from mid-May to mid-June they were fed a 1.5 mm, 45% protein, floating salmonid diet. Suitable oxygen levels (> 4 mg/l) were maintained with a 0.1 hp (75-w) surface aerator and air diffusion. Nitrite was the only parameter that exceeded acceptable levels of < 0.1 mg/l, but the chloride level of 6-10 mg/l naturally blocked the uptake of nitrite via the gills, to potentially prevent brown blood disease. By mid June fish measured 12-14 cm and weighed 30-45 g. More than12,000 fish were harvested, giving a survival rate of over 80%.

In mid-June, the two 1125-m^3 digester tanks were stocked respectively with 3,000 and 7,000 phase I fish (harvested from the 135 m^3 circular sludge tank), and filled with processed water. Water was static during the culture period, but each tank was supplied with one 0.33-hp (250-w) surface aerator and air diffuser to provide oxygen and prevent stratification. Again, all water quality parameters were within acceptable levels for paddlefish except nitrite, which was near 2 mg/l and required additional sodium chloride (i.e. 50 mg/l of chloride) to be added to block lethal uptake of nitrite by the fish. Of 3000 fish in tank 1, 2959 survived, (98.6%). These fish averaged 35 cm total length, and 225 g. Survival in tank 2 was 6,389 of 7,000 fish (91.3%). These fish measured 30-35 cm and averaged about 150 g. The fish were then stocked into two water-supply lakes for harvesting as mature fish for meat and caviar in 10 years time.

This pilot study has successfully produced phase I and II paddlefish at high survival rates for further grow-out. Other species such a largemouth bass and hybrid striped bass fingerlings are scheduled for testing under similar conditions in spring, 2007. Additionally, other wastewater treatment plants in Kentucky that have decommissioned old facilities are now interested in exploring their potential for aquaculture. Such sustainable resources could be useful in advancing aquaculture and the supply of seed stock for production of a number of suitable species.

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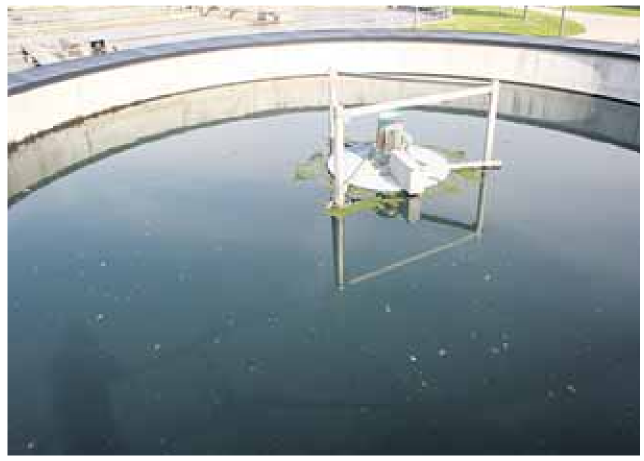
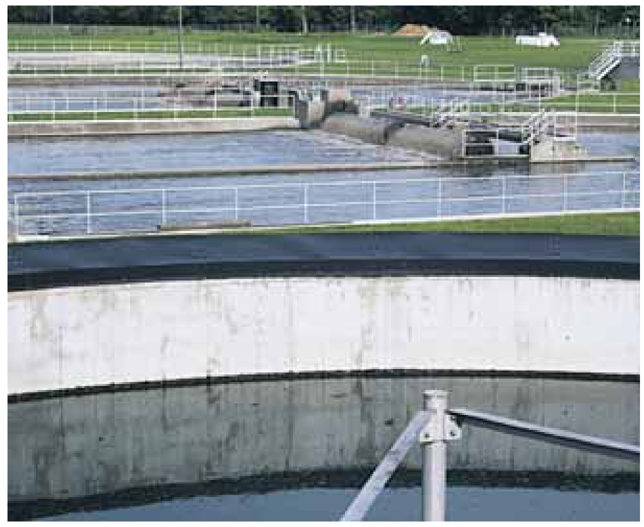
Clump of Daphnia for feeding to paddlefish larvae. Inset shows close-up.



Digester tank ready for paddlefish. The aerator is in the center.

Fingerlings feeding on pelleted food.



Modern sewage oxidation ditches with an old digester tank in the foreground.

Harvesting paddlefish fingerlings prior to stocking