ALLIANCE™
(https://www.globalseafood.org)

Responsible Seafood ADVOCATE

Responsibility

Direct energy use in channel catfish production

1 July 2008

By Claude E. Boyd, Ph.D. , Mike Polioudakis, Ph.D. and Gregory N. Whitis

Automated systems the most likely way of reducing electricity use for aeration

Aeration consumes about 27 percent of the energy used at channel catfish farms.

The main resources for aquaculture are water, land, nutrient sources and energy. There has been much discussion between the aquaculture industry and environmental NGOs about water and land requirements and the use of nutrient sources in shrimp and fish culture. Voluntary best management practice and certification programs stress efficient use of water, land and nutrients. There has, however, been much less dialogue about energy use. Because of the rising cost of fuel, energy conservation will become a critical issue in aquaculture.

The authors recently conducted a study on direct energy use in the pond culture of channel catfish in Alabama, USA. Work supported by the United States Department of Agriculture's Southern Regional Aquaculture Center and conducted by Auburn University considered six major direct energy inputs: pond construction, fingerling production, feed manufacturing, grow-out, harvesting and processing.

The data included complete fuel use and production data from a pond construction contractor, two hatcheries, a feed mill, 12 farms, a custom harvesting business and a processing plant.

Aquaculture and energy

Solar radiation is important for warming waters in aquaculture grow-out units and as an energy source for phytoplankton photosynthesis that is the base of the food web in aquatic systems. Humans also exert energy in the labor required to conduct aquaculture operations. However, the direct input of energy from electricity and other fuels are of greatest concern in relation to resource use in aquaculture. This includes energy used in constructing facilities, producing seedstock and feed, powering mechanical aerators, applying feed and harvesting and processing culture animals.

Some energy assessments attempt to account for the total amount of energy expended for a particular activity. In addition to the direct energy inputs for aquaculture, the total energy requirements include the energy used in terrestrial agriculture to produce feed ingredients and energy expended to manufacture fertilizers, fuels, machines and all other inputs. A complete accounting of energy would be extremely difficult to make and would not be indicative of the amount of energy dedicated specifically to aquaculture production.

Study data

The common unit of energy used in most scientific journals is the joule, but most aquaculturists are more familiar with the kilowatt hour (kWh) frequently used in measuring electrical energy. The factors used for converting fuel volumes to kilowatt hours are provided in Table 1.

Boyd, Energy equivalence factors, Table 1

Gasoline (1 l) = 9.61 kWh
Diesel fuel (1 l) = 11.04 kWh
Natural gas (1 l) = 10.44 kWh
1 kWh = 859.68 kcal
1 kcal = 1 cal (human nutrition)

Table 1. Energy equivalence factors.

Construction

Channel catfish ponds in Alabama typically are built using wheel tractor-drawn scrapers with laser-leveling systems. The contractor who participated in this study had 200-hp tractors such as typically used for catfish pond construction. These tractors consume approximately 40 l diesel fuel/hour. About 40 hours of tractor time were required per hectare of pond water surface area constructed. Thus, the diesel fuel use was 1,600 l/ha for pond construction. This volume of fuel is equivalent to 17,664 kWh/ha.

Hatchery

Most Alabama catfish farmers purchase fingerlings from hatcheries in the state of Mississippi. Only two major hatchery operations remain in Alabama. Both of these hatcheries use electricity as the sole energy source. Electricity use for producing 10- to 15-cm-long fingerlings was 0.0296 kWh each at one hatchery and 0.0269 kWh each at the other one.

Feed Mill

The feed mill produced 104,483 metric tons feed in 2006. The data provided on energy use included that consumed by the feed mill and for delivering feed by truck to farms. The total energy use was 0.296 kWh/kg feed produced and delivered. Of this energy, 61.8 percent was from natural gas and 31.8 percent from electricity used at the feed mill. Diesel fuel and gasoline comprising the remainder of the energy apparently were used primarily for the delivery of feed to farms.

Farm

Data on the use of electricity, diesel fuel and gasoline were obtained for 12 farms. Electricity was used mainly for powering floating paddlewheel aerators installed permanently in ponds. Ponds had an average of 7-hp aeration/ha, with aerators operated mainly at night May through September. Electricity use averaged 3,899 kWh/ha/growing season.

Tractor-powered paddlewheel aerators were operated in ponds on occasions when safe dissolved-oxygen concentrations could not be maintained by the floating aerators. Diesel fuel and gasoline also were used to operate feed trucks and feed blowers, to cut grass around ponds and other farm purposes. The combined petroleum-based fuel use was 275.5 l/ha. The energy content of the diesel fuel and gasoline was equivalent to 2,844.5 kWh/ha.

On average, farms stocked 17,186 fingerlings/ha, applied 13,183 kg/ha of feed and harvested 4,642 kg/ha of fish annually. These data were used with the energy use data to estimate the amount of energy necessary to produce market-sized catfish.

Catfish ponds usually have a service life of 20 years or more before major renovation is required. Using an average annual production of 4,642 kg/ha, the energy use amortized over 20 years is 0.19 kWh/kg fish. Assuming there is equilibrium between average annual stocking rates and average annual production, the energy cost of producing fingerlings was 0.104 kWh/kg harvested fish.

The energy used to make and deliver the feed to the farm was 0.841 kWh/kg of fish harvested. Operation of dedicated floating electric aerators required 0.840 kWh/kg fish. Emergency aeration, feeding and other farm vehicle use consumed 0.613 kWh/kg fish.

Harvesting, processing

The custom harvesting operation used diesel fuel and gasoline to power tractors used to operate seines and trucks for hauling fish to the processing plant. The volume of fuel used equated to 0.092 kWh/kg fish harvested. The processing plant used only electricity. Its energy expenditure was 0.42 kWh/kg live fish processed.

Energy inputs

The energy inputs per kilogram of fish production are summarized in Table 2. The major energy uses are feed, aeration and feeding, and other uses of farm vehicles and machinery. These data are for watershed ponds in Alabama filled by surface runoff. There would be an additional energy requirement for pumping well water or surface water from lakes or streams into embankment ponds.

Boyd, Direct energy use for production of 1 kg of channel catfish, Table 2

Activity	Energy Use (kWh/kg fish)	Percentage

Pond construction	0.190	6.13
Fingerling production	0.104	3.35
Feed production and delivery	0.841	27.13
Dedicated aeration	0.840	27.10
Emergency aeration, feeding, other vehicle uses	0.613	19.7
Harvesting	0.092	2.97
Processing	0.420	13.55
Total	3.100	100.00

Table 2. Direct energy use for production of 1 kg of channel catfish in ponds in Alabama, USA.

In a previous study, the energy cost of pumping well water into embankment ponds in the southeastern United States was estimated at 600-800 kWh/ha year – a relatively small input of 0.129-0.172 kWh/kg of harvested fish.

An energy input of 3.10 kWh/kg of fish is equivalent to 2,665 kcal/kg. One kilogram of live channel catfish provides about 600 g of marketable meat containing about 912 kcal (usually called calories in human nutrition). The return of direct energy input in marketable meat is at a ratio of 912:2,665, so about three times as much energy is used in producing catfish as obtained in catfish meat. Of course, even more energy would be required if total energy input was used instead of direct energy input.

Energy-saving opportunities

There probably is not much opportunity for reducing energy input for pond construction, fingerling production, feed manufacturing, harvesting or processing. Moreover, mechanical aerators used in channel catfish farming are almost exclusively of a highly efficient design developed at Auburn University.

The most likely way of reducing electricity use for aeration is to use an automated system for turning aerators on and off in response to dissolved-oxygen concentration. Such systems are available, but expensive, and most farmers simply turn aerators on in the evening and turn them off in the morning during warm months regardless of dissolved-oxygen concentration.

The most obvious way of saving energy is through better feeding practices that reduce feed-conversion ratios (FCRs). The FCR for farms in this study was 2.84, but when feed is applied carefully to avoid overfeeding such as is done in research, FCRs of 1.8 or less are not unusual.

An FCR of 1.5 would reduce feed use by farms in this survey from 13,183 kg/ha to 6,973 kg/ha, and direct energy use to provide feed would decline from 0.841 kWh/kg to 0.445 kWh/kg. Although it would require additional investment in labor and/or equipment, the lower FCR would represent a 12.77 percent decrease in direct energy use and very large savings in feed ingredients and feed costs. Moreover, the use of less feed should lead to a lower input of nutrients to ponds, and phytoplankton blooms should diminish. This would lead to a smaller requirement for nighttime aeration and additional energy savings.

(Editor's Note: This article was originally published in the July/August 2008 print edition of the Global Aquaculture Advocate.*)*

Authors

CLAUDE E. BOYD, PH.D.

Department of Fisheries and Allied Aquacultures
Auburn University
Alabama 36849 USA

boydce1@auburn.edu (mailto:boydce1@auburn.edu)

MIKE POLIOUDAKIS, PH.D.

Department of Fisheries and Allied Aquacultures
Auburn University
Alabama 36849 USA

GREGORY N. WHITIS

Alabama Cooperative Extension System
Auburn University
Auburn, Alabama, USA