EVALUATION OF IMPACTS OF POTENTIAL "CAP AND TRADE" CARBON EMISSION POLICIES ON CATFISH, BAITFISH, AND CRAWFISH FARMING

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PROJECT OBJECTIVES

1. Estimate net carbon balance for channel catfish, bait minnow, and crawfish ponds and propose science-based management practices that may increase net carbon capture by ponds.

2. Estimate the economic effects on U.S. catfish, bait minnow, and crawfish farms of alternative policy options under consideration to reduce carbon emissions, including cap-and-trade programs and carbon taxes.

3. Disseminate results for Objectives 1 and 2 through a general fact sheet that explains the impact of the carbon emissions issue on southern aquaculture, and specific fact sheets for the three species. A special session at a major, national, aquaculture meeting will also be organized.

ANTICIPATED BENEFITS

The study will estimate the carbon emissions balance at the farm level for catfish, baitfish, and crawfish farming in the southern United States. This information will allow an assessment of the possible effects of potential "cap and trade" carbon emissions policies on these three types of aquaculture. It will be possible to ascertain if production ponds can be operated as carbon sinks to develop carbon credits or if farms will be sources of carbon emissions. In addition to allowing predications about effects of possible, future, carbon emissions rules, the findings will allow an estimation of the farm-level carbon footprint of the three types of aquaculture.

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS

Objective 1. *Estimate net carbon balance for channel catfish, bait minnow, and crawfish ponds and propose science-based management practices that may increase net carbon capture by ponds.*

Auburn University

This component of the project is being conducted to determine the amounts of carbon emissions resulting from farm-level activities, and to evaluate the quantities of carbon sequestered in the sediment of ponds on catfish, bait minnow, and crayfish farms. The results will show the carbon emissions balance for the three types of aquaculture. In addition, production methodology will be evaluated and practices for increasing net carbon capture in ponds will be suggested.

Results at a glance...

- *Researchers at Auburn University have shown that channel catfish aquaculture at the farm level is essentially neutral with respect to carbon dioxide emissions because considerable carbon dioxide is sequestered in pond sediment.*

Carbon dioxide emission balance on farms will be determined as the difference between annual carbon dioxide sequestration rates in pond sediments and amounts of annual carbon dioxide emissions from aquaculture production operations. Direct carbon emissions from fuels (including electricity) will be estimated for pond construction (amortized over expected service life of ponds) and annual management operations. This assessment will be for farm carbon emissions only – carbon emissions for hatchery operation and fingerling delivery, feed manufacturing and delivery, and processing and product delivery will not be included. Data on fuel use for channel catfish production at the farm level are available from several energy use studies done by various investigators. Enterprise budgets also are available for both golden shiner production and crawfish farming that contain estimates of fuel use for pond construction and farm operations. University of Arkansas at Pine Bluff (UAPB) and Louisiana State University (LSU) teams will provide any additional information and advice needed by the Auburn University (AU) team for estimating amounts of carbon emissions. Researchers at AU obtained core samples from 233 aquaculture ponds in nine counties. Samples were subjected to physical and chemical analyses; the resulting database includes channel catfish ponds in Alabama and Mississippi and bait minnow ponds in Arkansas. Sediment accumulation rates and organic carbon concentrations also are available from previous research by Mississippi State University (MSU) in 45 channel catfish ponds in Mississippi. Data referred to above will be used to assess carbon sequestration rate in channel catfish and bait minnow ponds. LSU investigators are presently collecting bottom soil samples from crawfish ponds that will be sent to us for estimation of carbon sequestration rate.

Average carbon sequestration rates in catfish and bait minnow ponds were 517 g $CO_2/m^2/yr$ and 209 g $CO_2/m^2/yr$, respectively. The farm-level carbon dioxide emissions were estimated for channel catfish (Table 1). Each kilogram of fish produced resulted in 0.9405 kg CO_2. The largest contributor to carbon emissions at the farm-level (70.9%) was use of electric paddlewheel aerators. Average channel catfish production in 2010 was 5,553 kg/ha. Thus, carbon emissions were equivalent to about 5,223 kg

CO_2/ha or 522 g CO_2/m^2. Thus, at the farm level, catfish ponds sequester roughly as much carbon dioxide as is emitted by production activities. In other words, farms are essentially carbon dioxide emissions neutral.

Soil samples from crawfish farms in Louisiana were provided by LSU researchers. These samples were analyzed for organic carbon concentrations. The averages provided in Table 2 reveal that soil carbon concentrations did not differ between crawfish ponds and agricultural fields.

Data collected on sediment chemical and physical characteristics in bait minnow ponds in Arkansas as a component of an earlier study were used to estimate the annual carbon sequestration rate in bait minnow ponds (n = 9). The average rate of carbon sequestration was 57 $g/m^2/yr$ in the upper 20-cm layer – 570 kg/ha/yr.

The effort to assess the carbon dioxide emissions at the farm level for bait minnows and crawfish has nearly been completed.

Table 1. Farm-level carbon dioxide emissions for channel catfish production.

Activity	CO_2 emissions (kg CO_2/kg fish)
Pond construction	0.0361
Electric paddlewheel aerator operation	0.6668
Tractor use – emergency aeration, feeding, mowing	0.1502
Light truck and boat use	0.0651
Harvesting	0.0223
Total	0.9405

Table 2. Amounts of carbon in upper 0-20 cm soil layer in agricultural fields and crawfish ponds.

System	Total C (kg/ha)
Continuous crawfish cropping	
Crawfish ponds (n = 8)	39,555 a
Agricultural fields (n = 4)	43,007 a
Rotational crawfish cropping	
Crawfish ponds (n = 5)	30,660 a
Agricultural fields (n = 5)	29,216 a

Louisiana State University

The AU investigators met with their counterparts at LSU and explained the sampling requirements for the sediment samples from crawfish ponds. Eight single-crop permanent crawfish ponds in three Louisiana parishes and seven rice field-crawfish rotational production systems in four parishes were sampled for carbon analysis. Bottom soil core samples were collected from crawfish ponds and from nearby agriculture fields in each location. Samples were collected prior to the beginning of the respective production cycle for each scenario (August/September for permanent ponds and February – April for rice-crawfish rotational ponds).

Bulk density determinations were made for soil cores from 5-cm depth increments within the 20-cm plow-depth of fields and additional soil cores from 5-cm depth increments were sent to Auburn University for determination of organic carbon concentration. Data will be used to estimate carbon accumulation in sediment.

Researchers at LSU also worked with colleagues at AU to compile and define production data needed to ascertain customary carbon expenditures during the production phase of crawfish production, both under a single-crop farming practice as well as under the typical rice-crawfish field rotational approach.

Objective 2. *Estimate the economic effects on U.S. catfish, bait minnow, and crawfish farms of alternative policy options under consideration to reduce carbon emissions, including cap-and-trade programs and carbon taxes.*

University of Arkansas at Pine Bluff

UAPB has developed a general framework for simulating potential effects of "cap and trade" carbon emission policies on U.S. aquaculture. Researchers have developed baseline models for catfish and crawfish referred to as Catfish-CapTrade Policy Model and Crawfish-CapTrade Policy Model, respectively. The researchers have compiled baseline data (production/supply, consumption, producer and market prices, input quantity and prices, net carbon balance, etc.) and some of the parameters of these models (own and cross price elasticity of demand and supply).

The general framework of the model developed for simulating effects of "Cap and Trade" carbon emission policies on U.S. aquaculture is given in Fig. 1. The models postulate that the carbon offsets/taxes depend on a) net carbon supply of the aquaculture farms and b) government policies to distribute the revenue generated through the program. The model captures the potential effects of alternative policies on farmers as well as consumers through changes in input prices, output and market prices, and in real per capita income.

Net carbon balance of existing farm practices will

Results at a glance...

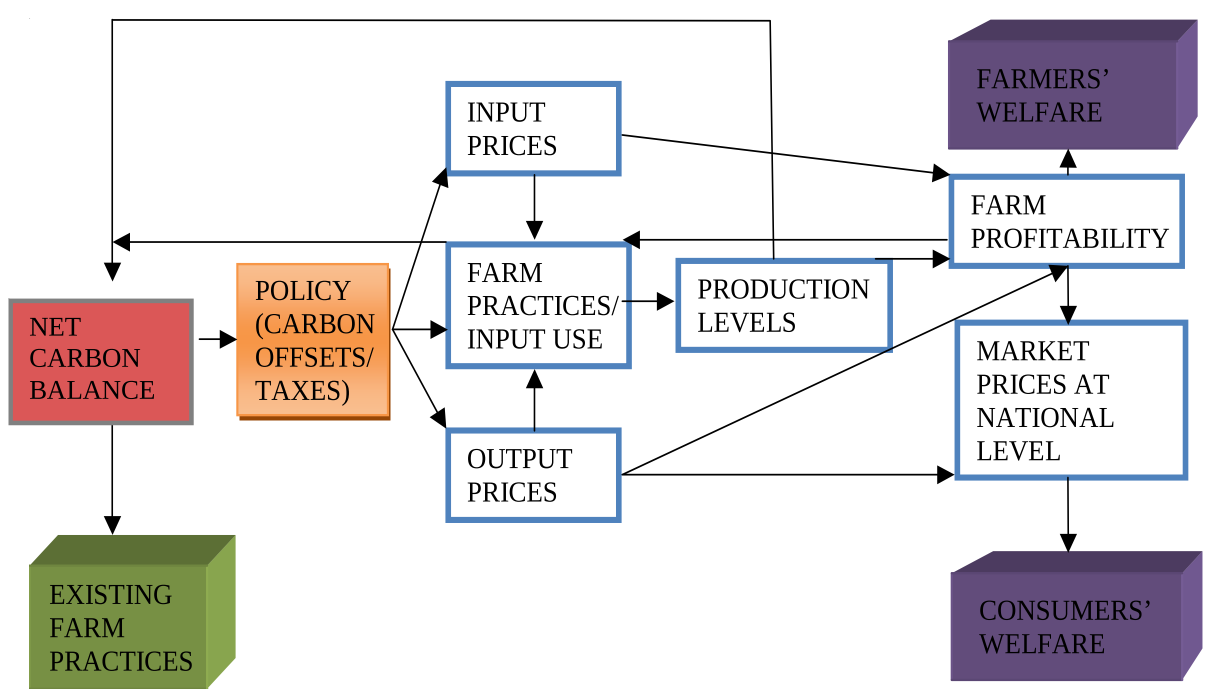
- *UAPB has developed a general framework for simulating potential effects of "cap and trade" carbon emission policies on U.S. aquaculture. The University has developed baseline models for catfish and crawfish called as Catfish-CapTrade Policy Model and Crawfish-CapTrade Policy Model, respectively.*

determine carbon emission policies (rates of carbon offsets/taxes). The policy will affect input and output prices. Farmers may adjust their farm practices and/or input use according to these policies. Changes in input and output prices can influence the existing farm practices/input usage. Changes in input and output prices and in farm practices will affect farm profitability, which will potentially affect farmers' as well as consumers' welfare. Changes in farm production levels and farm practices/input usage will result in new net carbon balances.

The UAPB team has conducted some simulations under baseline and different alternative "carbon sequestration efficiency" scenarios in exploring the potential impacts of possible "cap and trade" programs and carbon tax policies. Recently, a globally coordinated carbon charge of US $25 per ton of carbon dioxide (CO_2) emission had been proposed in the G20 meeting. But there is no fixed carbon pricing instrument recommended for implementation; the selection of carbon-related fiscal instruments lies with the individual countries. The question on whether to impose carbon tax on final consumption goods or on inputs (e.g., fuels) remained unsolved (IMF, 2011; B20, 2012).

As there is no specific tax policy instruments agreed for a possible "cap and trade" program and carbon taxes in the U.S., we made the following assumptions in the simulation exercise: (i) an increase in cost of carbon-based products, namely fuel/diesel and electricity, by 6 percent (CBO 2009); (ii) an increase in feed price by 6 percent; (iii) carbon-trading is

Figure 1. Model framework for potential effects of "cap and trade" carbon emission policies on U.S.



Results at a glance...

- *"Cap and trade" programs have the potential to affect catfish, baitfish and crawfish industries negatively. This negative impact of carbon tax could be reduced if farms can improve the net carbon sequestration without incurring additional cost.*

exercised through subsidy (net carbon sequestration) and/or tax (net carbon emission), which will then influence farmers' decision making in farming based on the net carbon supply of their farming activities; (iv) net zero carbon-balance under baseline scenario for all the three species, as suggested by the Auburn University team for catfish farming. In general, net carbon-balance varies across species, weather and farming practices covering inputs and management skills. Under a "cap and trade" program, farmers may change their farming practices to higher carbon sequestrated techniques and/or lesser carbon emitted practices. Therefore, we analyzed the potential impacts of "cap and trade" policy under the following alternative scenarios:

Scenario 1: 6% increase in the price of carbon based inputs, such as fuel and electricity; and 6% increase in feed prices, with net zero carbon balance.

Scenario 2: 6% increase in the price of carbon based inputs, such as fuel and electricity; and 6% increase in feed prices, with 5% increase in carbon sequestration efficiency.

Scenario 3: 6% increase in the price of carbon based inputs, such as fuel and electricity; and 6% increase in feed prices, with 10% increase in carbon sequestration efficiency.

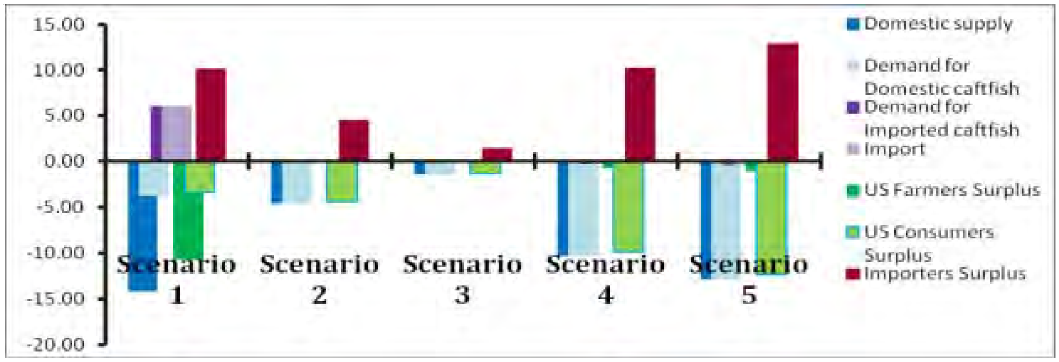
Scenario 4: 6% increase in the price of carbon based inputs, such as fuel and electricity; and 6% increase in feed prices, with 5% decrease in carbon sequestration efficiency or 5% increase in net carbon emission.

Scenario 5: 6% increase in the price of carbon based inputs, such as fuel and electricity; and 6% increase in feed prices, with 10% decrease in carbon sequestration efficiency or 10% increase in net carbon emission.

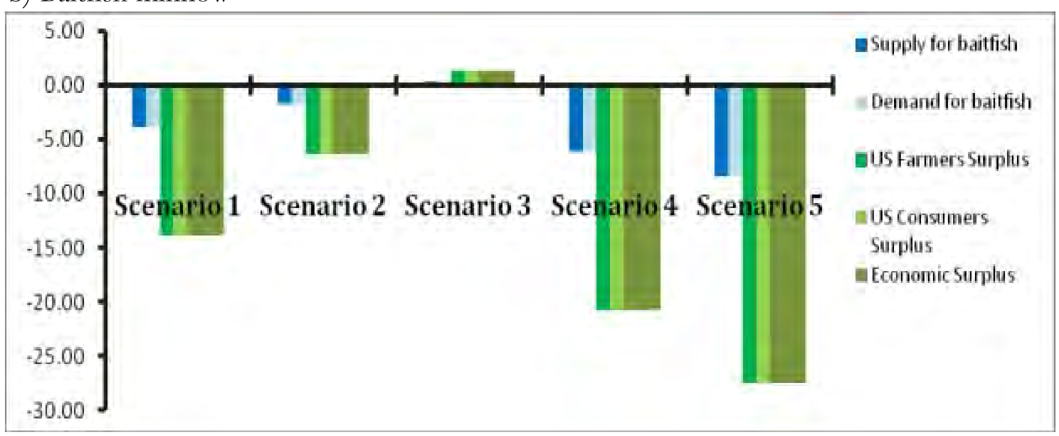
The results generated from the simulation exercises under baseline and alternative scenarios are presented in Fig. 2. The findings show that under Scenario 1 where carbon based inputs and feed prices increased by 6% with zero net carbon balance, the carbon tax policies will negatively affect the domestic aquaculture industry, which will reduce aquaculture productions and will reduce welfare of producers and consumers (as measured by producer and consumer surpluses) across all the aquaculture industries studied (catfish, baitfish and crawfish sectors). This negative impact of carbon tax could be reduced if farms can improve the net carbon sequestration without incurring additional cost (Scenario 2 and 3). Tax on inputs distorts production decisions and increases production cost. Even with substantial improvement in carbon sequestration (Scenario 3), taxes on inputs (such as, fuel and feed) might create negative impact on the welfare of catfish, crawfish and baitfish farmers. The negative effects may be mitigated with an increase in practices that favors net carbon sequestration; the higher the net carbon sequestration, the lesser will be the negative impact of carbon tax.

Fig. 2. Simulations results under baseline and different alternative scenarios (Axis Y – deviation from baseline (%); Axis X – different scenarios)

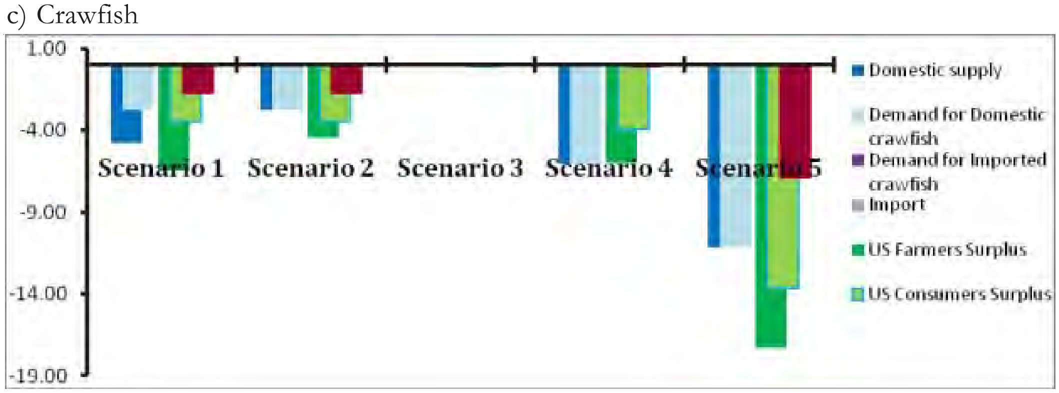
a) Catfish



b) Baitfish minnow



c) Crawfish



Objective 3. *Disseminate results for Objectives 1 and 2 through a general fact sheet that explains the impact of the carbon emissions issue on southern aquaculture, and specific fact sheets for the three species. A special session at a major, national, aquaculture meeting will also be organized.*

Louisiana State University, University of Arkansas at Pine Bluff, and Auburn University

This objective cannot be addressed until we are nearer completion of the work outlined in Objectives 1 and 2.

IMPACTS

Channel catfish farming appears to be carbon dioxide emissions neutral with respect to farm-level operations, i.e. ponds sequester as much carbon dioxide as farming activities emit. Models for evaluating the likely economic effects of possible, future, carbon emissions regulations are still being developed. However, the fact that catfish farming is carbon neutral and the likelihood that bait minnow and crawfish farming will contribute less to carbon dioxide emissions than channel catfish farming suggest that the economic impacts of carbon emissions regulations would probably be minor.

PUBLICATIONS, MANUSCRIPTS OR PAPERS PRESENTED

Manuscripts

Boyd, C. E. 2010. Aquaculture ponds hold carbon. Global Aquaculture Advocate 13(2):23-24.

Boyd, C. E., C. W. Wood, P. Chaney, and J. F. Queiroz. 2010. Role of aquaculture pond sediments in sequestration of annual global carbon emissions. Environmental Pollution 158:2537-2540.

Presentations

Dey, M. M., K. Singh, and C. Engle. 2009. Analysis of catfish supply, demand and trade in USA: baseline model, estimation strategy and preliminary results. Paper presented in: NAAFE (North American Association of Fisheries Economists) Forum 2009, May 17-20, 2009, Newport, Rhode Island (U.S.).

Dey, M. M., K. Singh, and C. Engle. 2010. Impact of marketing, trade and exchange rate policies on U.S. catfish and trout markets: results from disaggregated fish sector models. Paper presented in: Aquaculture 2010 – Meeting Abstracts, Page 506.

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