Catch and Culture

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INSIDE

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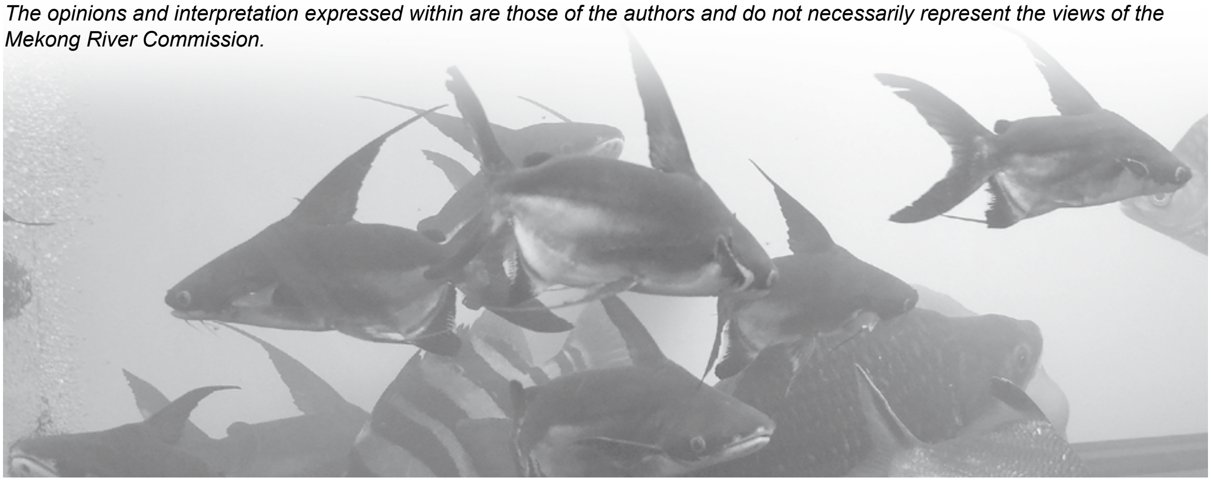

Cover photo shows Thai Prime Minister Prayut Chan-O-Cha displaying a Siamese fighting fish (*Betta splendens*) at a month-long plant and fish festival in Bangkok in June. The Prime Minister named this particular strain as "thong prakai sad" which loosely translates as "golden brilliance". This is the Thai name for nanche (*Byrsonima crassifolia*), a flowering plant from Central America, and also the name of a popular Thai film released in 2011 (photo courtesy of Prime Minister's Office).

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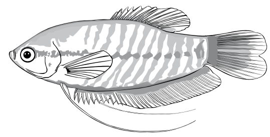
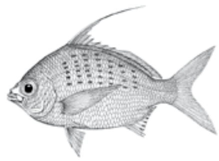
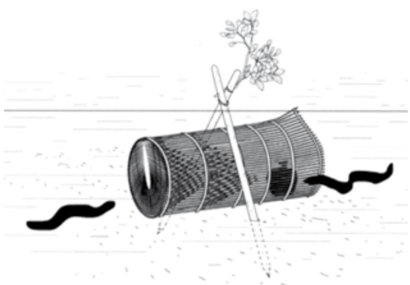






Aquaculture **carrying capacity** of Stung **Chinit** Reservoir: a **pilot project**

By David A. Bengtson, Chheng Phen, Tith Puthearath and So Nam *

Mass-balance modeling of phosphorous can serve as a template to determine allowable levels of aquaculture in reservoirs in Cambodia and perhaps throughout Southeast Asia

Cambodia has plans to expand freshwater aquaculture, including in reservoirs (Fisheries Administration, 2011). Lakes and reservoirs represent commonly owned or used water bodies and are therefore subject to the "tragedy of the commons", in which too many users can destroy the quality of the resource (Hardin, 1968). It is not unusual in Southeast Asia to see reservoirs in which aquaculture has grown beyond reasonable limits, with subsequent declines in water quality (e.g. the Cirata and Jatiluhur reservoirs in Indonesia, with tens of thousands of fish cages).

Aquaculture Carrying Capacity (ACC) refers to the limits to aquaculture in a common water body, as defined by the environment's ability to assimilate aquaculture wastes. McKindsey *et al.* (2006) reviewed the topic and discussed different entities that one might consider protecting (the farms themselves, the entire ecosystem, human society) in the calculation of ACC. Various kinds of models exist for calculating ACC, depending on what is to be protected and how much data one has to use in the models. For freshwater bodies with relatively little data available, mass-balance modeling of phosphorous (P) is often used, since P is normally the limiting nutrient for freshwater primary production. The basic P mass-balance model is rooted in the work of Vollenweider (1968) and Dillon and Rigler (1974), relating P levels and primary production in studies of eutrophication. That is, eutrophied waters eventually result in lowered dissolved oxygen (DO) levels due to decomposition of organic material. The aquaculture of fish in cages is usually based on feeding of some diets (chopped trash fish or formulated feed pellets) that add substantially to the organic load of the water.

Staff members of the Cambodian Inland Fisheries Research and Development Institute (IFReDI) received training in P mass-balance modeling and collected information to be used in the modeling. As described by Beveridge (1996), the modeling procedure is quite simple and requires relatively little input data. One needs to know volume of the water body (A), average depth (z) of the water body, turnover rate (number of volume replacements per year, ρ), initial P concentration before aquaculture [P]i, some acceptable final P concentration [P]f, and the fraction of P that is lost to the sediments (R). In addition, one needs to know about fish being proposed for rearing: species, P content of their feed, feed conversion ratio (FCR, a measure of how much feed must be provided to achieve desired growth of the fish), and the amount of P retained by the fish at harvest. The critical quantity is ΔP = [P]f – [P]i, the amount of new phosphorous that aquaculture can add to the system and still allow the system to be at or below the acceptable P level. Clearly, if [P]i is already greater than [P]f (due to nutrient runoff, etc), then no aquaculture can be allowed.

IFReDI researchers gathered available data about Stung Chinit Reservoir in Kampong Thom Province as a test case for aquaculture carrying capacity modeling in Cambodian reservoirs. Volume of the reservoir is 35.6 million cubic metres (MCM). Dry-season flow (November to April) in the Stung Chinit River, a tributary of the Tonle Sap Lake, is 460 MCM (for the whole season), whereas wet-season flow (May to October) was 1,586 MCM. [P] in the reservoir in 2008 (the last year for which we have an annual data set) averaged 92 mg per cubic metre in the dry season (range = 40-150) and 195 mg per cubic metre in the wet season (range = 50-520). The area of the reservoir is 16,720,000 m^2 in the wet season and 5,140,000 m^2 in the dry season, and the average depth is 1.5 m. In the absence of specific data, we are assuming that R = 0.5. With this information, one can use the relationship described by Beveridge (1996)

$\Delta P = [Lfish(1-Rfish)]/z\rho$,

where Lfish is the amount of P that can be contributed by aquaculture by rearranging it to solve for

$Lfish = [\Delta P z\rho]/(1 - Rfish)$.

One can then calculate the number of tons of fish produced to achieve Lfish. That is accomplished by multiplying the P content in a ton of feed times the FCR (to determine how much P is provided to the aquaculture operation, Pfeed) and subtracting from that the amount of P that is retained in a ton of fish, Pfish (and therefore removed from the system). In other words, the amount of P lost to the environment, Penv = Pfeed – Pfish, expressed as P loss per ton of fish produced.

One of the interesting things about this exercise is that there are some things that fish farmers and feed manufacturers cannot control (volume, area, depth, flow rate of the water body) and some things that they can (FCR, P content of feed). In addition, stakeholders of the water can decide on the acceptable level of P for that water body. For example, if stakeholders desire oligotrophic (clear, very low nutrient water) for tourism, then aquaculture production is unlikely. But if they really want to promote aquaculture, the higher levels of P would be permissible. Beveridge (1996) suggested that P levels up to about 250 mg per cubic metre are permissible for tropical culture of tilapia, carp and milkfish, although lower levels of 50-75 mg per cubic metre would be more protective of wild fisheries production.

We followed the above approach to calculate ACC for fish culture in Stung Chinit. Since this effort was part of a project to bring about the reintroduction of snakehead culture in Cambodia, we used that as our model species, although one could clearly model other species as well. We began by calculating ACC with the best current data available and an assumed acceptable P level of 200 mg per cubic metre. However, as part of the exercise, we also calculated ACC under different scenarios of FCR and [P]f. We were faced with

Spillway at the Stung Chinit Reservoir in Kampong Thom Province

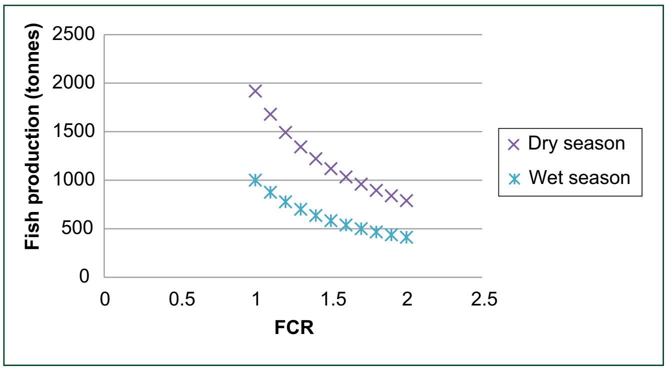
Photo: Chhut Chheana

the additional challenge that Stung Chinit has very different flow rates and [P]I values for the wet and dry seasons, but snakehead require about six to eight months to grow to market size, thereby encompassing both wet and dry seasons to calculate ACC separately for wet and dry seasons, but finally choose the lower of the two values for tons of fish production, so that production would be protected in the worst-case scenario.

For our current best scenario with acceptable P at 200 mg per cubic metre, farmers could produce 895 tons of snakehead (dry season) or 467 tons (wet season). Thus, annual production would be limited to 467 tons, the lower of the two values. As we examine other scenarios, we see that FCR is a powerful regulator of allowable tons of fish production. Setting acceptable P at 200 mg per cubic metre and just varying FCR demonstrates that an FCR of 2.0 allows only 790 tons of snakehead production in the dry season and 412 tons in the wet season (so we choose 412 tons for year-round production to be safe), whereas lowering the FCR to 1.0 would allow 1,918 tons of snakehead production in the dry season and 1,000 tons during the wet season (so again we choose 1,000 tons to be safe) (see first chart on next page). Similarly, holding FCR constant at 1.8, setting acceptable P at 150 mg per cubic metre would mean that aquaculture would not be allowed in Stung Chinit (481 tons in the dry season but a negative number in the wet season).

Feed conversion ratio

Effect of FCR on aquaculture carrying capacity in Stung Chinit Reservoir

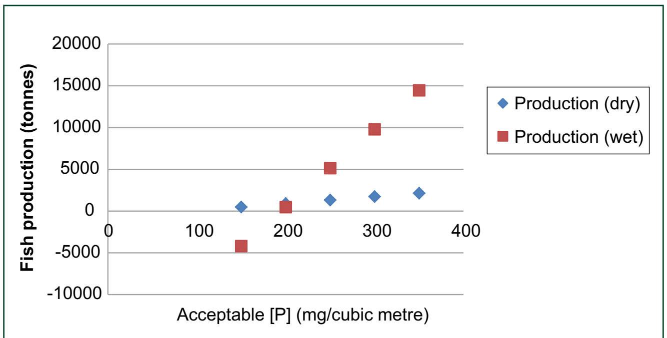


Setting acceptable P at 350 mg per cubic metre would mean that 2,138 tons would be allowed in the dry season and 14,448 tons in the wet season (so 2,138 tons to be safe) (see chart below). It is interesting that wet season production levels are always lower than dry season production levels and therefore determine year-round production at all FCR levels. When FCR is held constant and acceptable P varies, wet season production levels are higher and dry season production levels determine year-round production.

Some final issues must be considered regarding the introduction of aquaculture to Stung Chinit. First, we must be sure that the P levels do not violate Cambodian national standards for water quality. Those standards appear to allow P levels from 50-1,000 mg per cubic metre, so that should

Phosphorous acceptability

Effect of phosphorous acceptability criterion on aquaculture carrying capacity in Stung Chinit Reservoir



not be a problem. Second, we do not want to endanger the fish community that already exists in Stung Chinit and contributes to fishery catches. Monthly measured P values in Stung Chinit in 2008 ranged from 40-150 mg per cubic metre in the dry season and from 50-520 mg per cubic metre in the wet season. It is therefore likely that the fish community is already adapted to a wide range of P conditions in the reservoir and can cope with somewhat elevated average P values due to aquaculture. Finally, Stung Chinit averages only 1.5 m in depth, but has some deep areas that reach 10 m in depth. Whatever tonnage of fish production is allowed in Stung Chinit must also be consistent with good aquaculture practices of siting cages in deeper water. Thus, sufficient deep water areas must be shown to be available as part of the decision to allow aquaculture operations.

In summary, using P mass-balance modeling to project acceptable snakehead production levels in Stung Chinit Reservoir allows us, policy makers and farmers to see the impacts of different scenarios on potential snakehead production. It can serve as a template for modeling allowable levels of aquaculture in other Cambodian reservoirs and perhaps throughout Southeast Asia.

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References

Beveridge, M.C.M. (1996) Cage aquaculture (2nd ed.). Fishing News Books, Oxford, U.K.

Dillon, P.J. and Rigler, F.H. (1975) A simple method for predicting the carrying capacity of a lake for development, based on lake trophic status. Journal of the Fisheries Research Board of Canada 31: 1771-1778.

Fisheries Administration. (2011) The Strategic Planning Framework for Fisheries 2010-2019. Fisheries Administration, Ministry of Agriculture, Forestry and Fisheries, Phnom Penh.

Hardin, G. (1968) The tragedy of the commons. Science 162: 1243-1248.

McKindsey, C.W., Thetmeyer, H., Landry, T. and Silvert, W. (2006) Review of recent carrying capacity models for bivalve culture and recommendations for research and management. Aquaculture 261: 451–462.

Vollenweider, R.A. (1968) Scientific fundamentals of the eutrophication of lakes and flowing water with particular reference to nitrogen and phosphorus as factors in eutrophication. Technical Report DASISU/68-27. OECD, Paris.