Fact Sheet:

Estimating Aquaculture Carrying Capacity in Cambodia

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Aquaculture is absolutely necessary to feed the increasing population of the world. However, aquaculture can impact the environment in many ways, including habitat destruction, organic enrichment, introductions and transfers of species, harvesting of small pelagic fish from the ocean for fish meal, and so on. Organic enrichment of the environment is a major concern; that is, the feed provided to fish in cages that ends up as uneaten feed on the bottom, fish feces from undigested feed, and the ammonia that is excreted as a waste product by fish after they feed. As wastes increase, water quality declines, which can lead to increases in fish disease and mortality. **In other words, it is necessary to limit aquaculture production in any water body if we want aquaculture to develop in a responsible, sustainable way.**

A healthy environment provides ecosystem services, such as primary production by plants, nitrification (transformation of ammonia to nitrate) by bacteria, and decomposition (breakdown of dead organic material) by other bacteria. These processes allow ecosystems to remain in balance. When an industry like aquaculture organically over-enriches an ecosystem, the normal ecosystem services are overwhelmed, leading to an unbalanced, and possibly destroyed, ecosystem. With the expansion of aquaculture in both fresh and salt waters of Southeast Asia to meet the growing demand for fish, some water bodies have already exceeded their abilities to assimilate the wastes from aquaculture production. The need to determine the maximum amount of aquaculture that can take place in a given water body is great.

We can broadly define aquaculture carrying capacity (ACC) as the ability of the ecosystem to accommodate aquaculture, but more specific carrying capacities (CC) have also been defined. **Physical CC** is simply the maximum amount of aquaculture that can physically fit in a water body. **Production CC** is the maximum amount that does not cause unacceptable impacts to the **farms themselves**. **Ecological CC** is the maximum amount that does not cause unacceptable impacts to the **ecosystem**. **Social CC** is the maximum amount that does not cause unacceptable impacts to **human society**.

Aquaculture and ecosystems have each been the subject of modeling efforts for many years. A model is simply a representation of the relationships among variables and can range from very simple to very complex. Many types of models have been developed for aquaculture activities. Some of these models can be used to calculate ACC.

Aquaculture is expanding rapidly in SE Asia and there is great potential to exceed ACC in many common water bodies. Countries in the region would like to have and use models for lakes/reservoirs, rivers, and bays/estuaries. However, data to put into the models are quite limited, and there is uncertainty or disagreement within countries about what to protect, farmers only or whole ecosystems (i.e., production CC or ecological CC). It is clear that exceeding ACC in many places makes the aquaculture industry very inefficient due to high levels of disease or mortality, so efforts to calculate ACC and limit aquaculture development to sustainable levels will be rewarded by long-term aquaculture success.

Resource managers first need to decide what they want to protect (farmers, ecosystem, society), then try to calculate the appropriate carrying capacity. A variety of models can be used to predict the impacts of aquaculture wastes in the environment: benthic deposition models, water quality models, full ecosystem models, simple mass-balance models, etc. Use of each depends on needs, available data, and expertise of the user. Ideally, such models are used before aquaculture production begins, in order to allow regulators to only permit the appropriate amount of aquaculture and/or to properly site the aquaculture operations.

Some staff members at the Inland Fisheries Research and Development Institute (IFReDI) in Phnom Penh have been trained to calculate ACC in freshwater reservoirs using a simple modeling technique based on mass-balance modeling of phosphorus. Phosphorus (P) is used because it is the nutrient that most controls growth of plants in fresh water. Excessive plant and animal growth based on this excess nutrient leads to dying and decaying organic material that uses up oxygen as it decomposes. If we know the background levels of P in the water (based on monthly measurements for at least one year) before aquaculture is introduced (Pi), and we know the maximum P level that we want to allow in the water (Pf), then the difference between Pf and Pi is the amount of P that we can allow aquaculture to contribute to the system. Knowing this number along with some information about the fish feed, feed conversion ratio (FCR), the fish species being raised, and the water body (area, volume, flow rate), we can calculate the number of tons of fish that can be raised in the water body every year. That is the ACC.

IFReDI staff have conducted P mass-balance modeling of Stung Chinit Reservoir (Fig. 1) as a pilot project, using snakehead as a potential aquaculture species Because the reservoir‘s characteristics differ greatly between rainy season and dry season, they had to calculate ACC for each season and then conservatively use the lower ACC of the two seasons to determine the annual ACC. One interesting outcome of the modeling was that ACC depends greatly on the FCR, i.e., the conversion rate of fish feed into fish tissue. A lower FCR means that it takes less feed to make the same amount of fish tissue, so if farmers optimize feed and feeding practices to minimize FCR they can actually increase the ACC (Fig. 2) in both dry and wet seasons.

In summary, aquaculture production cannot grow without limits in a water body. Modeling of ACC allows us to limit aquaculture production to what the environment will accept and should result in fewer problems from fish disease and mortality.

Figure 1. Stung Chinit Reservoir in Kampong Thom province.

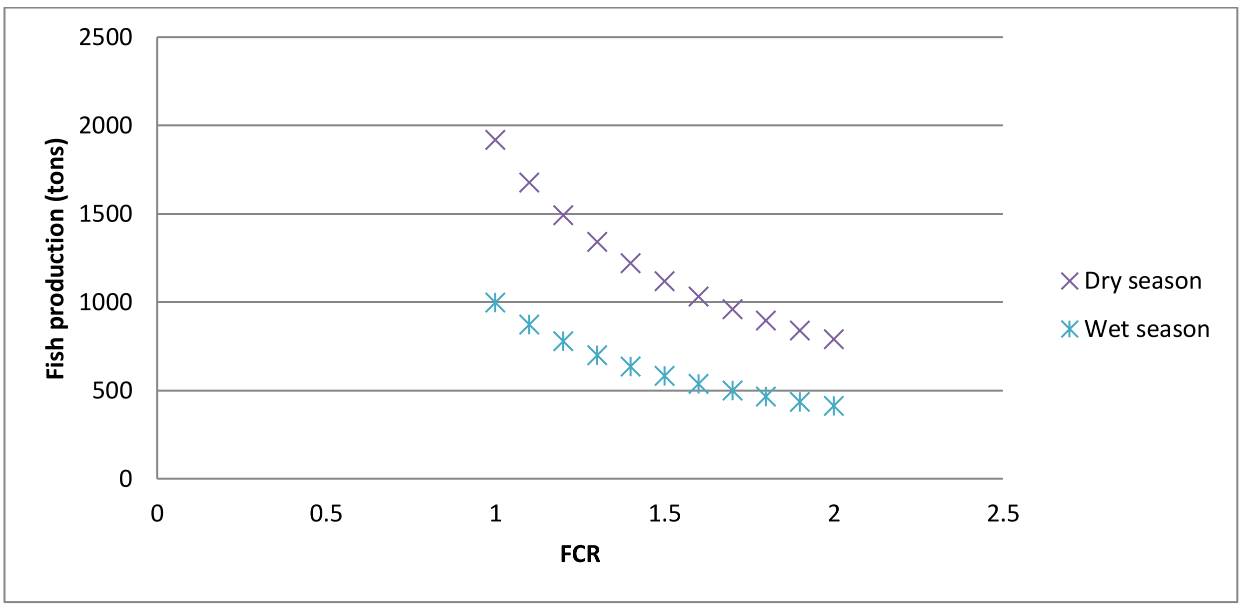

Figure 2. Effect of FCR on aquaculture carrying capacity in Stung Chinit Reservoir

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