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Managing environmental impacts in aquaculture

Aquaculture Department, Southeast Asian Fisheries Development Center

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Managing environmental impacts in aquaculture

The growth of the aquaculture industry has become an international phenomenon where the magnitude of the industry reached to a point where substantial environmental impacts have occurred. These impacts resulted in the reduction of production, disease outbreak in cultured and wild populations, and an increase of regulatory restrictions being placed on aquaculture operations. Environmental impacts include issues of recreation and aesthetics, as well as the uses of resources and discharge of nutrients and organic matter into the environment.

Analysis of the potential environmental impact of an aquaculture operation is an essential component of planning to respond to regulatory decisions with regard to the future of the aquaculture venture. Aquaculture operations should be developed and managed with considerations on how the facility's size, technology, and site will affect the environment. Degradation of the environmental quality has been caused by aquaculture operations. In some cases, the result of this concern has been the promulgation of regulations restricting the size of farms, the locations where farms may be developed, the amount of water used in a farm, the concentration of certain substances in the effluent water, and in some cases the total amount of a particular substance that may be released from an aquaculture facility. In other cases, environmental degradation has resulted in substantial reductions in water quality for the aquaculture operations themselves causing disease outbreaks and drops in production.

Resource costs of aquaculture production

Mass balances are convenient tools for examining the possible impact of aquaculture operations on the environment. The culture animals are fed with concentrated feeds as opposed to systems in which fertilizers are used and food production is carried out inside the culture systems. Inputs include feed, water, air or oxygen, and energy. Outputs include fecal and metabolic wastes, uneaten feed or the products of its decomposition, water and fish biomass. Mass balance can be defined in more detail for nutrients or substances (primary nutrients such as nitrogen and phosphorus, dissolved oxygen and organic matter) that are most likely to have significant effects on the environment.

Relationship between aquacultural operations and the environment

Cages. Fish production in 1989 was approximately 98 times the production in 1974. The amount of nitrogen released to the environment during the same time rose by a factor of 58 (from 200 mt to 11,600 mt) and phosphorus a factor of 50 (40 mt to 2,000 mt). The difference between the increase in fish production and rise in nitrogen and phosphorus release is explained by the improvements in feed conversion ratios and feeding practices. It is important to note that improvements were not caused by treatment, containment, or separation of part of the waste stream, but by its input to the system (feed quality and feeding practices). This approach, as opposed to efforts to treat the wastes produced, is understandable given the special characteristics of cage aquaculture and the difficulties that would be associated with containing, conveying and treating waste products from a cage.

Ponds. There are many transformations of nutrients and of organic matter that occur inside a pond, and these depend on how the pond is managed and on-site specific conditions of climate, soil properties, and background water quality. Approximately 17% of the organic carbon, 25% of the nitrogen, and 25% of the phosphorus in the fish are converted to fish flesh. Estimates are based on a feed conversion ratio of 1.6, a feed with 5% nitrogen, 1% phosphorus and 90% dry matter of which 10% is ash. Some of the nitrogen and phosphorus not fixed into fish biomass is lost from the pond as inorganic nutrients. Nitrogen may volatilize as ammonia, or as nitrogen gas if there is active denitrification in the pond, or it may leave the pond with the effluent in the form of ammonia, nitrite, or nitrate. Phosphorus tends to be less mobile and may be

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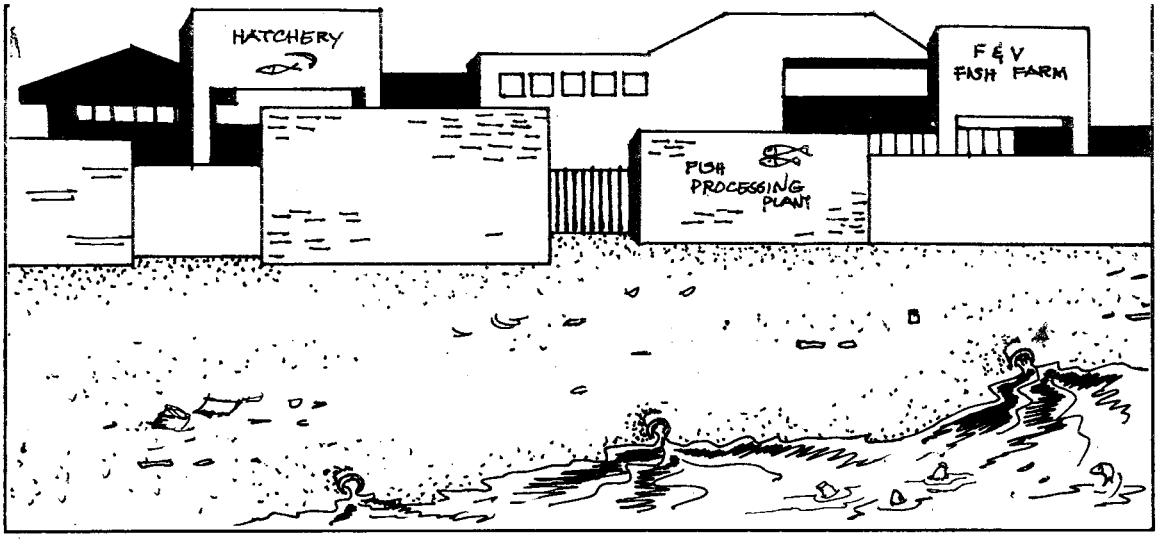

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the pond, or it may leave the pond with the effluent in the form of ammonia, nitrite, or nitrate. Phosphorus tends to be less mobile and may be lost to the pond sediments. Substantial amounts of nitrogen and phosphorus may, however, be lost from the pond in the form of organic matter, some of it actually produced in the pond. The production of 1 mt of catfish results in the production of 3 mt of algal organic matter. The estimate was obtained by difference (i.e., nutrient input in feed minus nutrient fixed as biomass)

Strategies for managing the environmental impact of aquacultural operations

Managing the environmental impact of aquaculture operations is usually limited to reducing the amount of water used and the amount of nutrients released, or of reducing and controlling the negative effects that nutrients released may have on the environment.

Site selection and integration with other activities. Site selection will affect the background concentrations of nutrients, the presence of other environmental "stressors" that may be affecting the overall quality of the ecosystem. Site selection will also affect the "tolerable" levels of nutrient release.

Site selection should be taken into account not only for nutrient releases and overall water quality changes, but also for issues such as the possible transmission of diseases. True quarantines are not technically practical or economically feasible in many aquaculture operations.

Aquaculture has been described as a non-consumptive user of water since water used in aquaculture is released to the environment while still being of very high quality, and approximately the same amount of water that is taken in by the aquaculture operation is released. Aquaculture is a benign water user and that effluents from aquaculture operations can be used in agriculture or other industrial applications. Although this may be true in some cases, it is important to consider the overall flow of various substances through aquaculture systems in order to develop a more comprehensive understanting of how aquaculture might affect the environment.

Input management. A reduction of nutrient inputs has been shown to be an effective strategy for lowering the amount of nitrogen and phosphorus released in the environment. The reduction in nutrient inputs may come in the form of improved feeds: lower feed conversion ratios and more efficient utilization of nutrients in the feed (e.g. nitrogen and phosphorus).

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