Aquaculture's Environmental Footprint
Some Findings Research on Shrimp Aquaculture

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Every use of resources has an impact. Science helps us understand the impacts and their implications. Ultimately, society must then decide which impacts are acceptable and which are not. Opinions about acceptable impacts and the decisions based on them can change over time.

So good science is important to any decision. However, so is inclusion and open debate on the subject. Perhaps the most important and the most neglected prerequisite of such dialogue is transparency. The kind of transparency that meetings like this should engender.

Such decisions are not ultimately about government versus industry or industry versus society. They are also about how industries react to each other in a globalized economy. Traditionally, the environmental costs of producing commodities such as those from aquaculture were passed on to society and, often, future generations. The low cost producers were often those who were allowed to pollute the most.

Better practices do cost money, at least in the short term. Who will pay? Who should pay? With globalization this is already an issue for both salmon and shrimp aquaculture.

It is within this context that WWF became interested in aquaculture, in general, and shrimp aquaculture in particular. We were interested in which form of producing shrimp, trawling or aquaculture, had the larger environmental impacts. Our work led us to two interesting observations. First, while both industries had tremendous environmental impacts, we believed that shrimp aquaculture already had technology and management systems that would allow that industry to reduce its overall environmental impact (Clay 1996).

Our second finding, however, suggested that one could say just about anything one wanted to about shrimp aquaculture and find the published science to back it up. We also found that most published articles were 4-5 years out-of-date before they went to press and this tended to perpetuate stale debates about old data. But, it was also true that many, both pro and con the industry, hid behind the fact that the data was old. Finally, we noted that publications tended to focus on either the positive or negative performance of the industry. Few writers focussed on how the performance could be improved (Clay 1997, Boyd and Clay 1998).

This then, is what WWF set out to do, with a little help from our friends.

The WWF/NACA/WB/FAO Consortium

In 1999, WWF joined with NACA, the World Bank and the United Nations Food and Agriculture Organization to create a consortium dedicated to the identification of ways that the environmental and social impact of shrimp aquaculture could be reduced. This work was undertaken because it was clear that one could say almost anything about shrimp aquaculture and find published sources to back it up. This issue is further complicated by the fact that most journal articles are, at best, 4-5 years out of date before they are published. Furthermore, few publications address specifically the ways the impacts of the industry are or could be reduced.

Over the past two years, the consortium has commissioned some 80 studies of various levels of detail from more than 20 countries involving nearly 150 researchers. Very few of the studies involved original research. Our goal was to generate more thorough, up-to-date and reliable information that could be used not only to discuss shrimp aquaculture but to help reduce its impacts.

Every use of natural resources has an impact. The question for society is which impacts are acceptable. The environment and social costs of production are often passed on to society. With many commodities, the lowest cost producers are often the most polluting. This is a very important issue within the context of increasing globalization and international trade.

Regarding shrimp aquaculture, reducing the impact of the industry will cost money. The obvious question, is who is prepared to pay this cost? Another question, however, is which of the initial costs will be repaid in the short to medium term? This then should influence the answer to the first question.

Many shrimp producers want to learn about better ways to run their operations, but few feel it is their responsibility to teach. They do not see that as their role. The purpose of the consortium's work was to fill this gap by identifying, documenting and analyzing those better practices that are already known locally but not necessarily widely practiced throughout the world. The purpose was to look at a wide range of issues from macro (e.g. zoning, carrying capacity, codes of conduct, and regulatory structures) to more micro (e.g. siting, pond construction, feed management, effluent treatment, and worker incentives). A goal was also to understand the costs of adopting BMPs as well as to understand other barriers to adoption.

Given that shrimp aquaculture is often a very contentious subject, one of the main goals of the consortium was to be transparent. The terms of reference for each of the cases was made available to anyone who wanted to comment on them. Many of these studies are now in draft form and available for comment. The suggestions from timely reviews will be addressed in the final drafts of the cases. To date the approach of the consortium and the initial lessons learned have been presented in more than 100 meetings attended by some 7,500 people.

Individual cases looked at BMPs for new and existing operations, for large versus small operations, and intensive versus extensive operations. The cases examined impacts at several scales--single interventions, farm-wide practices and operations, carrying capacity and monitoring issues at a watershed and ecoregional level, national and international issues and better practices and norms. Each case attempted to describe in detail the innovative practices and the degree to which they addressed impacts.

Once the individual cases are completed, they will be edited and translated into the appropriate language/s. The findings from studies on similar topics will be summarized into thematic documents. In one instance, some 18 country-specific studies have been summarized into one

thematic review on disease and disease management within the industry. Another similar thematic review has been prepared on what the industry has learned about the impact of its practices on mangroves and other fragile, coastal wetlands. Other thematic reviews will focus on such issues as best management practices (BMPs) at the pond, farm, ecosystem, national and international level; codes of practice; social and equity BMPs; feed and feed management; and the use of chemicals.

Some of the Preliminary Findings of the Case Studies

So, what did we find?

The findings are still very preliminary since many of the first draft's of case studies have not yet been received. However, there are some early indications of what ten of the findings may look like.

1. There are probably no "best" practices. There are better practices, and these practices have significantly lower impacts than worse practices. The range between better and worse practices is significant. Perhaps BMPs should stand for better management practices rather than best management practices.
2. Most of the impacts in any operation arise from only a few activities, perhaps 3-4. It appears that in two-thirds to three-quarters of these instances, mitigation measures pay for themselves in 2-3 years.
3. Most BMPs were discovered by producers trying to solve a problem.
4. The price of land, labor, and other inputs are increasing. Disease impacts are generally increasing. Shrimp prices are generally stable to declining for aquaculture sizes. Consequently, producers are seeking ways to reduce waste, create by-products, increase resource use efficiency, and increase the net income from their activities.
5. The learning curve in aquaculture is steep. Not everyone learns at the same rate. When industry says "we" know something, it is rarely true. Most of the industry has never learned as much as the innovators and those more in the public eye. However, it is true that learning is essential for industry to stay competitive, and most producers realize this. It is important to learn across countries not just within them. It is most important to learn how to think rather than what to think. The question is, whose role is it to gather the lesson learned and to teach?
6. Regulations don't tend to yield BMPs. At best, they yield compliance with management practices and performance levels that are politically acceptable. These are never the innovative practices that reduce impacts the most. While regulations are absolutely essential for the establishment of what is acceptable behavior, We should not look to them for innovations that might become the future standards.
7. The only outcome worse that an aquaculture operation with many impacts is one with many impacts which then fails.
8. It is clear that we need better, probably fewer, and certainly more cost effective indicators to monitor impacts. Furthermore, we need baseline date that often doesn't exist to monitor the impacts of the industry.
9. Growth does not solve problems or reduce impacts. More often, it compounds them. Reducing the impacts of shrimp aquaculture is all about the details.
10. There is no "one-size-fits-all" approach to reducing the impacts of shrimp aquaculture. What is appropriate in one area will not be appropriate in another.

Much of the rest of the talk will address some of the better and worse practices to show not only the contrasts but also the implications.

Siting of Operations

Worse Practices

Destroys mangroves or other important coastal habitats
Affects local hydrology, including saltwater intrusion
Requires more inputs and production downtime
Results in more stress and disease
Discharges effluents into intake zones for other farms

Better Practices

Built above high tide
No net loss of mangroves or other fragile wetlands
Intake and effluent canals sufficiently separated

Some analysts suggest that up to 90 percent of all subsequent impacts result from where a shrimp aquaculture operation is sited. While this is true of a single operation, the impacts are compounded by the cumulative impact of many different operations being built in an area over time. The first operation in a region will have some impacts, but the 10th, 100th, or 1000th will cause the biggest problems.

While the impacts of any operation in the world can be improved, retrofitting will rarely be better than a distant second best option. Even so, it could take 20 years or so before new ponds will represent most of the area in production.

BMPs change over time. For example, when the industry was beginning 20-30 years ago, shrimp farmers were advised to build on former mangrove areas. Today, it is known that this should never happen. This is the worst possible place to build. Ponds built on former mangroves have shorter life expectancies. This means that the investment is amortized over a shorter time. Ponds cost anywhere from $5,000 to $20,000 per hectare to construct. This is a considerable investment. Consequently most investors want to see the ponds last as long as possible.Similarly, ponds built in the wrong place require more inputs (e.g. lime, labor), more down time before restocking (e.g. to dry out for treatment). They perform more poorly (e.g. they have lower survival rates, more down time, higher water exchange rates). Simply put, they are not as profitable to operate.

While building above the high tide creates higher pumping costs, it also closes the ponds off from the ocean and can thus reduce other inputs and management costs and increase net profits.

Construction of Operations

Worse Practices

Causes erosion
Affects hydrology
Requires continuous maintenance
Leaves spoil piles and borrow pits that increase malaria vectors

Better Practices

Save and replace top soil
Re-establish ground cover
Use proper grading for slopes

In the traditional dirt-bottom farm, some 70 percent of effluents are bottom soil. This is caused by wind and water action as well as scouring during water exchange and draining for harvest. Not only does this produce more solids in the effluent, it also takes more labor, settlement ponds or canals, or other actions to reduce the impacts of problems that can be avoided through better construction practices at the outset.

Many construction issues result in financial impacts for shrimp producers. For example, it might cost $3,000 to $5,000 more per hectare of ponds to grade the slopes better, have a better mix of soils on the embankment, or to save and restore better soil and replant ground cover to protect the earth works from erosion. Those farmers who save money initially by cutting corners on construction costs often end up paying much more over time. In some cases, pond embankments have to be repaired after each crop, in others every year or so. Over a very short time, it would have been cheaper to have built the operation better from the outset. However, in addition to the direct costs (machinery, fuel, labor) of repairing embankments, producers also have production down time. For example, a farmer can loose more than 20 days of down time between each crop while he prepares the pond for cultivation. Over a year, this can amount to a month or more (or 1/4 of a crop) of down time. This is real money for most producers.

Water Exchange

Worse Practices
Use of freshwater to reduce salinity
Release of brackish water into freshwater systems
15 percent exchange per day or 200 m. per harvest

Better Practices
Closing the system
No use of freshwater
2 to 3 percent exchange per day for traditional systems
67 percent exchange per 130-day cycle in closed system
Water exchange rate based on objective reasons

The general trend around the world is to reduce water exchange rates. The better run operations in Asia use 3 percent or less water exchange per day and in Latin America 5 percent or less a day. These rates are down from the exchange rates of 15 percent or more per day that were common in the past. The reason that most farmers have reduced exchange rates is probably because water exchange may well pose disease risks for their ponds. Therefor, they keep such exchanges to a minimum.

There is still a notion, however, that water is a relatively free good. While we often hear about feed conversion ratios comparing the amount of feed to the amount of shrimp produced, we never hear about water conversion ratios. Water use is always talked about in percent exchange rates that are never related directly to production. If one changes the way the calculation is made it is quite interesting. Lower water exchange in more intense production systems allows them to have far better water conversion rates. For example, the shrimp in a shrimp cocktail are produced with 100 m3 or even 200 m3 of water on the one extreme as compared to only 0.4 m3 of water at the other extreme of actual practices today.

Species Selected for Production

Worse Practices
Wild-caught PL, by-catch and disease issues
Survival rates of 10 to 15 percent
No quarantine procedures
Introduced species through escapes
Use carnivorous species (require more fishmeal)

Better Practices
Hatchery produced animals, more disease resistance
Survival rates of 75 percent or more

Quarantine procedures
Use of local species
Use omnivorous species (require less fish meal)

The biggest environmental gains in shrimp aquaculture are likely to come from domestication and selective breeding programs. The impacts of these programs will be even more pronounced when compounded by similar gains in the development of shrimp feeds. These types of programs are only beginning at this time, however. Even so, there are some interesting preliminary observations.

At least 60 percent of all shrimp post larvae (PL) used to stock shrimp ponds are produced in hatcheries. This is helping to break the dependence on the wild and to reduce the impacts from capturing PL in the wild. However, most hatcheries still depend on the capture of wild broodstock. In this sense, the dependence on wild stock has not been broken. Operations with a number of different species are rearing their own broodstock in hatcheries. To the extent that these operations can produce disease free stock and reduce the risk of contracting disease from the wild, these operations will increase their markets for PL. Other areas where breeding programs offer as yet unrealized gains for the industry include time to market, feed conversion ratios (FCRs), protein content of requirements of feed, stress tolerance and disease resistance. Significant gains have already been made with some hatchery/grow-out operations achieving 90 percent survival rates.

The preliminary data suggest that more omnivorous shrimp species offer the greatest opportunity for reducing the overall level of fishmeal in the diet. While many shrimp require as much as 2-3 kilos of wild fish converted to fishmeal to produce 1 kilo of shrimp, omnivorous species such as P. vannamei have been produced at very attractive conversion ratios. One operation uses 0.7 kilos of wild fish to produce 1 kilo of shrimp.

Effluents

<u>Worse Practices</u>
Release untreated effluents
Release effluents into water bodies with low evacuation rates
Foul intake water with effluents
Excessive velocity of discharge causes erosion

<u>Better Practices</u>
Return better quality water to ecosystem than taken out
Use settlement ponds or canals to remove suspended solids
Use natural or artificial biofilters to remove excess nutrients
Use polyculture systems to remove nutrients

As shrimp farms become more intensive and as they become more concentrated in some areas, effluents have become a bigger problem. It is increasingly recognized that farms need to treat effluents before releasing them. Settlement canals and ponds are one option, but for many producers this means diverting land from production.

Even settlement canals and ponds only address suspended solid issues. Nitrogen and phosphorus are still problems. Some operations are using polyculture to reduce pollutants but to date there is far more talk about this than real on-the-ground experiments or practices. In rare cases, this is

being done in shrimp ponds, more commonly it is done sequentially with bivalves or other species filtering effluents in canals.

One of the most promising ways to remove nutrients is through bioremediation. Promising at it may appear, very few farmers are using bioremediation to treat wastes, however. One operation in Colombia has augmented a natural mangrove on the property to function as a biofilter. Through aggressive cutting, mangrove growth is stimulated to increase nutrient uptake. Consequently, 1 ha of mangrove processes the effluent from 2 ha of semi-intensive shrimp ponds. Till now, it has been assumed that 2-10 hectares of mangrove are required to filter every hectare of pond effluent from a semi-intensive operation.

As operations learn to close their systems, recycling water will become more common. In those instances reducing the creation of suspended solids from the walls and bottoms of ponds and canals will be very important. In addition, settling ponds and canals will be essential. However, the nutrients in ponds may not be as much of a problem. In fact, pond water is conditioned for growth. Learning how to reuse it may well reduce the time for conditioning new water, and this will be financially very attractive for producers by reducing the non-productive down time of their ponds.

Feed Management

Worse Practices
Use poor quality feed (e.g. raw fish, shellfish or fines)
Feed more than can be eaten
Feed one time per day (up to 30 percent wasted)
Feed Conversion Ratios (FCR) of 3 to 1
3 kg or more of wild fish to produce 1 kg of shrimp

Better Practices
Use formulated, extruded feeds
Feed multiple times with feeding trays to reduce waste
FCR of 1.1 to 1
.7 kg of wild fish for 1 kg of shrimp
Use water column in the pond to produce feed
Use worker incentives to reduce feed waste

The management of feed has improved tremendously over the past 30 years. Many operations use feeding trays to monitor feed use and to regulate how much feed is given. Whether feeding trays are used or not, it is clear that it is very important to stay abreast of how much feed is being given and consumed by the shrimp. In the past, up to 30 percent of feed was not consumed. Worse still, this set off a series of consequences. Uneaten feed causes water quality to deteriorate, this forces flushing but still usually results in animal stress and increased mortality. Consequently, even if feeding rates are reduced, overfeeding often continues which results in further deterioration of water quality and the cycle repeats itself.

Feed conversion ratios have been reduced over time as feed management and formulation have been improved. In the past feed conversion was as high as 3:1. Today, the industry norm is probably around 2:1. Some producers are down to 1.1:1.

One of the trends is the increased production of feed in the water column. This trend is likely to increase substantially in the future. This will reduce costs and effluents and increase resource efficiency.

Reduce Social Conflict

Worse Practices
Eliminate or reduce resources used by others
Eliminate or reduce access to critical resources by others
25 percent of labor costs spent on guards
Costs of barbed wire, lookout posts, theft
Expensive lawsuits
Business failure and lost investments

Better Practices
Be a good neighbor
Regular consultation with local people
Reliable, long-term workforce
Reduced costs
Spin-off Businesses or Joint ventures
Shrimp aquaculture as cornerstone for local development

Perhaps the area of greatest potential for shrimp farmers to increase the positive impact of the industry is in the area of employment, benefits and equity from the industry. While some individuals or companies have developed very innovative ways to address these issues in ways that provide benefits locally and increase net profits, most have not. Many producers, in fact, are resistant to adopting basic incentive systems that have been proven to work in many other businesses.

The shrimp aquaculture industry pays dearly as a result of social conflict. Companies have lost tens of millions of dollars as a result of conflicts with their neighbors, community groups and NGOs. A number of companies in different countries have gone bankrupt over such conflicts, others have lost their operating permits.

In many instances the expenses are more subtle but still come straight off the profits. Most producers have to fence all their ponds, set up watchtowers, hire guards, defend themselves in court or the press, travel to conferences for debates, take out ads to justify their company's operations, etc. All these things cost money. One company reportedly spends 25 percent of its labor costs on guards.

By contrast, some producers have attempted to address the needs and concerns of workers, neighboring communities and NGOs. It doesn't always work, but often solutions acceptable to all sides are found. At the very least, the problems and constraints are better understood.

There are operations that have such good relationships with their workers and neighbors that they do not have to fence their ponds. Some operations have so many training programs and benefits that working for them is very attractive. As a consequence, their turnover rate is 10 percent per year rather than 50 percent that is often common.

In Colombia, the cutting of wood and poles from a mangrove biofilter is a benefit to workers and local communities. Through their management, the company does not have to pay for this work. In exchange the workers have another source of income. In other instances, companies have spun off businesses to their workers so that they can concentrate on producing shrimp which is actually their business. These spin-off businesses include cafeterias, stores, transportation systems, laundry facilities for uniforms, etc.

There are other forms of benefits for workers as well. In Brazil, one operation has helped double the literacy rate in their immediate area. Their return has been a significant reduction in worker turnover and inefficiency. This same farm has had all its feeding trays manufactured locally as a way to involve local residents in their operation.

Perhaps the most promising internal program utilized by shrimp farmers is worker incentive programs. There is good anecdotal evidence from Latin America that worker incentive programs (right down to the level of the person that manages and feeds a pond) are extremely important ways to increase net profits at the farm level and wages and bonuses to workers as well.

At a wider level, many of the larger operations, particularly those in Latin America, provide directly (or because of their presence these things are provided by government) schools, health clinics, improved roads, electricity, and other infrastructure to neighboring communities.

There are joint ventures with local communities, equity in companies held by workers, and other forms of direct benefits that are in place at this time. In all these instances, workers or local communities that are happy with a shrimp operation are much more likely to defend it and even to protect it from others who would rob it.

Conclusions

While it appears that many if not most BMPs pay for themselves, there may be other ways than immediate financial self-interest to accelerate their adoption. Adoption of BMPs, for example, can serve as the basis for operating permits or licenses. They can also serve as the basis for investment screens. Many investors, for example, see BMPs as a way to insure the viability of an operation. Consequently, it reduces the financial risk of the investor.

BMPs can also serve as the basis of a purchase screen. A few hundred buyers in the largest seafood distribution companies buy the vast majority of shrimp in the world. A simple screen would allow such companies to make claims about how the producers they buy from are reducing their environmental and social impacts.

BMP screens could also be the basis of some sort of a certification program. I would favor a system that focuses on the 4-6 main impacts, however, rather than one that utilizes a laundry list approach. An environmental and social impact perspective it is more important to move the entire industry on the main impacts than it is to make a few companies "perfect." Finally, though, it should also be remembered that certification is as much about politics as science. A wide range of stakeholders needs to be involved. Industry developed standards, by themselves, will never be sufficient. Industry self-certification, too, will never be credible.

In closing, I would like to share a proverb from the Oromo, the largest group in Ethiopia. They have a saying that goes something like this, "You can't wake a person who is pretending to sleep."

Keeping this in mind, it is important for industry to "wake up." The industry does have impacts. Any industry does. Some of those impacts have been very serious and have affected many other people. But, there is also a lot of progress on reducing those impacts.

Opponents of shrimp aquaculture also need to "wake up." Shrimp aquaculture is a huge industry. It is definitely here to stay. Improvements have been made, but they are not universal. Improving the performance of the industry should be an overarching goal.

This is the current situation. How will we go forward from here? Will each group circle up the wagons, or will they begin to sit down and talk?

Let me leave you with a final question. A similar, multi-year study is being proposed for salmon aquaculture. Is this a good idea?

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