How Did We Get Into This Mess? Junk Science vs. Real Science[1]

Commercial aquaculture in the United States developed rapidly beginning in the 1960s, primarily in freshwater ponds and raceways. Marine aquaculture began a similar, though not as extensive a growth pattern in the 1980s. The rise of marine aquaculture paralleled the predicted decline in many capture fisheries that led to a leveling off of harvest in the 1990s. Aquaculture was expected to fill the gap in product availability associated with fully developed, and often declining commercial fisheries in the face of increasing demand by an ever-expanding human population. One driving force behind interest in further developing aquaculture in the U.S. was the fact that a several billion-dollar annual trade deficit developed between fish imports and exports.

The annual trade deficit in fisheries products is still in the multi-billions of dollars, global fisheries catch has peaked and remained fairly stable over the past decade, and now aquaculture is touted as being the most rapidly growing sector of U.S. agriculture. The last phrase, though probably correct, is misleading in that there is not currently much growth in any segment of U.S. agriculture, and the growth in aquaculture can only be considered anemic, at best. Recent events associated with increased imports are causing some economists to predict considerable declines in production of cultured channel catfish and salmon.

While there has been a considerable amount of optimism concerning expansion of the U.S. aquaculture industry the bottom line is that the U.S. is responsible for only about two percent of the world's aquaculture production according to United Nations Food and Agriculture Organization statistics. Why have the ambitious predictions of the 1970s and 1980s fallen so far short?

The Anti-Aquaculture Movement

The channel catfish industry was the backbone upon which expansion in the 1970s was based. Research results applied by catfish farmers kept those producers competitive and profitable as they continued to reduce their production costs in the face of what was sometimes double digit inflation. The research community, always looking for new species to culture, greatly assisted development of successful commercial production operations for salmon, hybrid striped bass, tilapia and shrimp. Expansion also occurred in the farming of trout and various types of molluscs. There were several changes in course along the way. The culture of domestic marine shrimp, for which there was a great deal of optimism in the 1970s, never developed as predicted. Instead, the industry turned to exotic species from Latin America and Asia. Freshwater shrimp was actively researched and a few commercial operations were established, but ultimately attention was shifted almost exclusively to marine shrimp species. Successful culture of such species as lobsters and crabs remained elusive and attempts to produce those species have largely been abandoned.

By the late 1980s most of the species being successfully raised today were in production and research was leading to improved performance and productivity. At the same time, some attention remained focused on the production of such new aquaculture species as red drum, sturgeon, abalone and mussels. More recently, efforts have been made to culture cobia, red snapper, dolphin (or mahi-mahi), tuna and others. Research on the culture of summer flounder, which had been abandoned in the 1970s, re-emerged in the 1990s and a fledgling industry is developing.

A sea change of significant proportions occurred in the late 1980s - or at least was recognized by the aquaculture community at that time - which began to deflate the bubble of optimism that had previously surrounded the domestic industry. The sniping at aquaculture, largely an activity of environmental groups but also joined by some in the scientific and regulatory community, and which was largely being ignored by aquaculturists, finally became so organized and focused that it could no longer be disregarded.

Many, if not most people who have become involved in aquaculture over the past three or four decades would tell you, if asked, that a major impetus for their involvement, whether as producer, supplier, processor, educator or researcher, was associated with a desire to bring high quality seafood to the marketplace. The profit motive cannot be disregarded, but a certain amount of altruism seemed to be pervasive. An analogy that I used in a keynote address to the triennial meeting of the World Aquaculture Society, National Shellfisheries Association and Fish Culture Section of the American Fisheries Society in Reno, Nevada USA in 1998 was that members of the aquaculture community had, until about 1988, considered themselves to be wearing the white hats (picture Roy Rogers, king of the cowboys). Most felt that they were fully credentialed environmentalists as one of their primary goals was to provide the best possible environment for the animals (or plants) with which they were involved. It is also safe to say that most aquaculturists have been the recipients of a good deal of formal education and consider themselves to be environmentally aware, sensitive and confident that their activities represent good environmental stewardship. Opponents hold just the opposite opinions.

Opponents of aquaculture, on the other hand, painted the aquaculture community as being the cowboys in the black hats (recall Clint Eastwood's character with no name in some spaghetti westerns in the 1960s).

The aquaculture community ignored the criticisms of the opposition, or at least gave them no credence, until the late 1980s when much of the discussion that took place at another triennial meeting in Hawaii revolved around how the industry

should deal with the opposition. The first major outcome was acknowledgement that critics had raised some legitimate issues that needed to be addressed. From that time until the present, a great deal of time and effort have been devoted to responding to an ever increasing number of criticisms.

One too many?

Much of the opposition to aquaculture development has been focused on coastal areas where aquaculture is typically the newcomer among users of environments that were already heavily burdened by the activities of those that came before. Boaters, fishermen, residential housing, resorts, commercial shipping, docks, marinas, birdwatchers, marine mammal watchers, heavy industry…and the list goes on and on. Was aquaculture the final straw? In some circles, it was apparently deemed to be so.

Boiled down to simple terms, the antagonism to development of aquaculture in coastal regions was seen as an invasion of the commons. Critics were not, at least initially, opposed to pond culture such as was, and is, practiced on private land – the primary example being the channel catfish industry. Putting culture facilities in public waters is another story. Primary targets were net pen operations that were becoming established in the states of Washington and Maine.

Culture operations on private land but adjacent to public waters have not escaped intense scrutiny and criticism. One example is shrimp pond culture in Texas. Operators of large shrimp pond operations were excoriated for releasing turbid water that was associated with shoaling of the receiving waters, eutrophication, escapement of exotics and the potential for introduction of diseases from cultured to wild shrimp.

Coastal waters in the U.S., as around much of the world, accommodate a wide variety of users. Perhaps the newcomer, commercial aquaculture, was the proverbial last straw. Other explanations for the severe opposition include the fact that the fledgling marine aquaculture industry is a convenient target of those opposed to development of any kind in coastal regions and of animal rights groups.

Target: Aquaculture

The broadsides of opposition to aquaculture have come from a number of quarters. Thus far, the response to criticism has been largely reactive, though it has also been associated with introspection. Some of the criticisms have a great deal of merit and have been addressed by the industry, often in collaboration with researchers who have developed appropriate responses to deal with what have been acknowledged as legitimate problems. In cases where opponents have been able to get their unsubstantiated and often grossly inaccurate views published in newspapers, magazines and, in some cases, respected scientific journals, attempts by the aquaculture community to set the record straight have largely been ignored. The truth just doesn't have the impact of the possibility, no matter how far-fetched, of an imminent threat of environmental destruction, loss of natural resources or threat to humanity by flooding the marketplace with unhealthy food. Claims of such nature have been a part of the mix and have received the attention of the media.

Each time the aquaculture community responds to a criticism by debunking it or, in cases where there is validity, responding by making appropriate adjustments in culture methodology, a new criticism is developed and the process is repeated. The problem is not global at this time but is focused on nations, like the United States, that do not depend upon aquaculture as a primary source of food for its people or as a much needed commodity for export to underpin their economies. Should the opposition be successful in eliminating commercial aquaculture in and around coastal waters in the developed nations, would they be satisfied? The likelihood is that inland aquaculture in those same nations would be the next target, followed by the much more difficult problem of attacking aquaculture in the developing nations where the activity is much more deeply entrenched and where it receives much more universal support from society. Notable exceptions to the generalities mentioned above do exist, of course. In Japan, for example, aquaculture thrives in a highly developed nation and marine aquaculture facilities are viewed in a very positive light because they provide high quality food. A group of net pens that would be considered an eyesore by some in the U.S. are viewed as an amenity in Japan. One can often find resort hotels overlooking aquaculture sites in Japan.

Elements of Controversy

'Concern' must be one of the most overworked words in the English language. If an individual or group expresses concern about something and can gain sufficient attention, demands will be made to address that concern, no matter how valid or

ludicrous it might be. It is very easy and inexpensive to develop a concern. It can be extremely difficult and commonly inordinately expensive to respond to a concern whether it is valid or not. A few examples of criticisms lodged against commercial marine aquaculture and steps the aquaculture community has taken or can take to address them are presented in the following paragraphs. The list is not meant to be exhaustive. To make it so would require an entire issue of **World Aquaculture**.

Exotic species

The majority of plants and animals used in United States agriculture are exotic species. There has been no demand to eliminate the production of swine, cattle, chickens, soybeans or potatoes, but exotic fish production has been roundly criticized. The difference is undoubtedly associated to some degree with familiarity. No one opposed to the introduction and use of exotic species was even alive when most of the exotic agricultural species were introduced. While exotic introductions of both plants and animals continue (particularly with respect to horticultural species), the focus of the opposition has been on aquaculture. Again, this may largely be associated, in part, with opposition to the establishment of aquaculture in the commons, though that explanation does not explain opposition to production of such freshwater species as grass carp and black carp which are produced on private land. Opposition to such exotic fishes relates to predicted environmental destruction that is predicted from escapees that establish reproducing populations, as has actually occurred.

Competition with native species and the potential for introduction of exotic diseases are common reasons given as objections to aquaculture introductions, including those of the freshwater fishes just mentioned and many others. In some cases, the objections are to translocation of a species from one area where it is native to another (e.g., use of European or Canadian Atlantic salmon in Maine) due to fears of deleterious alterations in genetic stock structure in the indigenous conspecific. Yet, there seems to be little or no opposition to the introduction of exotic landscape plant species or animals used as pets (including many ornamental fishes).

The junk science associated with the use of exotics in aquaculture comes largely from the predictions of dire consequences without, in many cases, direct evidence. Most predictions of disastrous results are based on little or no data but a good deal of emotion.

Several motives are behind the opposition to exotic introductions. One explanation may, once again, be that the industry is quite small in the U.S. and makes a convenient first target. Regardless of the incredible mix of exotic aquatic and terrestrial species into which a new aquaculture organism might be introduced in the United States, the most pragmatic approach is to avoid the use of exotics. When the use of native species is not possible, best management practices should be followed to eliminate escapement to the extent possible and protect against the introduction and transmission of disease.

Visual Pollution

The concept of visual pollution, which was the basis for some of the first objections to salmon net pen culture, has not been recognized by the courts, but it continues to be an issue with landowners who live adjacent to coastal areas where net pens are located within sight of their property. To deal with the issue of visual pollution, while at the same time defusing many other contentious issues associated with aquaculture in coastal waters, and in particular, in bays, fjords and estuaries, the same solution applies. That solution is to site activities in inland locations where water of suitable salinity occurs, in upland recirculating systems or by establishing facilities offshore, preferably out of sight of land. Inland saline waters are relatively scarce and the costs associated with recirculation systems and offshore culture are much higher than those for operations established in protected coastal waters. However, given the controversy surrounding marine culture activities, many are looking at one or more of the three alternatives as viable options.

Habitat Degradation

Opponents of marine aquaculture in coastal regions, in particular, have raised the specter of habitat degradation through a variety of mechanisms. Nutrients that leach from waste feed and feces, along with ammonia excretion by cultured animals have been cited as causes for eutrophication of coastal waters. Settling feed and fecal material can collect under net pens leading to gross alteration if not elimination of the normal benthic community; sometimes with the result being development of anoxic zones. Statements have been made that the waste from a net pen is equivalent to that from the wastewater in a small city. While the impacts on water chemistry of fish farm effluents and human sewage are not comparable in any way, such junk science claims have been picked up and widely reported in the media.

Proper sighting is one way in which such problems can be avoided. Facilities should be sited in areas that have sufficient currents to dilute and broadly distribute nutrients and particulate matter, the density of facilities such as net pens and total biomass of organisms at a particular site should be carefully controlled so as to not overload the system and it may be necessary to have a period of fallowing between crops to ensure that the environment recovers from even minor degradation. Frequent sampling should be conducted to monitor environmental quality. If degradation effects are observed, remedial action should be immediately taken.

By employing the proper techniques, the amount of waste feed from a culture facility can be minimized. In addition, feed formulations can be altered to reduce the level of phosphorus entering the water by providing that nutrient in more highly digestible forms than have been used in the past. Proper diet formulation can also lead to more highly efficient conversion of dietary protein to fish tissue rather than having as much of the protein burned for energy and the generation of ammonia as a byproduct.

Fish Meal

Opponents of aquaculture express concern not only about waste feed, but also object to the fact that fish meal is a commonly used ingredient in fish feeds. Some have indicated that it takes as much as 5 kg of captured fish to produce 1 kg of cultured fish. In reality, aquaculture is

a minor, though increasingly important, user of fish meal. Globally, terrestrial livestock feeding accounts for most fish meal utilization. Also, fish can, in general, convert feed to flesh more efficiently than any terrestrial food animal with the exception of poultry, and some fish are even more efficient than chickens. Research has been underway for several years to reduce the amount of fish meal used in aquaculture feeds by substituting various other protein sources. Some success has been achieved throughout the industry, with the shining example being channel catfish feeds, which currently contain extremely low levels of fish meal and are expected to have no fish meal in them at all in the near future. If fish meal is present as a small percentage of diet, several kilograms of fish can be grown on the fish meal produced from a kilogram of industrial fish.

Disease

Opponents of aquaculture express their concern about transmission of disease from cultured to wild fish, while aquaculturists fear just the opposite. Both points of view probably have merit. Certainly, when animals are crowded, disease transmission is facilitated. The fact is that diseases exist in aquatic environments and the aquaculturist must be constantly vigilant. Problems can be reduced through maintenance of a low-stress environment for the animals, vaccinating the fish when appropriate vaccines are available and treating at the earliest stages of an outbreak. Prophylactic disease treatment should not be conducted and when treatment chemicals are used, label directions should be meticulously followed. This issue is not one that can be resolved unless animals that are totally resistant to disease can be developed, which is highly unlikely any time in the foreseeable future.

Escape

A major issue with opponents of aquaculture is escapement. Fears are expressed that cultured (read inferior) fish will breed with wild fish causing dilution of genetic diversity and ultimately reducing the ability of wild fish to survive. If the escapees happen to be exotic species, they are predicted to compete with native species, leading to the displacement or direct demise of the natives through predation, competition for spawning sites, etc. As with all of the issues discussed thus far, there is the potential for the predicted dire consequences to actually occur, though few examples are available to support many of the claims being made. Regardless, the aquaculturist can be proactive in reducing the perceived threats. Biosecurity is critical and is important whether fish that escape can create problems for native communities or not. No culturist wants to see his or her fish escape because of the economic loss that would be incurred. And, yes, the culturists do share concerns about potential impacts of escapees on native aquatic species. Various techniques, including use of predator nets, preventive maintenance and frequent inspection for structural integrity will help ensure against escapement. When native species are being produced in situations where they can escape and intermingle with wild stocks, selective breeding programs should be designed to maintain, to the extent possible, the genetic diversity of the founder stock so that escapees are as genetically similar to the wild fish as possible.

Genetically Modified Organisms (GMO)

You may have seen reports that genetically modified salmon, called 'Frankenfish' by some, have been developed. The fish reputedly grew to extraordinary sizes very rapidly according to reports in the media. The fish farmers who developed these monster fish reportedly destroyed them out of fear that the fish might escape and wreck havoc throughout the world (which would be the basis for a new movie entitled "The Fish That Ate Chicago)[2]. It seems highly unlikely that any aquaculturist would use the term 'Frankenfish' in the first place, or that if they were proponents of aquaculture that they would use the term in public. Genetically modified fish are of interest to culturists, however, and some production of them is currently underway. Such fish will only be cultured in the U.S. with approval from the Food and Drug Administration, and such approval comes only after exhaustive study to indicate that the animals do not pose a human health threat. Scares about GMO rank right up there with those associated with food irradiation. Of all the examples mentioned, the GMO controversy has been the topic of more fear mongering than any other. It is fodder for those who distribute junk science.

Dealing with the Opposition

The aquaculturist is at a distinct disadvantage in dealing with the opposition. The aquaculturist must rely on existing scientific data or wait until data are developed if he or she is to refute the claims that are being made. Those making claims against aquaculture, on the other hand, have no need to let scientific evidence get in the way of their claims. Their message plays best when it appeals to raw emotion. Also of great importance is the fact that every time the aquaculturist addresses one issue, the opponents can come up with a new one. This is a seemingly never ending process – which is sometimes quite imaginative - with the opponents having nothing at risk, while the aquaculturist may have to seek research information, perform costly and repeated tests on water quality or disease diagnosis and often hire lawyers to help fight permitting battles. There is no simple solution for dealing with the problem. Attempts to get the media to present the full story rather than mostly publishing and airing the viewpoints of the opposition have not been very successful. Even rebuttals to articles in scientific journals that distort the facts are often rejected by the editors, which has undermined the credibility of some highly prestigious publications.

While success in blunting the objections of those opposed to various forms of aquaculture will not come easy, the alternative; that is, to do nothing, is not acceptable unless the aquaculture community is willing to largely abandon marine culture in the U.S. Aquaculturists have recognized that some of the practices that have been employed have led to problems. The opposition is certainly not totally wrong, but it is often unwilling to accept the fact that aquaculturists have willingly made honest and often costly attempts to remedy the real problems that have been recognized.

There are many associated with both the non-governmental environmental organizations and the ecological and

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conservation biology scientific communities, as well as state and federal agencies who are amenable to working with the aquaculture community in finding additional ways to provide an opportunity for aquaculture to thrive in an environmentally friendly operating mode. In addition, at least some courts have been convinced that commercial aquaculture can be practiced responsibly in coastal areas under existing permitting requirements.

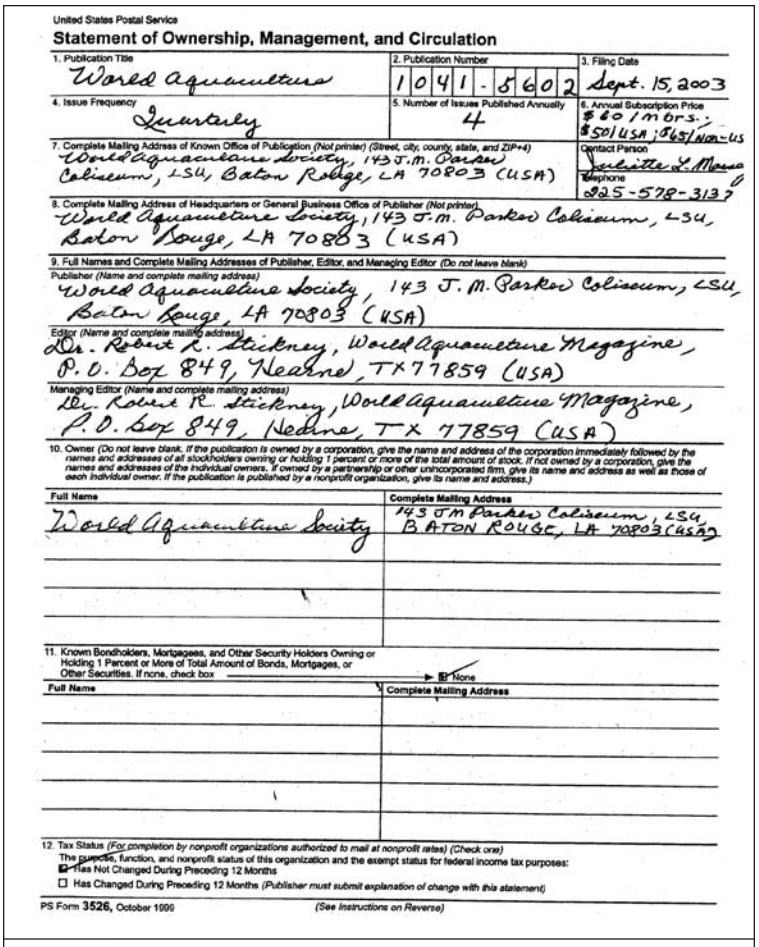
Reasonable people should be able to discuss issues such as those surrounding aquaculture and reach consensus on best management practices that will result in positive outcomes that are appreciated by all parties. The tactics of those extremists who want to curtail aquaculture will be blunted if well-intentioned parties can develop solutions that are acceptable to the majority and if the information is properly conveyed to the public. Responsible reporting of the facts is as important to the process as responsible production procedures. Clearly, there is a long way to go, but ultimately contentiousness often leads to exhaustion and the realization that cooperation and consensus building offer a much better method than extremism by either party in a dispute.

Notes

[1]Adapted from a presentation made at the Aquaculture 2002 meeting of the United States Aquaculture Society convened in San Diego, California USA in January 2002.

[2]Earlier this year (2003), on of my favorite novelists, Clive Cussler, published *White Death*, a great read that to my chagrin has an aquaculture firm as the villain. In the book, GMO salmon were decimating the food web in the Maritimes of Canada.

—Robert R. Stickney



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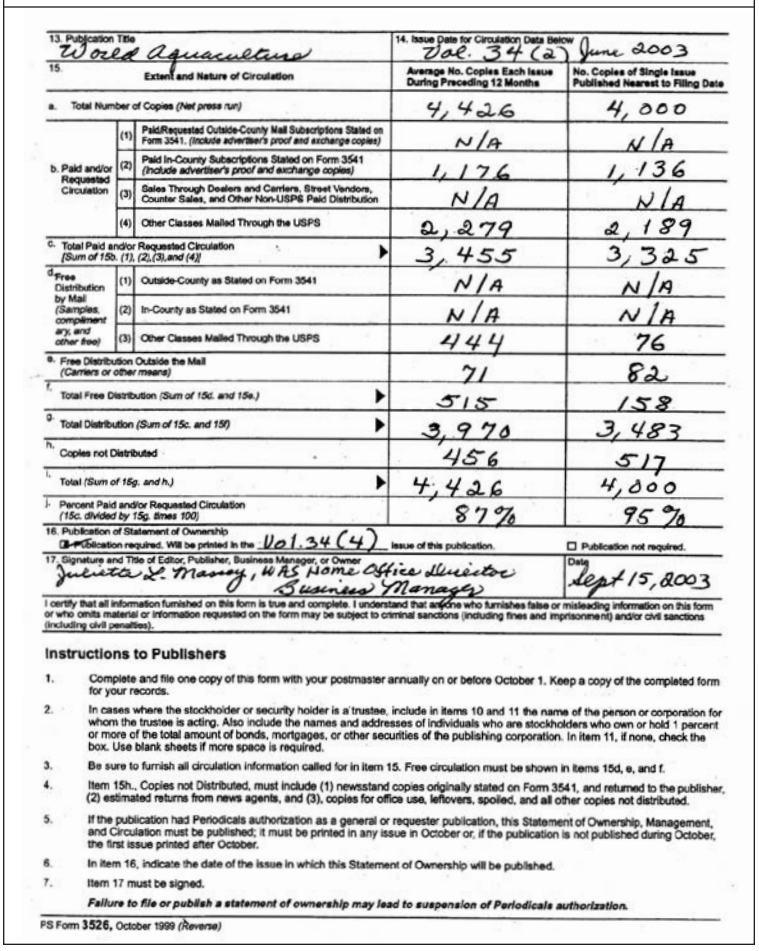

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