Sustainable Aquatics
110 W. Old Andrew Johnson Highway
Phone: (865) 262-0507 Jefferson City, Tennessee 37760 Fax: (865) 262-0498

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Cyanide and the Live Fish Business
John Carberry

This is a story that emphasizes the interconnectedness of many parts and processes in our world. In this case, it connects geography, mining, industry, fish for food, fish for ornamental use, culture and habits, politics, economics, the law, and all manner of human self-interests in the short and long term. It is in large-part a story about fish and cyanide.

Overview:

Cyanide is used widely today in the Coral Triangle to catch live reef fish. The Philippines is the largest supplier of live fish to the world and also has the largest diversity. The Philippine archipelago of 7,107 islands, of which only about 2,000 are inhabited, is at the northern part of the Coral Triangle. The Coral Triangle reaches to Papua New Guinea, the Solomon Islands, Vanuatu, Indonesia, and parts of Malaysia and the surrounding environs. These regions supply the vast majority of the live fish industry.

The live fish industry has evolved much during the past twenty years. Today live fish for restaurants now dominates the total shipments with about an 85% market share. In live fish shipments, food fish now represent 1 billion USD of the 1.2 billion USD market. Most all of the live food fish are caught with cyanide. This is done to avoid damage and injury (especially from hooks) but especially because it is much more efficient.

Many of the fishers who catch marine aquarium fish also catch live food fish. Cyanide is widely available in most countries in the Coral Triangle in-part because of the very large tonnage of sodium cyanide used in the refining process of gold and silver.

In the 90s much testing for cyanide was done in the Philippines, and by 1999 when the testing programs were shut down, it was estimated that cyanide usage for ornamentals had been reduced due to this program of testing to 8%. Today cyanide-use has been estimated to be over 90%. This is primarily because virtually all live food fish are caught with cyanide, and the fishers, who are also catching ornamental fish, have easy-access to cyanide.

Using cyanide to catch fish is against the law in most all countries in the Coral Triangle.

The Lacey Act makes it illegal to trade in illegally caught or collected wildlife, but the US Government will not prosecute unless certain conditions can be clearly demonstrated:

1) The importer “knew” the animals were caught illegally;

2) The importer acted with intent;

3) The exporting country has reasonable enforcement practices; and

4) The exporting country asks for prosecution in the US.

Given these perspectives, it may be that some importers and retailers are motivated to *not* know about cyanide use. Therefore it seems that this cyanide problem cannot be easily solved within the borders of the US alone. If something is to be done, it must be by personal and organizational initiative, one brick at a time. An easy, inexpensive, and reliable test for determining if a fish was caught with cyanide and using this test to qualify suppliers as being cyanide free could represent two of these bricks.

Testing for cyanide is possible, but there is still much to be learned about testing methods and about the biological processes involving how fish react and detoxify cyanide. There are many effects of cyanide at many levels and on many species that must be characterized to satisfy most or all constituents to force a solution to this problem by testing.

How Cyanide Based Fishing Affects SA:

Sustainable Aquatics' Sustainable Islands Division has found itself struggling, until recently, due in very large part to the fact that we hold and grow fish for long periods of time, some as long as 8 months. We learned that if we worked with cyanide-caught fish, we experienced very large delayed mortality, especially over the first three weeks. Delayed mortality is characteristic of fish injured through fishing with cyanide.

We learned that if we worked with cyanide-free net-caught fish, our losses were normally much less than 5% compared to the 30 to 90% losses seen with cyanide-caught fish. We learned that qualifying a supplier by holding their fish for three weeks and closely-monitoring health and mortality gave us a clear decision as to the use of cyanide and our ability to work profitably with that supplier. We now have a cadre of suppliers with whom the SI Division can do effective business.

It is noteworthy that we recently reviewed the list of qualified suppliers and found that they all were owned and managed by senior industry people with experience running importing businesses in the US and Europe. We assume that this experience informed them as to the exceptional value of cyanide-free fishing.

Most all of the rest of the supply chain, especially in the US, has very high velocity through their facilities, holding fish often for two or three days before moving them on to the next station in the supply chain. There seems to be very little data collected on systemic losses from catch to success in the hobbyists' care. We believe that most colleagues in the trade really do not know what the cyanide related losses are. We also believe that most of the animals may die from "unknown" causes in the hobbyists' care.

SA is working to understand the issues relating to cyanide and to work only with suppliers who pass our qualification testing, thereby offering fish that will do well for our retail customers and their customers and supporting cyanide-free collectors, even when this involves higher costs.

How Cyanide is used and works:

Cyanide is a compound of carbon and nitrogen with a triple bond between the two. It is most commonly available as sodium cyanide. It is a very lethal poison.

Fishermen use a squirt bottle into which they mix sea water and one or two sodium cyanide pills. They squirt this cloudy mixture over the reef, which exposes the fish to a cloud of sodium cyanide. The cyanide stuns the animals, making them easy to collect. This is also dangerous to the fishermen. In the seawater, sodium cyanide breaks down into ions of sodium and cyanide. In humans, it blocks the oxygen-transporting protein hemoglobin, which can cause rapid death. Probably because the oxygen content in sea water is so low, about 8 ppm, the hemoglobin in fish is much more efficient than humans, and so the cyanide is even more lethal to them.

Cyanide also interferes with enzyme processes, and in fish, this interference combined with stress can cause delayed death syndromes that go on for many weeks. Organs where enzyme processes are abundant suffer the most damage, such as the heart, liver, and kidneys. Here is an overview by Patricia Debenham in her paper *Background Paper on Cyanide Detection Tests for Live Fish* presented from the Proceedings of the International Cyanide Detection Testing Workshop in Orlando in 2008**:**

"Metabolism of Cyanide in Fish: Hydrogen cyanide enters a fish's bloodstream through the gills and intestine and is rapidly distributed to other body tissues. Cyanide is toxic to fish because it interferes with oxygen metabolism by blocking the key enzyme system, cytochrome oxidase (Metzler, 2001), and blocks enzymatic pathways in the liver (Solomonson, 1981). Some of the effects, such as blocking enzyme functions, are irreversible and lead to the death of the fish (Way, Leung et al., 1988). Once inside the fish tissue, cyanide reacts with thiosulfate in the presence of rhodanese to produce the comparatively nontoxic thiocyanate. The thiocyanate is excreted in the urine. Rapid detoxification enables animals, such as fish, to ingest high, sub-lethal doses of cyanide (Eisler, 1991)."

History of Cyanide use in the Live Fish Trade:

The use of sodium cyanide in fishing has been documented as early as the 1950s and reached a peak, especially in the Philippines in the 1990s before temporarily falling off.

In the time that has passed since the 90s, the use of sodium cyanide is believed to have risen dramatically, and now cyanide fishing dominates in the collection of both live fish for ornamental use and live fish for food use in many areas of the Coral Triangle. Several factors have combined to result in this redevelopment of cyanide fishing for the ornamental live fish trade:

- In the past twenty years, the trade in live fish from the reefs, especially in regions logistically near to major cities such as Hong Kong, has shifted dramatically from fish caught for ornamental trade to fish caught as live food fish. Whereas 20 years ago the majority of live fish sold was dominated by the ornamental side, today it is dominated by the live food fish trade. Reports peg the live food fish portion of the market at USD 1 billion today and the ornamental at USD 200 million.

- The fishers are generally catching fish for both markets: live food fish and marine ornamental fish;

- Most-all the live food fish are caught with cyanide. Marks from hooks or damage from other catch techniques are not attractive in these markets.

- Most of the regions where these fish are caught are also rich with mining operations for gold and silver, so that great tonnages of sodium cyanide are in the market and readily available to the fishermen.

- Since the fisher needs to have the squirt bottle in-hand for the live food fish, he also almost always has it in-hand catching marine aquarium fish, which are generally hunted at the same time in the same reef areas. For this reason, as the testing programs were shut down and as live food fish demand grew, the use of cyanide for marine aquarium fish recovered to very high levels.

Availability of Cyanide in the Coral Triangle:

One of the larger industrial applications for cyanide is refining of ore to extract gold and silver. The Coral Triangle is part of the "ring of fire," the volcanically-active area surrounding the Pacific. Gold and silver are often found in "veins" in volcanic structures, so gold and silver are widely found in these structures. As a result, there is an abundance of sodium cyanide everywhere in these regions. For instance, a consolidator in Manila does not have to supply cyanide to his fishers, or even "know" if the fishers are using cyanide. The fisher has many abundant sources for sodium cyanide, and because of this abundance, it is more-or-less impossible to control the fishers access to cyanide.

The cyanide extraction of gold and silver is based on dissolving of the gold and silver-bearing rocks in cyanide, given that the metals are very fine and very finely distributed in the rock. A sodium cyanide solution is milled with the rock, and the gold and silver are separated from the milled mixture as gold cyanide or silver cyanide solution. Often zinc is added to precipitate out the silver and gold metals. The zinc is then removed with sulfuric acid.

These mining and extracting operations are widely-distributed in most of the areas where live reef fish are found. It is thought that most of the heavy metals on earth, including gold, were originally formed by supernova explosions or colliding neutron stars. It is thought that most of the world's gold is at its center. Gold found in the earth's crust either came in from space on meteors or asteroids or was brought to the surface by volcanic activity.

The islands and regions where most of our live fish are caught were formed mostly by volcanos. For instance, the Philippines are processing about 35 tons of both gold and silver each year in a dozen or so discrete sites. This has resulted in a remarkable confluence of fishing and availability of sodium cyanide.

Testing for Cyanide, **Methods of testing for Cyanide**:

Testing for cyanide fishing can be done in several ways, but it is not always quick, easy, or inexpensive, and we do not know how long various detection methods might work after the fish was exposed. For instance, there are metabolic processes specific to each fish and the level of dose they received over time. In some cases, metabolites from the detoxifying processes can provide markers we can measure, for instance thiocyanate in fish urine, so there is a real need for sound scientific work to benchmark many of the metrics and processes.

This should change in the future, but only if someone has the will to make it happen. It is not a technology hurdle as we will see below. An example is SA's three-week qualification test for suppliers, which mirrors reports in peer-reviewed literature with regard to morbidity over time of fish exposed to cyanide, so called delayed mortality, or Death After Arrival (DAA).

1) Researchers funded by the Portuguese Science Foundation have developed a method of detection based on the observation that fish exposed to cyanide excrete thiocyanate anions in their urine as a means of cyanide detoxification. This anion can be detected quickly from water samples using an optical fiber and a liquid chromatograph:

   "Optical Fiber Based Methodology for assessment of thiocyanate in Seawater"; Journal of Environmental Monitoring, 2011,12,1811, Silva et al

   "Excreted Thiocyanate Detects Live Reef Fish Illegally Collected Using Cyanaide-A Non-Invasive and Non Destructive Testing Approach", PLos One, Vaz et al, April 2012, volume 7, issue 4, e35355

This link below will bring you to these papers describing this process and equipment:

   http://www.plosone.org/article/info:doi/10.1371/journal.pone.0035355

2) One can also micro-distill larger amounts of blood, water, and/or tissue and use various forms of analysis such as gas chromatography to find markers.

3) A third way involves keeping the fish for extended periods of time and tracking any losses in the supply chain for three weeks or more. Given not just our experience but also widespread reports in the literature, we know that losses of fish caught with cyanide and kept for extended periods of time are very large, and losses of net-caught fish are minimal. The difference is clearly statistically very significant and viable.

The Proceedings of the International Cyanide Detection Testing Workshop held by the National Oceanic and Atmospheric Administration, National Marine Fisheries Service NOAA Technical Memorandum NMFS-OPR-40 August 2008 reported these remarkable facts: "the testing appeared to serve as a deterrent, at least in the initial years, as the proportion of aquarium fish testing positive declined from about 43% in 1996 to 8% in 1999. Unfortunately, the numbers of fish testing positive for cyanide has increased in recent years, and most CDT labs were closed in the mid 1990s."

A helpful review of methods in use or being developed can be found in a paper:

"Recent developments in cyanide detection: A review", Jian Ma and Purnendu K. Dasgupta* Department of Chemistry and Biochemistry, University of Texas, 700 Planetarium Place, Arlington, Texas 76019-0065, United States, Anal Chim Acta. 2010 July 19; 673(2): 117–125. doi:10.1016/j.aca.2010.05.042.

The Proceedings of the International Cyanide Detection Testing Workshop held by the National Oceanic and Atmospheric Administration, National Marine Fisheries Service NOAA Technical Memorandum NMFS-OPR-40 August 2008 can be found in this link below. It is the most complete and cogent overview of the issue available:

http://www.nmfs.noaa.gov/pr/pdfs/nmfsopr40.pdf

This report details the testing experience of the Cyanide Detection Testing (CDT) labs in the 90s as well as a very comprehensive overview of this topic.

So testing for cyanide in the supply chain is not impossible, but it is currently difficult and expensive. It is in-part an immature science and technology at this time and very complex. It is fraught with very sophisticated biochemistry, molecular biology, physics, and biology. One can see this by reading all 175 pages of the workshop document from Orlando in 2008. Still, the results from the six labs in the Philippines in the 90s and our own self-awareness of the power of our political and economic resolve can and should allow us to conquer this problem with grace. But sadly, one must conclude that the Lacey Act will not be the solution:

The Lacy Act and why it is unlikely to Curb Cyanide use in Live Caught Aquarium Fish:

The Lacey Act, signed into law more than 100 years ago by President McKinley in May of 1900, is often cited as a means to deal with the cyanide problem. But here we find the government's position in this regard, and it is probably best to recognize the political realities underlying this analysis:

"Recommendation 8: Implement Complementary Legislation against Cyanide Fishing in Importing Countries from the Proceedings of the International Cyanide Detection Testing Workshop in Orlando in 2008:

"The officials of exporting countries at the workshop strongly advocate U.S. legislation regulating the ornamentals trade. This legislation would be fundamental for building political will and designing regulation and enforcement in exporting countries. The legislation or Code of Federal Regulations (CFR) could make U.S. imports of fish containing cyanide illegal, as well as clearly state standards for permissible imports (e.g., exporting partners must have testing system in place, species restrictions, habitat impact assessments and protection, etc.). The Lacey Act makes it illegal to import, export, transport, sell, receive, acquire, or purchase fish, wildlife, or plants taken, possessed, transported, or sold in violation of a federal law, treaty, regulation, or Indian tribal law. It also is illegal for a person to import, export, transport, sell, receive, acquire, or purchase in interstate or foreign commerce: fish or wildlife taken, possessed, transported, or sold in violation of a state law, state regulation, or foreign law (16 U.S.C. §§ 3371-3378). Since most exporting countries have laws banning the use of cyanide and other poisons for fishing, a large portion of the aquarium fish imported to the United States (an estimated 90%) are illegal under the Lacey Act. However, enforcement of the Lacey Act is difficult and time-consuming. For example,

- *A successful case must show importer knowledge and intent to import illegal fish.*
- *Origin countries must have good faith enforcement efforts in place.*
- *A U.S.-based investigation under the Lacey Act must be supported by the nation whose law or regulation was violated.*
- In the case of cyanide, the fish samples would not be analyzed in the United States until three weeks after time of import because of backlogs and resource constraints. These shipments would have been processed, shipped to retailers, and sold by that point.
- The United States is unlikely to rely on accuracy of a cyanide test performed in an exporting country.
- The standards for a test to be considered legally enforceable in the United States are high: the test would have to be peer-reviewed, reliable, and in-use for a period of time.
- Each case takes hundreds of hours per shipment to prove. An effective enforcement effort would immediately overwhelm the current system resources."

Note that it can be inferred here that the US government, through this publication, is indicating its belief that 90% of marine ornamental imports are illegal. Also note that the government itself is saying in the first bullets (italicized by me for emphasis) that ignorance of the use of cyanide is an *asset* and not a liability. The second and third bullets require many governments to actively enforce their laws and make a complaint to us under the Lacey Act for this law to apply here in the US.

New Approaches and Developments to Deal with the Problem of Cyanide use in Live Aquarium Fish by testing:

There are several approaches that can be used or are in development, approaches which can be helpful to us in the live fish business. However, it would seem based on the analysis above that the reason there is virtually no testing is because given the wide spread use of cyanide, the status quo demands we not know.

It seems that there are three general methods to test or control for cyanide:

1) Test for presence of a cyanide marker in urine from shipping water (testing for thiocyanate by liquid chromatography);

2) Test the tissue or blood of sacrificed fish for cyanide markets; or

3) Qualify collectors by holding fish in healthy systems for 21 days where the difference in losses between cyanide-caught fish and non cyanide-caught fish has been shown to be significant.

Since we in the United States have very little control or influence using the first two methods today, and there are fair and reasonable scientific objections or questions to be addressed and answered, we must use the power of our checkbook and purchase-orders to have influence. There is this third option as a way of managing trade and motivating suppliers: By only purchasing from a supplier who can be qualified in a three-week holding test and by paying profitable prices for net caught fish.

Based on the situation today, testing will most-likely have to be done at receipt here in the US. A method for testing for cyanide here in the US by sampling shipping water will most-likely require significant work and data to be credible.

Using fiber optics in liquid chromatography to sample shipping water for thiocyanate can be done reasonably fast (a few minutes per test) with equipment that is reasonably inexpensive and is relatively easy to operate. When measuring the level of thiocyanate, we need to be able to infer if the animal was exposed to cyanide for catching or not: a “go,” “no-go” gauge. The level of thiocyanate can tell us if it was cyanide caught only if we have tables and curves which can characterize these variables:

a) The type of fish
b) The size of fish
c) How much time since the fish was caught with cyanide
d) Exposure/dose of cyanide
e) Volume of shipping water
f) Duration in the shipping bag
g) Since fish detoxify cyanide in their system at different rates, this will result in differing amounts of thiocyanate present in the shipping water. We must then be able to estimate the exposure or

dose of cyanide in the time-frame since capture to confirm cyanide fishing by correlating this variable “processing rate” to the amount of thiocyanate in the bag.

h) Comparison to control tests

SA will begin this development work in the early part of 2014. We hope to have a calibrated peer-reviewed method and database by mid-year 2015. We will then begin disciplined testing on all our incoming shipments. We will also offer testing services to the industry and community through a new Division of SA to be formed at that point, Sustainable Aquatics Analytical Services. SA Analytical Services will also offer turnkey systems and training should any entity wish to do testing at their own facilities. Anyone should then be able to control cyanide and certify wild-caught cyanide-free animals.

Other causes of delayed mortality in Wild Caught Marine Ornamental Fish:

To be sure, fishing with cyanide is not the only cause of delayed morbidity in wild-caught marine ornamental fishes. Starvation is another key cause.

Most marine ornamental fish from the reefs of the equatorial and near-equatorial areas spend most all of their day eating. They have short gastrointestinal tracts and also have limited capacity to store energy in the form of fats. As a result, they are not well-suited to fasting for very long. When they are subjected to long fasts, they can quickly begin ketosis as a source of energy for survival. During fasting or starvation, the body starts using fatty acids instead of glucose. Ketones are generated in the liver that allow this metabolic state where vital elements and tissues are converted for energy. Once a certain level of ketosis is reached, the trauma to the animal can be irreversible. Often, the trauma to the organs is severe enough that a first feeding following the fast can cause a toxic shock with near-term death.

Most of the feeds in our market are thermally processed, which denatures the fatty acids, the omega III and antioxidants which are critical to animal health and to good taste. Presenting wild-caught animals with a feed that is not thermally processed and preserves these ingredients elicits a more aggressive and healthy feeding response.

Conclusion:

This white paper has been viewed by some as an advertisement for SA. It is a description of a problem and some approaches to addressing this problem. SA is pursuing these approaches aggressively. All of the colleagues in our industry have available to them the ability to pursue these same approaches, and SA stands ready to collaborate. Last year at the annual National Animal Interest Alliance meeting in California, Dr. Temple Grandin stood up and lectured us on the importance of cleaning our houses, opening our doors, and inviting all in to see what we do and how we do it. She said that if we do not do this ourselves, the government and others will do it for us. Here is a report on The McDonald’s Corporation’s approach to her advice:

“Executives at a global corporation have turned to a woman with autism, and they've asked her to transform their industry. The company is McDonald's—they've launched the first campaign of its kind to pressure slaughterhouses that provide their meat to dispatch the animals more humanely. As we reported in **Cracking Down on Egg Suppliers*****, the company is also pressuring animal farmers to change their ways. The record suggests that the company is partly reacting to political pressures, but whatever the motives, McDonald's is prompting the entire U.S. food industry to make "animal welfare" a major issue. And executives say they couldn't have done it without Temple Grandin.***

SA is committed to follow Dr. Grandin's wise advice. Doing so compels us to take, to a daunting degree, a no-compromise approach.

As far as quality, customers chose to buy loyally from a supplier because they appreciate the animals: their color, size, health, variety, and especially the high level of survivability. This is more-easily achieved in hatchery operations where one can control all parameters from broodstock nutrition through growout. However, in the case of wild-caught fish, this level of quality necessitates a different and to some degree more complex set of protocols. An operator must know that partners and suppliers can be relied-upon to follow these same protocols. Assuring that one is handling net-caught fish free of cyanide is a key element to assuring this.

Two key things happen when fish are caught with sodium cyanide: First there is a critical enzyme inhibition that results, among other things, in an inability of the animal to handle stresses they need to manage. These include stresses due to catching, shipping, spending time in a bag with elevated ammonia and depressed pH, starvation, and so on. Estimates of mortality from these stresses are from 30 to 98%. Secondly, there is endocrinal damage, especially to the liver and kidneys. This injury can take weeks to play-out in what we call delayed mortality, or death after arrival (DAA) as opposed to being dead on arrival (DOA). Fish caught with nets and without cyanide survive these stresses as much as 98% of the time.

We must all observe that cyanide-caught fish are hurting our industry and our hobby. Many retail store operators recognize that cyanide-caught fish die in the care of the hobbyists. This is unfair to the hobbyist and unfair to the industry. Many potentially-successful aquarists leave the hobby prematurely -- discouraged by their inability to keep targeted pets alive.

It is common-practice in our industry that the consolidators in the locations where the fish are captured, the catchers themselves, the wholesalers in the United States, and even retailers seldom keep the animals in their care for more than a few days. There is no chain-of-custody record-keeping, so the full impact on survivability (from capture to success in the hobbyist aquarium) is not known. If we are to thrive as an industry, we must assure that the animals do not end-up dying for "unknown" reasons in the care of a dutiful hobbyist because they were caught with cyanide.

Seeking to assure one is offering cyanide-free fish on the basis of a three-week minimum "qualification test" where one keeps the animals separated for observation is one avenue. Many in our industry protest that they do not "know" if the fish are caught with cyanide, and since there is no way of knowing, they are doing the best they can. The references above teach us a key reason that such knowledge is a liability. Since the residence time is so short, there is not a short-term economic benefit from such knowledge.

We must be highly motivated to know. For instance, the difference in mortality here in the SI division between net-caught (cyanide-free) fish and cyanide-caught fish is so stark that we can defiantly say a supplier can be qualified as being one or the other. Since we pay the economic price for cyanide-related losses based on our industry-leading holding times, our motivation to know is of course in-part seeking to do the right thing, and in-part seeking a very high yield so we can survive and succeed economically.

Of course anecdotal proof of the collectors supplying fish caught with cyanide can be evidenced by micro-distillation of the shipping water and analysis through performing gas chromatography, but the three-week test is even stronger in our opinion because it is not a sample; the entire shipment is quarantined and cared-for with the best husbandry and meticulous records. Testing shipping water for thiocyanate using fiber-optic liquid chromatography will elevate the reliability of testing for cyanide such that it could be universally employed.

The goal of everyone in this industry is the success of the hobbyist and the success of the retailer helping to entertain, educate, and serve the hobbyist. Our animals, whether from the hatchery or from the ocean, will provide the highest survival-rate and commercial success for the hobbyist, and we must guarantee this. We can best-assure this by knowing to the full degree possible that wild fish are collected without cyanide, and this is one of the foundations behind this guarantee. A three-week test today is at minimum a good start toward better testing in the future, which we hope to offer in 2014.

Postscript:

Humans can be said to be very good at simple, short-term problems. It comes in large-part from our evolution as hunter-gatherers over millions of years. The most mature humans pay close attention to their emotions and use reason, delayed gratification, knowledge, and experience to *proactively* make the wisest decisions. Less wise humans *react* based on emotions with short-term, simple perspectives. It can be that we *listen to ourselves* when we read and react to emotion, and we *talk to ourselves* when we process what our emotions tell us, and then act through reason, wisdom, delayed gratification and principals. We need to do both, first listen, then talk.

The use of cyanide to catch live fish has had two dramatic effects on the harvest of live fish in the Coral Triangle:

1) It has made the harvesting of hump-head wrasse, coral trout, and groupers for the live fish food industry very efficient, resulting in continually-reduced harvest in tonnage and continually-escalating prices for the fish (it has appreciated the value of each fish)

2) It has made the harvesting of the many species of marine ornamentals much more efficient, but as yet it has not caused reduced harvests, meaning with the much reduced yields, it has resulted in dramatic reductions in the price of the fish (it has depreciated the value of each fish).

The demand for live fish is growing in most all markets, and it is very unlikely that the ecosystem can supply the demand going-forward unless we expand farming. In many cases, this will require significant investments in technology. The incentive to invest in these technologies is being enhanced by the appreciation in the value of the live food fish caused by shortages resulting from cyanide fishing. In the case of marine ornamentals, the incentive to invest in breeding animals is severely depreciated by the effects of cyanide fishing.

Where will all this take us if it continues as it is now? Well, there will most likely be investments in the live food fish based on the high value of the product caused by shortages. But if cyanide fishing for ornamental fish continues unchecked, it is unlikely that the economic incentive to invest in the technology for breeding these animals will arise until the last reef is destroyed by exploitive cyanide fishing and the value of the fish rises to profitable levels. Solving this problem earlier than later and well before this deadly “endpoint” will save the enormous and vital world resources that are the ecosystems and reefs that are the Coral Triangle.