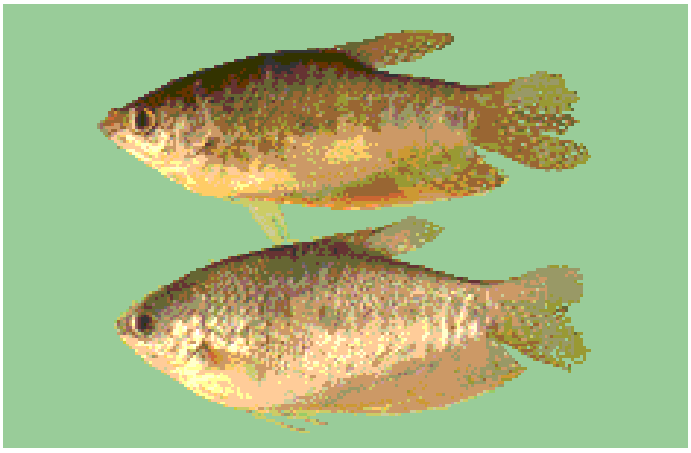
A Manual for Commercial Production of the Gourami, *Trichogaster Trichopterus*, A Temporary Paired Spawner



Brian Cole, M.S., Clyde S. Tamaru, Ph.D., Richard Bailey, B.A.
Sea Grant Extension Service/Aquaculture Development Program
School of Ocean and Earth Science and Technology

Christopher Brown, Ph.D.
Hawaii Institute of Marine Biology
School of Ocean and Earth Science and Technology

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Introduction to the Gourami

All gouramis belong to the suborder *Anabantoidei* and are commonly known as the labyrinth fishes. These fish are characterized primarily by an accessory breathing organ called the labyrinth organ. The labyrinth organ is located next to the gill cavities and is made up of folded membranes mounted on a bony frame. The delicate tissue has a high concentration of blood vessels and functions much like a terrestrial lung. If a labyrinth fish is denied access to the air it will drown because the gills alone will not provide sufficient oxygen to the fish.

There are over one hundred *Anabantoids* that are currently traded in the tropical fish industry. Many are color varieties of the same species within the various genera. This would include about thirty species in the genus *Betta*, about twenty species of *Ctenopoma*, several species in the genus *Colisa, Macropodus, Anabas, Helostomidae, Pseudomodas* and *Sandelia* and the numerous species of *Trichogaster*.

The genus Trichogaster contains many of the more popular gouramis traded in the industry, including the "Pearl gourami", "Moonlight", "Snake skid", "Three spot", "Blue", "Silver", "Gold", "Opaline" and hybrids in the same genus. All of these fish reproduce in a very similar manner and for that reason this manual will concentrate on the Genus Trichogaster. It should be noted that many of the procedures for the reproduction of these fish can be successfully applied to many of the other genera of gouramis.

Taxonomy

There are 16 genera and 50 species of *Trichogaster* distributed over Asia, the Indian subcontinent and Central Africa (Degani et al., 1992 and Alfred, 1962). Like the nomenclature of many other families of fishes, there has been a considerable amount of renaming and \ or reclassification at the level of genera or species. The Gouramis are no exception. *Trichogaster Trichopterus*, the "Three Spot Gourami", was originally known as *Labrus trichopterus*, then in 1801 was renamed Trichogaster Trichopterus which is the present classification (Richter 1988). Other names which might appear in the literature include *Trichopodus Trichopterus, Trichopus trichopterus, Trichopus sepat, Osphromemus siamensis, Osphromenus trichopterus, Trichopus siamensis, Trichopodus maculatus* and *Osphromenus saigonensis*. Most of these changes in nomenclature occurred in the mid 1800's until the current name, *Trichogaster Trichopterus*, was settled upon as the standard classification. Table (1) gives the current taxonomic classification of the *Anabantoids* (from Richter, 1988).

Table 1. Current taxonomic status of the Anabantoids (Modified from Richter 1988.

ORDER	*Perciformes*
SUBORDER	*Belontiidae*
FAMILY	*Belontia*
SUBFAMILY	*Trichogaster, Colisa*
GENUS	*Anabantoidei*
SUBFAMILY	*Belontinae*
GENERA	*Trichogasterinae*
SUBFAMILY	*Ctenopinae*
GENERA	*Pseudosphromenus, Parosphromenus, Malpulutta, Trichopsis, Ctenops, Betta*
SUBFAMIL	*Macropodinae*
GENUS	*Macropodus*
SUBFAMIL	*Spaerichthyinae*
GENERA	*Parasphaerichthys, Sphaerichthys*
FAMILY	*Helostomidae*
GENUS	*Helostoma*
FAMILY	*Osphronemidae*
GENUS	*Osphronemus*
FAMILY	*Anabantidae*
GENERA	*Anabas, Sandelia, Ctenopoma, Oshimia*

Biology

Distribution

Labyrinth fishes are only found in southern and western Africa and eastern and southeastern Asia. Figure (1) represents the natural range of these fishes. The natural distribution of Labyrinth fishes has a northern boundary in China at latitude 50 degrees. The eastern boundary of natural distribution is in Korea at a longitude of 130 degrees. The southern most ranges are in Sumatra south to the equator with the western limits in India to longitude 70 degrees east. *Trichogaster Trichopterus* occurs naturally in southern Vietnam, the Suda Islands, Thailand and the Malayan Peninsula (Richter 1988).

Trichogaster Trichopterus is the most common species of fish in rice-field areas and is sometimes collected for food in certain parts of Asia and Africa (Alfred 1962). Generally the *Trichogaster* spp. inhabit the thickly vegetated areas of rivers, canals, ditches, lakes and swamps to avoid predation from birds and fish.

Figure 1. Natural distribution Anabantoids

Morphology

Most of the labyrinth fish have developed very similar types of fins as illustrated in Figure 2. In addition many of the Anabantoids exhibit some form of sexual dimorphism either in the form of color and \ or differences in the finnage. *Trichogaster* spp. are good examples of finnage dimorphism. The males dorsal fin is longer than the females and reaches back to the caudal peduncle. The "Dwarf gourami" exhibit color dimorphism. The males display much brighter color as well a wide range of color combinations while the females of any given strain have only a dull silver color. The *Betta splendens* male exhibit both color and finnage dimorphism. The male has much longer fins than the female and usually has intense body color. The female in contrast has short fins and a very dull color.

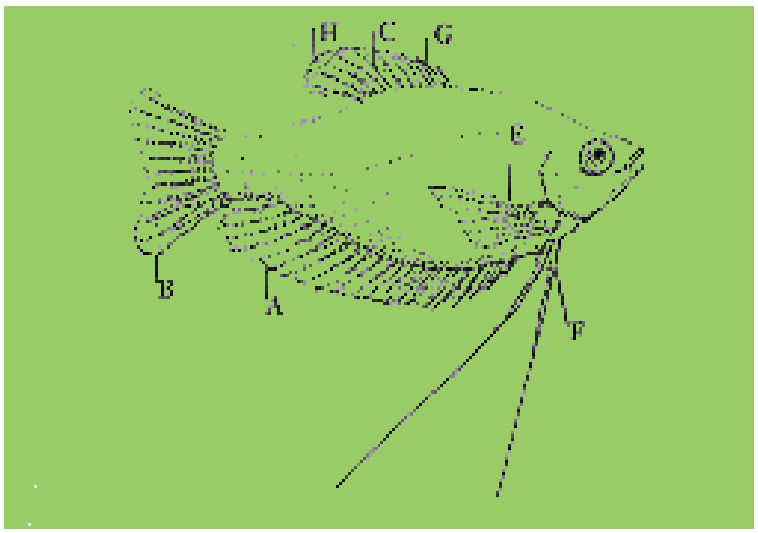

Figure 2. Typical finnage of Trichogaster Trichopterus. *A = anal fin; B = caudal fin; C = dorsal fin; E = pectoral fin; F = ventral; G = dorsal spine; H = dorsal rays (branched or soft).*

Sexing

Within the genus Trichogaster one of the most reliable methods for sexing the fish from a very young age is inspecting the dorsal fins. Males characteristically have a longer dorsal fin, usually long enough to reach the caudal fin when relaxed or laid down along the back of the fish as shown in figure 3. In the females the dorsal is always shorter, sometimes just long enough to touch the caudal peduncle as shown in figure (3). In addition a mature female will be much rounder in the stomach region and may be smaller than the male.

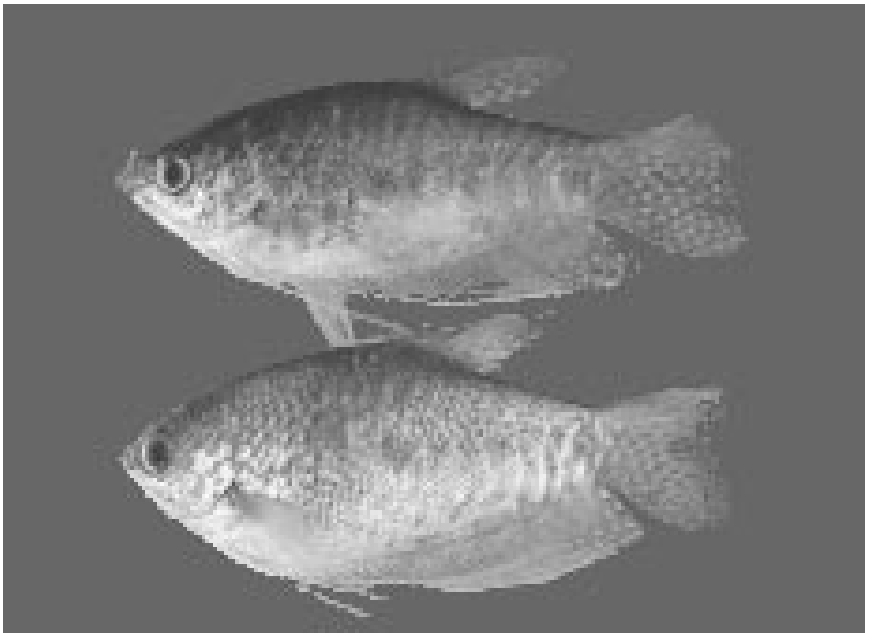

Figure 3. Picture of male (top) and female (bottom) Trichogaster Trichopterus.

Reproductive Biology

Trichogaster Trichopterus will reach a maximum length of 15-20 cm, (6-8 inches), (Axelrod et al. 1993) and will reach sexual maturity at seven cm, (2.8 inches) and 12-14 weeks of age (McKinnon et al. 1987). There are several egg types associated with the Anabantoids that can be broken down into three basic categories as illustrated in table (2).

Table (2). Reproductive modes of *Anabantoids* (modified from Richter 1988).

Type of egg produced	Number of eggs produced
Floating egg producers	**800 - 20,000**
Sinking egg producers	**100 - 300**
Sinking egg mouth brooders	**40 - 800**

Foam nest builders create a nest at the surface of the water or under water. The foam nest consists of bubbles with a mucus membrane usually constructed by the male. Surface nests are placed in floating plant matter and subsurface foam nests can be placed on any stable substrate. This includes stone, wood and plant matter. Depending on the species of labyrinth fish, they will use a natural site that is suitable or one of the adults may construct a suitable site for the foam nest. Free-spawning species will not construct a nest of any kind. They simply spawn and the eggs either float or sink and no parental care is given. Mouth brooding species also do not create a nest of any kind. When spawning occurs the male will catch the eggs in the anal fin and the female then picks them out and places them in the male's mouth for incubation. Species that do not catch the eggs will allow them sink to the bottom, and the male then collects them after spawning has ceased. Floating eggs contain oil and are lighter than water. After spawning the buoyant eggs rise to the surface. The yolk sacks of the hatched larvae contain oil so the larvae also float to the surface. Floating eggs are generally the smallest and the larvae have relatively small yolk sacks. The larvae receive little parental care and require suitable feeds early in the larval life cycle. Labyrinth fish with floating eggs are free spawners or foam nest builders. Sinking eggs do not contain oil and are heavier than water and sink after spawning. Sinking eggs are generally larger and the larvae have larger egg sacks. The larvae do not require suitable feeds as early in the larval stage as the floating eggs, but are able to utilize larger feed items once they begin to feed. Labyrinth fish with sinking eggs are either foam nest builders or mouth breeders (Scheurmann 1989). Table (3) lists some common species and their spawning method.

Oogenesis of *Trichogaster Trichopterus* has been described as: 1. Chromatin nucleolar stage, 2. Perinucular stage, 3. Chromatin nuclear stage, 4. Vitellogensis (VTL), 5. Germinal vesicular break-down (GVBD), and 6. Ripe egg stage (Degani 1992). During the reproductive cycle the first four stages are found in the ovary in varying proportions. Females with a low percentage of VTL in their oocytes are not ready to reproduce. The male stimulates the female with high VTL by nest-building and other courtship behavior and GVBD in the oocytes follows. The water in which the male builds the nest contains steroid glucuronides which affect a female high in VTL, promoting maturation (Degani 1992).

Table 3. Examples of some labyrinth fish and spawning behavior

Nest Type	Egg Type	Species	Common Name
Foam	Floating	*Colisa sota*	Honey Gourami
		Colisa fasciata	Little Giant Gourami
		Colisa labiosa	Thick-Lipped Gourami
		Colisa lalia	Dwarf Gourami
		Macropodus chinensis	Round-tailed Paradise fish
		Macropodus concolor	Black Paradise Fish
		Macropodus opercularis	Paradise Fish
		Trichogaster leeri	Pearl Gourami
		Trichogaster microlepis	Moonlight Gourami
		Trichogaster trichopterus	Blue Gourami
		Ctenopoma ansorgii	Ornate Ctenopoma
		Ctenopoma nanum	Dwarf Ctenopoma
Foam	Sinking	*Betta imbellis*	Peaceful Betta
		Betta splendens	Siamese Fighting Fish
Mouthbrood	Sinking	*Betta picta*	Painted Betta
		Betta pugnax	Mouth brooding Betta
		Betta taeniata	Banded Betta
Free spawn	Floating	*Helostoma temmincki*	Kissing Gourami
		Ctenopoma kingsleyae	Kingsley's Ctenopoma
		Ctenopoma maculatum	Single-Spot Ctenopoma
		Ctenopoma muriei	Nile Ctenopoma
		Ctenopoma oxyrhynchus	Mottled Ctenopoma

Modified from Shurmann, 1989

In addition there are also behavioral traits that can be applied to the type of husbandry that different types of Anabantoids exhibit. These differences are a function of the evolutionary development of the different Genera. Table (4) shows the five reproductive behavioral patterns common to different Genera. Trichogaster Trichopterus falls into the first category of parental care shown in table (4).

Table (4). Five categories of parental care exhibited by Anabantoids (modified from Richter 1988).

Type of parental care	Genus exhibiting behavior
Father family with large number of floating eggs	*Trichogasterinae, Anabantinae*-nest building type, *Ctenopoma, Osphronemidae*
Father family with small number of sinking eggs	*Ctenopinae* except mouth brooding *Betta*
Father family with some help from mother and large number of floating eggs	*Macropodinae*
Mother family with small number of sinking eggs; mouth brooding	*Sphaerichthyinae*
No family protection with large number of floating eggs	*Helostomidae, Anabantinae, Anabas*

Most of the floating egg spawners are very popular production items on commercial farms since they are generally easy to spawn, produce large numbers of eggs, and the fry are relativity easy to rear. Some of the smaller species such as the Dwarf Gourami need very little room to spawn and can be done in one gallon containers. Most of the Gouramis that fall into this category bring a lower price ($0.20 - 0.40 each farm gate) but are marketed in large quantities. The exception to this in the floating egg producer category is the “Paradise Fishes”. They produce low numbers of eggs and are more difficult to culture. They are not currently popular in the industry but may bring $1.00 - $2.00 each.

The sinking egg producers are primarily comprised of the Bettas. They have been popular with hobbyist since their first introduction to the hobby. *Betta splendens* ranked fourth in both the number of fish imported and value for October 1992 (Chapman et al. 1994). The Bettas are labor intensive to produce in large numbers on farms. The males are highly aggressive to other males and females as well, and must be kept individually in containers. These behavioral factors along with the relatively low fecundity of the females makes this fish a poor candidate for mass production. Most are either imported, bred on small speciality farms or produced by the hobbyist.

The *Ctenopoma* sp. although easy to produce, are not highly popular in the industry due to their generally dull coloration. These fish are generally sold in small numbers as collectors items.

There are also several mutations, hybrids and varieties produced in the industry. Mutations are inherited traits, not the result of interspecific crossings. And in fact some of the most popular Gouramis are mutations. The ones known to date are the *Macropodus opercularis* - albino form, *Anabas testudineus* - xanthorous form (an excess of yellow pigmentation), *Helostoma temmincki* - xanthorous form, *Trichogaster Trichopterus* - golden and silver forms, *Betta splendens* xanthorous and black forms (Richter 1988).

Varieties are fish produced by selecting the parent fish for desirable characteristics and improving upon them over a period of generations. Dwarf gouramis are a good example of varieties bred for various color intensity and patterns. Hybrids are produced by crossing different species of fish. A hybrid will take on a mix of traits of both parents, or exhibit traits from the dominate parent. Many times hybrids will produce sterile offspring, so a particular hybrid may have to be bred from genetically pure parents each time. The best example of hybrids in the labyrinth fishes is the *Betta* sp. Various hybrids have produced the wide array of color and fin types that you see in pet stores.

Fecundity

Reports of fecundity in *Trichogaster Trichopterus* range from 300 - 400, up to 1000 (Pethiyagoda 1991), and others up to 4000 (Richter 1988). Larval production at the Windward Community College aquaculture site averaged 1000 per spawn. Commercial breeders use a low average, usually about 500, to determine the number of breeders required for larval production to stock a tank or pond. Like many other fish there is a correlation between the body weight of the parents and larvae produced as shown in figure (6). Degani 1989 states, “No correlation was found between the body weight of the fish and the size of the nest. A relationship was found between the body weight of the parents and the number of larvae. There was also a correlation between the size of the nest and the number of larvae with more larvae produced in the larger nest figure (7).” This statement suggest that small nest produced by an inexperienced male or a male not yet in spawning condition will affect the number of eggs that the female will deposit. Studies by McKinnon and Liley 1987, Pollak et al. 1978 and Lee and Ingersoll, 1979, also suggest that there is a sexual pheromone produced by the females that plays an portant role in reproduction. Males discriminated between ripe females and non ripe females, as well as non ripe females and plain water (McKinnon and LiIey 1986). Pollack et al. 1978, carried out experiments in which the males nares, the site of chemoreception located in the end of the ventral fins in *Trichogaster* sp., were cauterized or amputated. Males with there nares cauterized seldom build nests or spawn successfully (Pollak et al. 1978).

Many tropical fish books describe recently mated females as “spent” or “Spawned out”.

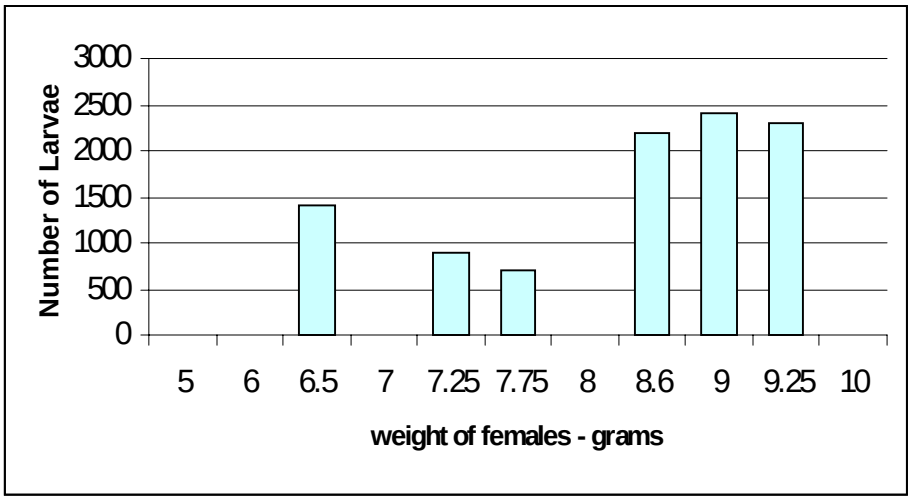

Figure 4. - Weight of females and number of larvae produced (modified from Degani 1989).

There are many reports in the literature of females spawning several times during a season in the wild (Pollak et al. 1978). However experiments by Pollak et al. 1981 and personal experience suggests that multiple matings can take place. Egg production in *Trichogaster Trichopterus* is prodigious and probably does not severely limit the frequency of mating. Both males and females are clearly capable of mating with as little as 24 hours separating successive spawning (Pollak et al. 1981). Commercial farms will condition and spawn gouramis every two to six weeks depending upon the species. Females have been observed spawning twice in a 24 to 78 hour period (Pollak et al. 1981). In addition females have also been observed releasing large numbers of unfertilized eggs. Rather than representing a conditioned of heightened spawning readiness, spontaneous egg release is more likely a method of rapidly eliminating over ripened eggs from the ovaries (Pollak et al. 1978). This can be associated with large numbers of oil droplets on the waters surface.

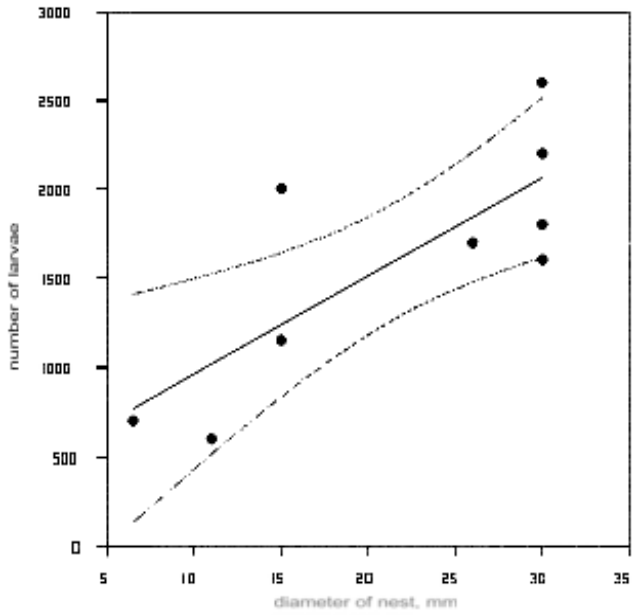

Figure 5. Relationship of nest diameter to the number of larvae produced, Number of larvae = 412.5 + (55.0 x length of nest - cm). N=9 R2=0.615 p<0.05. Points on the graph are actual numbers, dotted lines represent 95% confidence intervals.

Temperature and Light

In tropical regions the two main reproductive cues are temperature and day length with little seasonal variation. Figure 6 shows the maximum and minimum water temperatures at Windward Community College over a 3-year period. Nest building occurs and eggs are laid in a temperature range of 23-29°C (73-84°F), however no optimal temperature was found within that range (Degani 1989). This is also the optimum temperature range for conditioning of the broodstock. No conditioning or spawning will take place at a temperature of 20°C (68°F) and temperatures of 18°C (64°F) or less can be lethal. Degani states that reduction of light by dense plant population had a positive effect on nest building. In light conditions the females generally laid there eggs by the second day after being placed in the spawning container after which the number of nests built declined. In dark conditions spawning began more slowly and the decrease in spawning was slower. More spawns in total were achieved in conditions of darkness verses light as shown in figure 7 (Degani 1989).

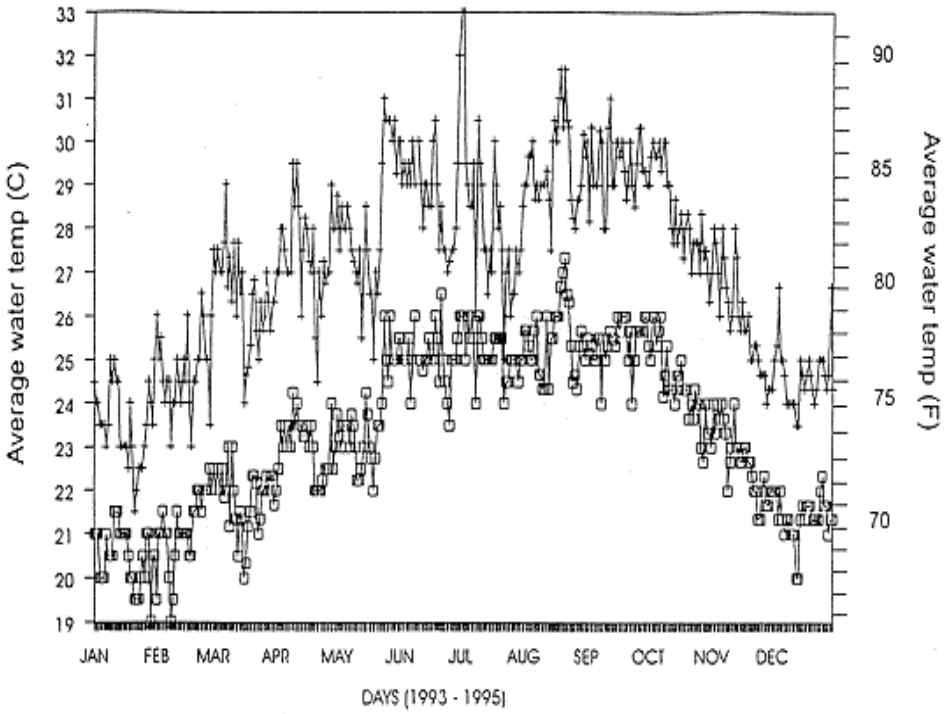

Figure 6. Maximum and minimum water temperatures at the Windward Community College aquaculture site.

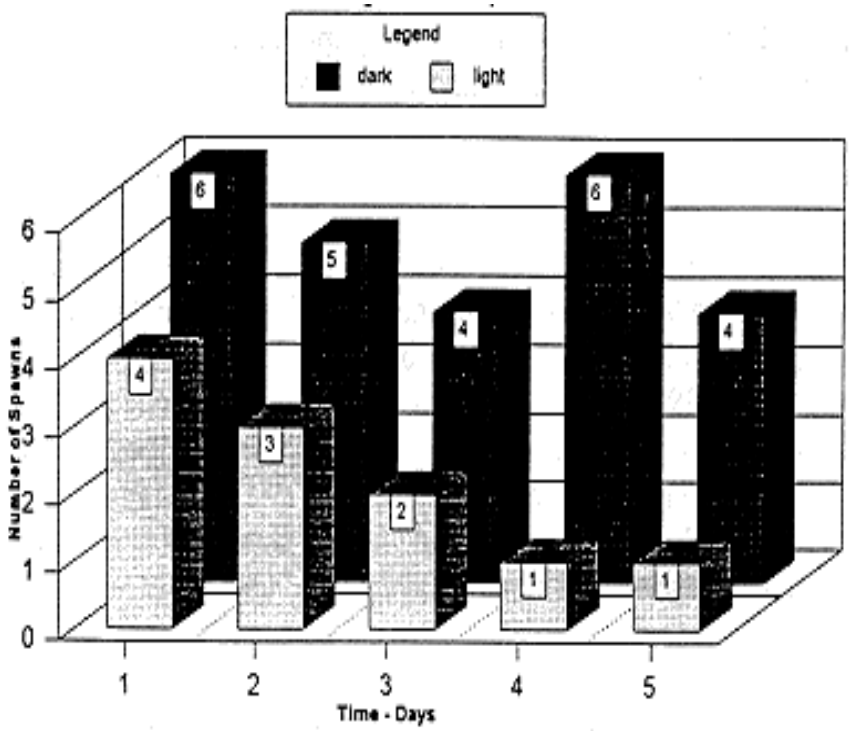

Figure 7. Light intensity and spawning in Trichogaster trichopterus

Commercial Production

For the commercial production of *Trichogaster Trichopterus*, several steps must first be followed in order to synchronize spawning to have large numbers of fry of the same age for stocking.

Step 1. Sexing - Male gouramis can be distinguished by their longer dorsal fins which extend back to the caudal fin. In many cases they are also more brightly colored than the females. The females will have a shorter dorsal fin and should show some plumpness in the abdomen area. Broodstock should be selected based on size, color and apparent egg development in the females based on the plumpness of the female.

Step 2. Male and female broodstock are then placed in separate tanks for conditioning at a rate of one fish per ten liters (3 gal) with a ten percent water exchange per day to insure adequate water quality and provided with high quality feeds at least three times a day. Fish should be fed to satiation with caution taken to remove any uneaten feed from the tank. It is advisable to give a variety of feeds to the broodstock fish. This would include a complete commercial diet that contains at least 32% protein with a pellet or grind size no larger than about 1.0 mm. In addition to the commercial diets provide either a live or live frozen feed such as black worms, tubifex worms or blood worms as well as a paste made up primarily of beef heart and liver with a high percentage of vegetable matter such as peas and spinach (see appendix 2). Incorporating a high quality flake may also be helpful.

Step 3. After two weeks of conditioning the broodstock should be ready to spawn. Males are placed into the spawning tanks early in the morning so they acclimate and establish a territory. Ten gallon aquaria work well for Trichogaster sp. but use a larger or smaller container depending upon the size or genus offish you are spawning. The hatchery should be dimly lit with as little foot traffic as possible to avoid disturbing the pairs. In many cases males will begin construction of a bubble nest in the first two to three hours. With the Trichogaster sp. it is not necessary to add a floating substrate to facilitate construction of the bubble nest such as a floating ring, the bottom of a styrofoam cup or floating plants. In general, Anabantoids that are free spawners or mouth brooders do not require a floating substrate. Those that build foam nest and have floating eggs may not require a floating substrate but many times it is helpful in stimulating nest building behavior and spawning. Spawning containers should otherwise be bare and without any type of aeration as this will impede construction of the bubble nest. The females are then placed into the spawning container between 3:00 p.m. and 5:00 p.m. that same day.

Step 4. Spawning will take place over a period from one to four days. It is sometimes difficult to distinguish the eggs from the nest itself. The eggs are about the same size as the bubbles that make up the nest but have a darker golden or brownish tint to them. After spawning has taken

place, it is advisable to remove the female in order to avoid injury due to the males aggression. The male will then care for the nest and fry once they are hatched.

Step 5. The eggs will hatch in about 24 hours at 27^{o}C (80^{o}F) and remain in the nest another two to three days while the yolk sack is being absorbed. The fry are free swimming on about day four or five post spawn and are five to six millimeters in length. When the fry exhibit a distinct change in behavior swimming throughout the water column, they are ready to start actively feeding.

Step 6. The fry, in this stage of development are very delicate and should be moved with great care. Fry transfers should take place in the morning to avoid extreme differences in temperature and pH as well as avoiding photic shock. The fry tank water should be siphoned down using a large screened end on the siphon hose with a mesh size of 100 microns until there is 2-4 cm of water left in the tank. The entire container is then taken to the pond, being careful to keep sloshing to a minimum. Acclimation can then proceed normally adding small amounts of the growout tank water until the temperatures have equalized.

Step 7. Once the fry are ready to feed it is important to provide them with infusoria, rotifers or small *Daphnia* sp. Figure 8 provides a graphic representation of dietary transitions typically used in the rearing of larval gouramis. The change to freeswimming feeds is usually done by transferring the fry to a nursery pond or tank that has been prepared no more than ten days in advance. Nursery tank preparation is usually done by filling the tank with fresh clean water and adding a fertilizer with an N:P:K ratio of 1:3:0 usually in a liquid form with a concentration of 10-30-0. This fertilizer is applied at a rate of one milliliter per fifty liters of water. Additional or reduced fertilization may be needed for any particular site as long as you develop a plankton bloom dense enough to get a Secchi disk reading of 20-30 cm. Other fertilizers can be used at rates the farmer should determine for his particular site to achieve the desired Secchi disk reading. The larval tank can then be inoculated with *Daphnia* sp. or rotifers. Primary producers such as algae form the base of the aquatic food chain. In particular microalgae are of great importance to the commercial production of bivalves, crustaceans and finfish (Fulks and Main 1991). The rotifers *Brachious calyciflorus* and *B. rubens* have become the most commonly cultured rotifers in freshwater aquaculture (Hoff and Snell 1989). The *Daphnia* species are well adapted to considerable fluctuations of environmental conditions (Ivleva 1973). The proper species should be chosen to fit the environmental parameters of any particular farm site. For a reveiw of culture methods for microalgae, rotifers or *Daphnia* see Hoff and Snell 1989, lvleva 1973 and Fulks and Main 1991.

If the desired bloom is not achieved, the recently developed microencapsulated feeds and artificial plankton feeds can substitute for most if not all live feeds currently used on most commercial farms. Simply take the artificial feed add it to water and blend until all of the powder has been wetted. Spray this solution over the surface of the tank three to four times a day.

Step 8. Newly stocked fry should be fed to satiation 2-3 times a day with a commercial swim up diet and newly hatched Artemia from stocking until day 10 when the amount of *artemia* can be reduced at about ten percent a day until the fish are feeding exclusively on the commercial diet.

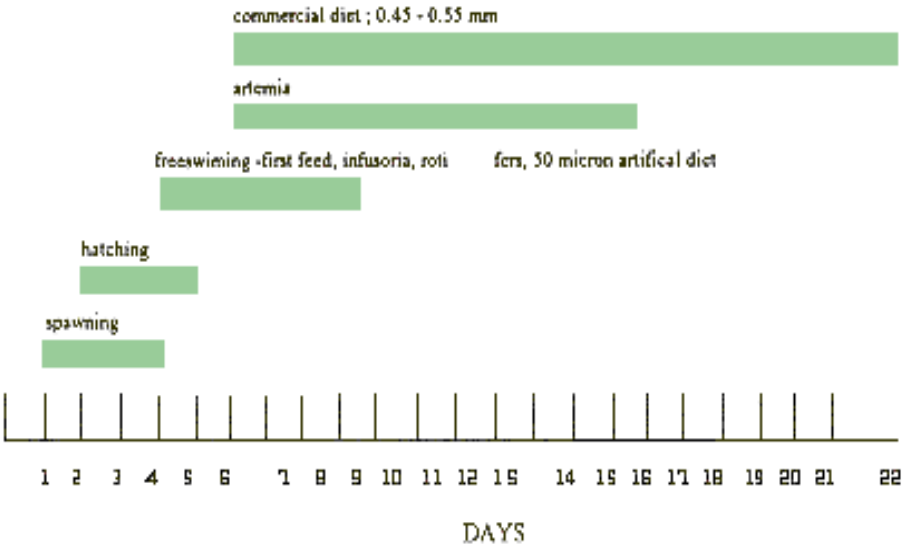

Figure 8. Diagram of feeding schedule for Trichogaster trichopterus.

Growth

Stocking trials at the W.C.C aquaculture complex have shown that with low densities approximately 0.5 fry per liter (1.9 per gallon) growth is fairly uniform and fish can be grown to market size in well under 12 weeks. Production of market size fish in six weeks stocked at low densities have been reported in Hawaii. With higher stocking densities, 2.0 per liter (7.5 per gallon), market size fish can still be grown in under 12 weeks although there will be a large

Variation in sizes within the population. Historic commercial stocking densities in static water ponds with no aeration are much lower, 0.25 per liter. Figure 9 represents the growth of

Trichogaster Trichopterus cultured in a twelve foot diameter tank over a 120 day period at a stocking rate of 2.0 per liter. The regression formula given applies to growth at thirty days of age and beyond. Total length is measured in millimeters from the tip of the snout to the tip of the caudal fin.

Figure 10 represents the length-weight relationship in *Trichogaster Trichopterus* also grow in tanks over a 120 day period. The regression formula also applies to fish thirty days old or greater. By measuring the length of a sample of the population being cultured the estimated weight of the population can be calculated and the appropriate amount of feed applied as a percentage of the estimated total weight.

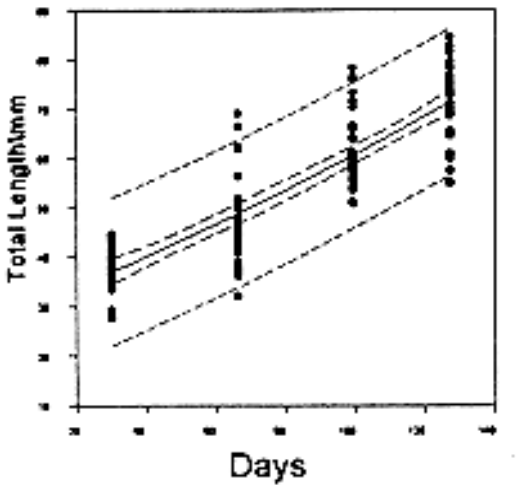

Figure 9. Growth of Trichogaster trichopterus *cultured in tanks. Total length - mm = 28.1 + (0.278 x days) + (0.00048 x days2 R2 = 0.750, p<0.0001, N=120. Dots are actual data points, the inner broken line represents standard deviation, outer broken line represents the 95% confidence interval.*

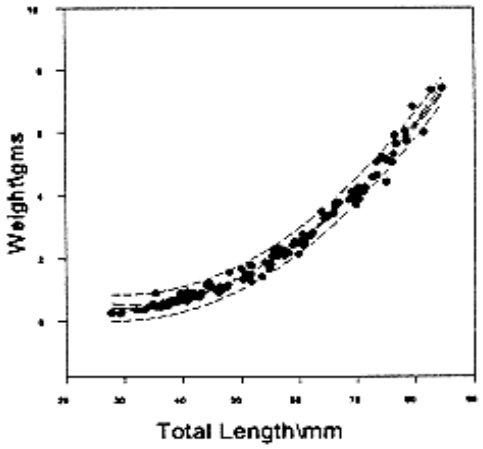

Figure 10. Length-weight relationship of Trichogaster trichopterus. *Weight = 2.31 - (0.130 x total length) + (0.0022 x total length2) R2 =0.988 p<0.001 N=120. Dots are actual data points the inner broken line represents standard deviation, outer broken line represents the 95% confidence interval.*

After 120 days of growth all of the gouramies are of a marketable size. Figure 11 illustrates the size distribution of *Trichogaster Trichopterus* from a sample of the population. Over 42% of the fish fall into the 70 - 80 mm range or a 3 inch saleable size class and 95% of the fish are 2 inches or above, This indicates that most of the fish can be selectively harvested and sold prior to 120 days of growth.

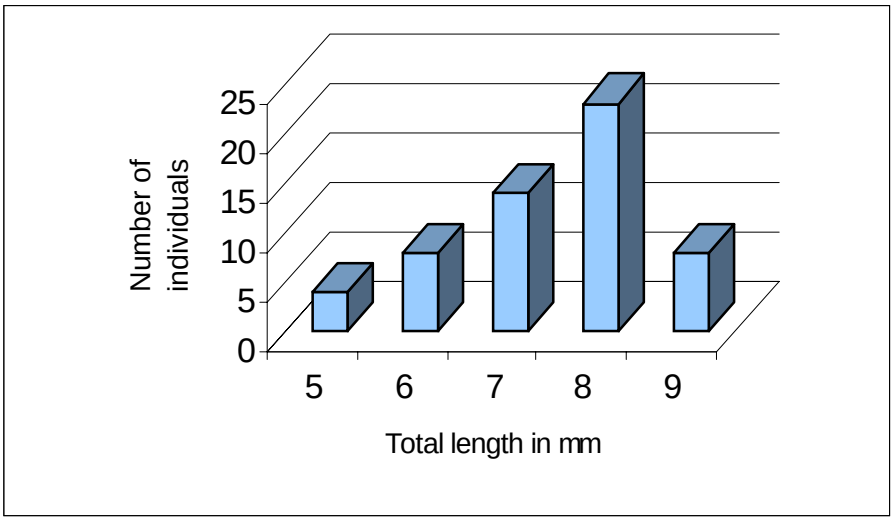

Figure 11. Size distribution of Trichogaster trichopterus. *Mean = 69.7 mm, standard deviation = 9.6, N = 54.*

Feeding

Trichogaster Trichopterus are considered carnivorous, the natural diet being different species of invertebrates (Degani 1990). In an intensive culture situation where natural foods are limited a complete diet must be used in order to achieve optimal growth. In addition, formulations capable of enhancing the pigmentation of cultivated tropical fish have considerable application. There are several color enhancing compounds are available. These include beta carotene, canthaxanthin, astaxanthin and xanthophyll. The maximum absorbance was achieved using canthaxanthin as a color enhancer, specimens on a canthaxanthin fortified diet also exhibit a greater iridescence in the chromatophore along the entire integument. These pigment enhancers are usually supplied in the feed at a rate of 0.05 percent active ingredient (Fey and Meyers 1980). Fish are fed in tanks or ponds at least twice daily at a rate of 3-5 percent body weight per day. Experiments carried out by Degani 1990 showed that there was no significant difference in growth of larvae fed commercial diets or a diet consisting of yeast or yeast and egg yolk. Water quality has a more profound effect on growth than the different diets. It has been reported that increased nitrite and nitrate had the most effect on decreasing growth rates (Degani et al. 1990).

Water Quality

The *Trichogaster* spp. are considered hardy and highly adaptive and have been found in the wild inhabiting areas that differ widely in water quality parameters (Inger 1962). Geisler et al. 1979 surveyed three streams in Thailand and found *Trichogaster* sp. occurring in environments with not only widely different substrates ranging from sand to large rock, but also widely varying water chemistry parameters. Fish were found in water with conductivity ranges from 22 to 718 uS, Total hardness from 1.3-185 mg\l CaCo3, and pH values of between 5.8 to 7.4 (Geisler et al. 1979). Streams also had a wide range in concentrations of trace elements. The optimal water quality ranges for culture are presented in Table (5) below.

Table 5. Optimal water quality ranges for the culture of *Trichogaster* sp.

Water Quality Parameters	Values
Temperature	23-29°C (73-84 F)
Hardness	50-100 mg\l CaCo3
Salinity	0 °\oo
PH	6.8-8.0
Nitrite	< 0.5 mg\l
Nitrate	<0.5 mg\l
Total Ammonia	<1.0 mg\l
Dissolved Oxygen	>2.0 mg\l
Phytoplankton	Secchi disk 20-30 cm depth

Harvesting

Thirty days prior to any harvesting taking place the pond should be inspected for aquatic weed infestation, the proper herbicides applied if necessary with the proper lead time. Tank culture systems eliminate aquatic emerging plants problems which lessens the degree of management problems.

One week before harvest, fish are sampled and examined for any ectoparasites or bacterial infections, the proper treatment is applied if necessary, and resampled prior to harvest to insure the fish are in good health. These procedures insure a smooth harvest and minimizes mortalities.

Harvesting gouramies on a commercial scale is done by seining. To reduce injury a seine net made of nylon knotless Ace or Delta weave netting with a mesh size of 1/8 inch is used. Seine nets should have a length 2.5 times the width of the pond being harvested, and have a depth two times the depth of the pond. Seines used for harvesting ornamental fish should also be equipped with twice as many floats and bottom lead weights as is normally recommended.

When using a seine net for harvesting, particular attention should be given so that the fish are not overcrowded when pulling in the seine into the pond bank at the end of the harvest. This could lead to excessive injury to the fish or stress which can cause future mortalities. Once inside the holding tanks, any debris that has come in from the harvest should be removed.

Holding Tank

After harvesting the fish should be placed into a holding tank equipped with running freshwater and aeration as soon as possible. After placing the fish inside the holding tank(s), any debris that has come in from the harvest should be removed and dead or injured fish discarded. Salt is added to the water to bring the salinity up to 9.0 ppt, which is an isotonic solution, to help reduce the handling stress by stimulating the fish to naturally produce a slime coat. The harvested fish can be maintained in the holding tank indefinitely and their guts allowed to be urged prior to sorting, packaging and transport.

Preparation of Anesthesia

Once the desired size fish is acquired they are then anesthetized using either quinaldine or MS-222 in an aerated bucket or tank. To make up a stock solution of quinaldine, in a container, add one milliliter of quinaldine and 2.5 milliliters of acetone, shake well, and bring the volume up to one liter with water. This gives a stock solution of one part per thousand. To use this stock solution to sedate fish for sorting, start with a dosage of 2.5 milliliters per liter of water that the fish are being held in and increase slowly to obtain the desired effect. Recovery time is short and quinaldine is generally safe for most fish up to a concentration of 100 parts per million. Tricane Methanesulfonate (MS-222) is considered to be one of the most effective anesthetics and at this time is the only one cleared by the Food and Drug administration for use with fish intended as food. MS-222 usually is available as a white water soluble powder. To make a stock solution, simply add five grams to one liter of water. Use ten milliliters of stock solution for every liter of water the fish are being held in. Increase slowly if necessary, once the fish are properly sedated, they are then dip-netted and placed on the glass top sorting table that has been coated with a commercially available synthetic slime which reduces handling injuries.

Sorting and Grading

Sorting methods are determined by the species morphology and target market. Fish are first sorted by size using a bar grader and then sorted by color and when necessary by sex. In some cases additional sorting by hand for size may be necessary. Bar graders widths come in various standards. The preferred type is manufactured with interchangeable baskets that fit into a floating frame and is sold in gradations of 2/64 of an inch with each size representing a number grade size (e.g. 10/64 is a 410 grader). Fish are netted and placed into the floating grader box. The smaller fish swim through the grader bars while the larger ones are retained in the box. By changing grader widths any size fish can be easily sorted for increments as small as a quarter inch in length. Females tend to have wider girths when gravid, so care must be taken so that a large ratio of females is not selected for. A test grade should be performed to obtain the size fish the market demands. An initial grading is recommended at pond side to reduce the number of fish that are handled in the sorting area.

The sorting procedure is one of the more laborious activities but is necessary to insure that the selected fish are marketed as well as eliminating individuals that are an incorrect size, “off color” or deformed.

Step 1. Harvested fish are collected from the holding tank and anesthetized.

Step 2. A sorting table consisting of a glass plate placed on a tabletop is coated with a commer-

cially available synthetic slime (See Appendix 3) which reduces handling injuries. Buckets containing freshwater are placed on one edge to catch the sorted individuals.

Step 3. Once the fish are properly sedated they are dip netted and placed on the sorting table. Sorting for sex, color and size is done by sliding the sedated fish across the tabletop into separate aerated buckets (e.g., males, females, undersized, and those to be discarded). Discoloration and body deformities are the main reasons for separating out fish to be marketed o laced back into the population.

Step 4. Only Gouramies that have sexually dimorphic color development are sold by pairs, one male and female. Fish are then counted into box lot quantities (150 individuals/box) and placed in separate holding tanks equipped with running freshwater and aeration until they are ready to be shipped. Egglayers are usually shipped with a 5% overpack (to offset for mis-counts and mortalities) and placed in flow through tanks that can be drained to a volume that will fill the shipping bag by 20%. When it is time to ship the fish, the tank is drained down, and the fish and water are gently poured into the shipping bag. The air in the bag is purged, and the bag is inflated with pure oxygen then sealed with a rubber band or banding machine. The bags are the laced into styrofoam boxes and taped shut for air cargo shipping.

Disease Prevention, Treatment and Management

The management of fish health on a commercial farm is one of the critical activities that occurs on a day to day basis. Procedures for production, feeding, handling of any kind, must at be designed to minimize the risk of infection or transfer of disease and parasites and yet not be so burdensome as to increase labor above reasonable cost (see Table 6).

Disease occurs in natural populations of fish but is rarely noticed by individuals unless it causes a mass mortality. Such large mortalities are usually attributed to conditions brought about by human activity and are usually associated with some form of pollution.

In an aquaculture situation however, conditions such as high population densities, extreme biological loads along with necessary handling can cause conditions conducive to outbreaks of bacterial, fungal, viral and parasitic infections.

Table 6. Six general methods of disease control in fishes (Post 1987).

1. Test and slaughter
2. Quarantine and restriction of movement
3. Drug therapy and sanitation
4. Immunization and disease resistance
5. Destruction or reduction of a link in the transmission cycle
6. Control of toxic substances

For example, samples from individual production units are checked weekly for the development or outbreaks of external parasites. This is done by clipping samples of fins and gills, placing them

on a slide, adding a drop of water, or more preferably physiological saline, placing a cover slip over the sample and examining it under the microscope.

Most parasitic infections can be diagnosed with minimal training to the farmer. Fungal and bacterial cultures along with the proper sensitivity tests can be done on site with some additional training. The commercial availability of prepared diagnostic kits has simplified this process.

Viral epizootics usually lead to extensive mortalities or require destruction of the animals and disinfection to control the spread of the disease. It is recommended that if diagnostic facilities are not available on site, or if an adequate diagnosis can not be made, that samples be sent to a local veterinarian familiar with fish pathology.

The three most common problems that commercial farmers encounter are the Protozoa (*Trichodina*), the Monogenea (*Dactylogyrus* and *Gyrodactylidae*) and the Fungi (*Saprolegnia*). *Trichodina* is round saucer or domed shaped protozoan with cilia and when seen through a microscope are constantly in motion moving quite distinctly and rapidly. They are most commonly found on the gills and soft tissue, such as the fin rays, of the fish. Heavy infestations can cause respiratory problems by causing the gill tissue to produce excess mucus. There are several control methods to reduce and/or eliminate this parasite from the culture system. The most common procedure is to use an indefinite bath of formalin at 25 parts per million (ppm). Once diagnosed and treated, the fish should be checked daily to monitor the effectiveness of the treatment and if necessary, retreatment.

Monogenea, Dactylogyrus and *Gyrodactylidae*, are also commonly found on the gill and soft ray tissue of the infected fish. Transmission is usually by direct contact. After the eggs hatch, free swimming larvae seek out a host and attach themselves using a series of hooks and sucking valves at the base and appear worm-like under the microscope. Fish infected usually exhibit what is commonly called flashing, which is actually the fish rubbing itself on a hard substrate or shaking its body in an attempt to remove the parasite. There are two common treatment methods. The first is a formalin bath at a concentration of 250 ppm for one hour. This is the preferred method when handling large numbers offish since no handling is required and the tank is simply flushed after the specified time period. The second method is a sodium chloride (non-iodized salt) dip at a concentration of from 25,000 to 35,000 ppm. Duration of the dip is determined by the tolerance of the individual species to high salinity and the effectiveness of the treatment. It is recommended that preliminary tests be run on small samples of fish to determine the proper length of time and concentration.

The Fungi, *Saprolegnia*, usually occurs as an opportunistic infection as a result of injuries incurred in handling the fish. It usually appears as a white or light grey patch on the surface of the fish. Under the microscope it is best described as having a cotton strand appearance. *Saprolegnia* can be problematic to treat since as of this writing some of the most effective compounds have been regulated out of use. However, some of the newer copper and iodine compounds currently available work well. One of the tried and true methods is still a formalin bath at a concentration 250 ppm for one hour a day for five consecutive days.

Formalin Preparation

All of the diseases mentioned employ formalin as one of the means of combating the disease. Formalin is a colorless liquid that is used as a general fixative for preserving tissues. It is made up of a solution of water in which formaldehyde gas has been bubbled into solution. Concentrated formalin normally contains 37 to 40% formaldehyde. *NOTE: USE EXTREME CAUTION USING CONCENTRATED FORMALIN*. For use as a disinfectant and/or treatment of parasites, concentrated formalin is usually diluted to very low concentrations (10 to 300 ppm).

The equation that is normally used to determine the amount of formalin to be used for treating a disease outbreak does not employ the percent active ingredient because by convention 30-37% Formalin is considered to be a 100% active solution. An example of the calculation to determine the amount of Formalin to be used to make a 100 ppm solution in a 100-l (i.e., 26 gallon) tank is resented below:

Note: 1 *ppm = 1 ml* /1000*l*

Concentrated Formalin = (100 *l* x (1 *ml*/1000*l*) x (100 *ppm*)

From the above calculation 10 ml of concentrated formalin must be added to the 100-1 (i.e., 26 gallon) container to obtain a final concentration of 100 ppm. Pour the concentrated Formalin into the tank and make sure to distribute it evenly.

Economics

Figure 12 represents the general price trend increase over the last 15 years. This figure is based on one Singapore-based transhipper for a two inch *Trichogaster Trichopterus* (Blue Gourami). Table (7) is a breakdown of equipment, supplies and start up cost for a single species, (*Trichogaster trichopterus*), hatchery. In practice any given species raised on a farm is referred to as an enterprise. This enterprise will consume a given amount of resources the farm has available. Once the variable and fixed costs associated with the consumption of these resources is determined profit margins can be calculated. An example is given in Table (8). For a detailed economic analysis of various sized farms and costs associated with them please refer to the study “Report on the Economics of Ornamental Fish Culture in Hawaii” available through the Center for Tropical and Subtropical Agriculture or the University of Hawaii Sea Grant Extension Service.

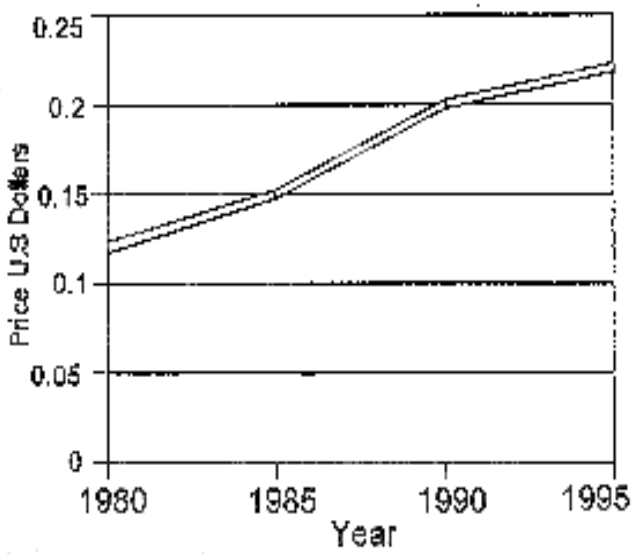

Figure 12. Representative price increase for Trichogaster trichopterus *over time.*

Table (7) Breakdown of equipment and supplies and start up cost for a single species production hatchery capable of producing 10,000 Gouramies per month.

Categories	Quantity	Price
Equipment		
12' diameter tanks	2	900
ground liner	1 roll	90
Regenerative Blower (1/3 h.p)	1	398
Air stones (sm)	15	12
Air stones (1g)	2	15
Air tubing	1 roll	27
0_2 Bottle Rental	1	50
0_2 Regulator	1	70
PVC Pipe and Fittings		200
Bird Netting	1 roll	10
Bar Grader	1	300
Thermometers	2	50
Field Microscope	1	20
Aquariums (10 gal.)	15	120
Lumber (hatchery construction)		2619
Used Pickup Truck	1	4000

	Quantity	Price
Supplies		
Chlorine	5 gal.	100
Broodstock	50	12
Feed (Artemia, brood and production)		85
Rubber Bands	1 bag	10
Transport Bags	40	16
Transport Boxes (inner)	40	140
Transport Boxes (outer)	40	100
Water Test Kit	1	300
Misc. Chemicals		100
Dip Nets		100
Totals		$ 9844

Table 8. Enterprise budget for production of 10,000 gouramies per month

Income		
Gouramies (small 10,000 @ $ 0.22 each.)	$2,200	
Total		$2,200
Variable costs:		
Salt and Chemicals	10	
Feed (brine shrimp, beefheart, trout starter)	50	
Repairs (hatchery, aquariums, growout tanks)	20	
Transportation and Marketing	78	
(100 mi. @ $ 0.28\,mi., phone-fax)		
Labor (40 hrs @ $10\ hr)	400	
Miscellaneous	10	
Total variable cost		$ 568
Income above variable cost		$1,632
Fixed costs:		
Land charge (1\20 acre @ $200\acre)	10	
Water charge (1 gal\min @ $0.60\1000 gal)	25.92	
Deprecation (broodstock)	3.30	
Depreciation (aquariums and tanks)	13.33	
Total fixed cost		52.63
Total cost		620.63
Estimated profit		$1,011.37

Assumptions; production of 12,500 fry with 80% survival to market
purchase of 50 broodstock @ $0.22 each with one year production
purchase of two 12' diameter tanks @ $200 each with five year life
purchase of two brood conditioning tanks (300 gal) @ $100 each with five year 11
purchase of 15 ten gallon aquariums @ $8 each with five year life

Each culture site will have different production costs and overhead costs associated with each enterprise on a farm. These figures should be added or deleted to the enterprise budget in order to get as precise an estimate of cost as possible. The use of this model provides a relatively easy method to determine the cost of reduction of a given item.

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Listing in this appendix does not constitute a recommendation for, or a guarantee of, any of the products or services that the listed manufactures, suppliers or organizations may provide. For a more comprehensive listing consult your local extension agent or the buyer's guide or directory editions of one of the industry related publications.

Appendix 1.

Paste Formulas for Conditioning Broodstock Fish

Formula 1	Formula 2
3 lbs ground beefheart	5 lbs beefheart
3 lbs ground beef liver	5 lbs beefliver
4 raw eggs	2 lbs. high protein mixed cereal baby food
6 oz spinach	2 lbs raw wheat germ
6 oz peas	10 oz split peas
6 oz carrots	20 oz spinach
4 oz oat bran	4 raw eggs
24 drops water soluble multivitamin	8 oz whole shrimp
4 packets unflavored gelatin	4 oz brewers yeast

1. Trim all the excess fat and any connective tissue or tendon (stringy stuff) from the bee heart and liver.

2. Use a food processor or blender to ground the meat into very small pieces or mash.

3. Mix the remaining ingredients except for the gelatin in formula I in a blender or food processor.

4. 4A. For formula 1, the gelatin acts as a binder to hold the mixture into a paste. Mix the gelatin in a pot with as little hot water required to fully dissolve the gelatin. Allow the mixture to cool slightly (still fluid). Pour the mixture into "zip-lock" bags and press them into flat sheets. The paste should be refrigerated until used or stored for long periods frozen.

5. 4B. Formula 2 requires the mixture to be cooked using a double broiler until the mixture becomes slightly grainy. The mix is then placed into "zip-lock" bags and pressed into sheet for stor age. The mix should be refrigerated until used, and stored for long periods frozen.

There are many variations on these formulas. Each one can be tailored to suit nutritional needs of specific fish and available ingredients. The one thing they all have in common, is high quality protein. Other ingredients such as *Spirulina* can be added at 0.5 - 1.0 % by weight. For fish that are more herbivorous, the fish meal or red meat components can be reduced and vegetable protein such as soy bean meal can be substituted. Before making up your own paste formula, consult the literature to find the natural diet of the fish and then formulate it.

Appendix 2.

Hatching Brine Shrimp (*Artemia*) and Preparing Them for Feeding

A considerable amount of cost in fry production is linked to cyst cost and hatching efficiency. It is prudent to optimize every gram of cysts since the cost has escalated in the past years (cost per pound can, $35-45.00 in 1995) due to a lack of supply resulting from severe winter weather. When taking into consideration higher survival rates and nutritional value indicated by elevated weight gain over time versus other feed sources, the significance of feeding *Artemia* becomes obvious. Fish that do not readily take prepared feeds almost always will accept *Artemia.*

Artemia Supplies and Strains

Artemia from various parts of the world have different size and nutritional qualities. The most commonly available strains of Artemia are from the Utah's Great Salt Lake which have 486 micron size instar one nauplii (first hatch stage) and San Francisco Bay strain having slightly smaller 428 micron nauplii (Sorgeloos et al. Vol. I CRC Crustacean Aquaculture). *Artemia* also come in varying hatch grades, with the higher hatching rate grades commanding a corresponding higher price.

When choosing an artemia source or brand, you should consider the following: 1.) cyst hatching rates, 2.) nauplii size at hatch (instar I), 3.) nutritional value and 4.) packaging method. Gouramies do well on either strain of *Artemia*, and cost may be the only factor here when choosing sources for reduction.

Hatching Container

Hatching containers can be purchased from a supplier or constructed out of local materials such as inverted 5 gallon drinking water containers fitted with a rubber stopper and plastic valves. The design of the hatching container is important, having a conical shaped, smooth inside surface, translucent and easily drained bottom, and a dark opaque top. Newly hatched nauplii are attracted to light (positively phototactic) which aids in harvesting when using hatching containers with translucent bottoms.

Cleanliness and Sterilization

Probably the biggest reason for poor hatches results from a lack of cleanliness. Slime or detritus on the hatching container walls and airlines contributes to significant bacterial interference. By thoroughly cleaning the parts that are in contact with water during hatching can improve the consis-

tency and percent hatch of cysts. Fill one hatching container with tap water and add either powdered bleach or liquid and aerate for 20-30 minutes for disinfecting. If you use powdered bleach (calcium hypochlorite) add approximately 300 mg per liter, or if you use liquid laundry bleach 5.25% active (unscented), add 3.5 ml per liter (San Francisco Bay Brand 1988.

Light

Provide a light source (60+ watt bulb) above the container during the first couple of hours during re-hydration. Cysts are dehydrated before being packed to eliminate bacteria growth. When cysts are placed into water they begin to re-hydrate at which time light is needed to stimulate the hatching mechanism of the cyst. The light may be left on over the container during the entire hatching period. The light over the hatching container is removed and moved to the translucent bottom of the container during harvesting.

Temperature

On the average, *Artemia* will hatch into the instar I stage nauplii in 14 to I 8 hours at a temperature of 25-30°C, and at lower temperatures hatching time will increase. Different sources of *artemia* will have different hatch rates and temperatures. It is important to know -when first hatch is completed so the *Artemia* can be harvested at the smallest size possible making them easier to be consumed. In addition to size, the instar I stage nauplii has a higher nutritional value in comparison to later stages which should be maximized. Maintaining a constant temperature in the hatching containers will fix a harvest time that best coincides with feeding schedules. *Artemia* nauplii can metamorphose into the next stage (instar II) in several hours, so time the harvesting to gain maximum nutritional value is beneficial.

Salinity

The hatching water should be made up with 5 grams rock salt (do not use iodized salt) per liter tap water or to seawater density of 35 ppt. Although you can hatch cysts a lower salinity the pH becomes harder to control which will lower hatch rates.

Cyst Density and Preparation

When hatching *Artemia* on a commercial scale, cyst density needs to be addressed. Hatching cysts in densities greater than 2 grams per liter saltwater can cause the pH to drop whereby adversely effecting the percent hatch. Use no more than 2 grams of cyst per liter of saltwater. When hatching significant amounts of cysts, bacteria play a significant interfering role which if not properly addressed can lower hatch rates. Bacteria blooms feeding on cysts decaying organic of shed outer shells of *Artemia* cysts can cause a reduction of the pH and dissolved oxygen with resultant decreased hatch rate. Disinfecting the cysts prior to hatching will lessen the initial bacteria load which covers the cysts. This can be done by placing the cysts in a chlorinated freshwater solution for 15-20 minutes prior placing them into the hatching saltwater. The chlorine solution can be made by adding 3 grams of 70% active calcium hypochlorite or 40 ml of 5.25% active sodium hypochlorite (unsented household bleach), to 10 liters of fresh tap water suitable to disinfect 500 grams of cysts (one can). After 20 minutes of disinfecting the cysts, they should be rinsed off with tap water and placed into the saline hatching solution for Incubation.

pH

The pH should be maintained above 8.0 during hatching. When hatching large quantities (> 2 grams cysts / liter) of cysts, the pH will drop. By adding 2 grams of Sodium Bicarbonate per liter hatching solution will raise the pH to a optimal level (San Francisco Bay Brand, 1988). Remember hatching water that has a salinity below 35 ppt, often has lower ability to buffer the pH, and hence will most likely need sodium bicarbonate to help maintains pH of 8.0.

Cyst Storage

The cyst hatching rate will start to decline a few months after the nitrogen filled container has been opened at room temperature. Once a can of *Artemia* cysts has been opened it should be covered with the provided plastic lid and stored in a refrigerator. Cool storage decreases the chance of bacterial degradation and hydration through atmospheric humidity prolonging high percent hatch rate.

Harvesting and Preparing for Feeding

Once the *artemia* cysts have hatched into the first nauplil stage they should be harvested. Remember that not all of the cysts hatch at the same rate, but follow a bell curve rate. To assure the highest number of nauplii are being harvested at the right size several test runs should be performed and analyzed with temperature and time noted. To harvest *Artemia* nauplii, remove the light source above the hatching container and laminate the bottom translucent area of the container to draw the larvae to the light source and drain valve. Turn off the aeration and allow the container to sit for approximately 10 minutes. At this time unhatched cysts will float to the surface and the hatched nauplii will swim towards the light source. Open the bottom drain valve to allow any settled debris to escape into a vessel to be discarded and close the valve once the fluid becomes orange-brown in color. Place a container to receive the newly hatched brine shrimp under the hatching container and open the valve slowly. Once the fluid becomes clear, close the valve. The orange color *Artemia* nauplii in the are then poured into a brine shrimp net or screen (125-150 micron nylon mesh). Thoroughly rinse off the nauplii with fresh tap water to remove bacteria, and hatching metabolites. The *Artemia* nauplii are now ready to be given to the young fry.

Storage of Newly Hatched *Artemia*

Unused harvested and washed nauplii can be placed back into a container with fresh saltwater and aeration for future feedings. Since the metamorphosis of *Artemia* nauplii is very rapid, placing the container and aerating it in a refrigerator will slow down metamorphosis and help retain the nauplii in the instar I stage as long as possible and nutritional value high.

Artemia Production Flow Chart

1. Clean hatching container with chlorine solution (concentration stated above).
2. Drain and fill with saltwater to 35 ppt.
3. Disinfect *Artemia* cysts with chlorine solution and place them into the hatching container (concentration stated above).
4. Add aeration and heaters (if necessary).
5. Turn off aeration and above light source after hatch (time dependent temperature).
6. Place light source at the translucent bottom area of the hatching container.
7. Allow 10- 1 5 minutes for the hatched *Artemia* nauplii to swim to the bottom light source, and unhatched cysts to float to the surface.

8. Remove any bottom debris by opening the bottom drain valve until the fluid becomes orange in color. Discard this fluid.
9. Open the drain valve again and collect the hatched nauplii until the fluid becomes clear
10. Pour the contents over an *Artemia* net of mesh size 125-150 microns, and rinse thoroughly. The are now read to feed to larval fish.

Appendix 3. Directory of Suppliers and Organizations

General Aquaculture Product

Aquacenter Inc. 166 Seven Oaks Road LeLand, MS 38756 ph (1- 800) 748-8921 fx (601) 378-2862	Aeration equipment, water pumps, PVC fittings, filters, nets, test kits, tanks
Aquaculture Supply 33418 Old Saint Joe Road Dade City, FL 33525 ph (904) 567-8540 fx (904) 567-3742	Aeration equipment, water pumps, laboratory equipment, biological filtration, algal and rotifer nutrients and inoculant
Aquanetics Systems, Inc. 5252 Lovelock St. San Diego, CA 92110 ph (619) 291-8444 fax (619) 291-8335	Aeration equipment, water pumps, sterilization equipment, chillers, heathers, PVC fittings recirculation systems and components
Aquatic Eco-Systems, Inc. 2056 Apopka Blvd. Apopka, FL 32703 ph (407) 886-3939 fx (407) 886-6787	Aeration equipment, water pumps, monitors and controls, recirculation systems, laboratory equipment nets, tanks and liners
Area P.O. Box 13303 Homestead, FL 3309 ph (305) 248-4205 fx (305) 248-1756	Aeration equipment, valves and figgings, meters test equipment, filtration, disinfection equipment

Chemical Products

Argent Chemical Laboratories 8702 152nd Ave. N.E. Redmond, WA ph (206) 885-3777 fx (206) 885-2112	Chemicals, therapeutics, specialty feeds, laboratory equipment, books and manuals
Brewer Environmental Industries Inc 311 Pacific Honolulu, HI 96718 h (808) 532-7400	Herbicides, insecticides, fertilizer, agriculture products
Chemaqua P.O. Box 2457 Oxnard, CA 93033 ph (805) 486-5319 fx (805) 486-2491	Therapeutics, water conditioning products
Crescent Research Chemical 4331 E. Western Star Blvd. Phoenix, AZ 85044 ph (602) 893-9234 fx (602) 244-0522	Therapeutics, bacterial cultures, water conditioning products, CPE, HCG, LHRH, test kits meters
Fritz Chemical Company Aquaculture Division P.O. Drawer 17040 Dallas TX 75217	Therapeutics, water conditioning products
Hawaiian Fertilizer Sales, Inc. 91-155 C Leowaena Street Waipahu, HI 96797 h (808) 677-8779	Fertilizer, herbicides, agriculture products

Netting Products

Memphis Net and Twine Co., Inc. 2481 Matthews Ave. P.O. Box 8331 Memphis, TN 38108 ph (901) 458-2656 fx (901) 458-1601	Seines, dip nets, gill nets, floats, lead, aprons, knives, rope, baskets, commercial fishing supplies

Nylon Net Co.
615 East Bodley
P.O. Box 592
Memphis, TN 3810
ph (901) 774-1500
fx (901) 775-5374

Seines, dip nets, gill nets, floats, lead, aprons, knives, rope, baskets, commercial fishing supplies

Tenax Corporation
4800 E. Monument St.
Baltimore, MD 21205-3042
ph (410) 522-7000
fx (410) 522-7015

Plastic netting, liners

Water Quality Test Kit

Hach Company
P.O. Box 389
Loveland , CO 80539-0389
ph (303) 669-3050
h (1-800) 227-4224

Laboratory equipment, chemical reagents, test kits meters

LaMotte Company
P.O. Box 329
Rt. 213 N
Chestertown, MD 2162
ph (1-800) 344-3100
fx (410) 778-6394

Laboratory equipment, chemical reagents, test kits meters

Tanks And Liners

Integrated Construction Technologies
150 Poopoo Place
Kailua, HI 96734
ph (808) 261-1863
fx (808) 262-3828

Concrete holding tanks

Lim Foo, W and Sons
Fiber glass tanks
1130 Wilder Ave. Suite 10
Honolulu, HI 96822
h (808) 521-5468

Fiberglass tanks

Lomart Tanks Liners and Filter — Prefabricated tanks and PVC liners
Prefabricated tanks and PVC liners
114 Kekaha Place
Honolulu, HI 96825
ph (808) 395-5786
fx (808) 395-7175

Pacific Lining Systems — HDPE fabricated tanks
74-5606-F Pawi Place
Kailua Kona, HI 96740
ph (808) 326-2433
fx (808) 329-9170

Plas -Tech Inc. — Fiber glass tanks
Sand Island Rd.
Honolulu, HI 96819
ph (808) 847-2339
fx (808) 845-4337

Rainwater Resources — Steel circular tanks
P.O. Box 62015
Honolulu, HI 96822
Ph (808) 947-3626

Fish Graders

Commerce Welding and Manufacturing Co. — Aluminum interchangeable bar grader
2200 Evanston
Dallas, TX 75208
ph (214) 748-8824
fx (214) 761-9283

Magic Valley Heli -Arc and Mfg. — Aluminum adjustable bar grader
P,O. Box 511
198 Freightway St.
Twin Falls, ID 83301
ph (208) 733-0503
fx (208) 733-0544

Feed Additives

Dawes Laboratories — Nutrients, trace elements, vitamin premixes
4801 W. Peterson
Chicago, IL 60646
h (312) 286-2100

Hoffmann -LaRoche Inc. Animal Nutrition and Health 45 Eisenhower Drive Paramus, NJ 07652-1429 ph (201) 909-5593 fax (201) 909-8416	Nutrients, trace elements, vitamin premixescolor enhancing additives
Red Star Speciality Products Division of Universal Foods Corp. 433 E. Michigan Street Milwaukee, WI 53202 ph (414) 347-3968	Nutrients, trace elements, vitamin premixes color enhancing additives

Shipping Bags

Diverse Sales and Distribution 935 Dillingham Blvd. Honolulu, HI 96817 ph (808) 848-4852	Plastic Bags
Koolau Distributors, Inc. 1344 Mookaula Honolulu, HI 96817 ph (808) 848-1626	Plastic Bags

Shipping Boxes

Pacific Allied Products, Ltd. 91-110 Kaomi Loop Rd. Kapolei, HI 96707 ph (808) 682-2038	Styrofoam boxes and sheet material, corrugated outer boxes
Unisource 91-210 Hanua Wahiawa, HI 96786 ph (808) 673-1300	Corrugated foam core boxes

Aquaculture Publications

Aquaculture Magazine P.O. Box 2329 Asheville, NC 28802 ph (704) 254-7334 fx (704) 253-0677	Published bimonthly - covers both fresh an saltwater culture, tracks world and national industry trends

Fish Farming News
P.O. Box 37
Stonington, ME 04681
ph (207) 367-2396
fx (207) 367-2490

Published five times per year - covers regulatory trends and laws, general aquaculture news

Local Organizations

Hawaii Aquaculture Association
335 Merchant Street Rm. 348
Honolulu, HI 96813
ph (808) 587-0030
fx (808) 587-0033

Speaks as one voice for Hawaii's aquaculture industry, disseminates information, works wit government agencies, also a member of the National Aquaculture Association

National Organization

American Fisheries Society
5410 Grosvenor Lane, Suite 110
Bethesda, MD 20814-2199
ph (301) 897-8616
fx (301) 897-8096

Publishes quarterly journals of recent research, bi-monthly magazine, tracks national legislation

World Aquaculture Society
143 J.M Parker Coliseum, L.S.U.
Baton Rouge, LA 70803
ph (504) 388-3137
fx (504) 388-3493

Publishes quarterly scientific journal, bimonthly magazine, tracks world trends in fresh and saltwater culture