

X. GUIDELINES FOR 80:20 POND FISH FARMING

INTRODUCTION

The concept of “80:20” pond fish culture is to raise crops of fish in ponds where approximately 80% of the harvest weight is composed of only one, feed-taking” high-value species” with high consumer demand, and approximately 20% is composed of "service species” such as filter fishes that help clean the water and predaceous fishes that control wild fish and other competitors.

The objective of 80:20 pond fish culture technology is to provide farmers and government decision makers with a feed-based production technology more economically and technically efficient than the traditional pond fish polyculture systems previously standard in China. In practice 80:20 may be used for production of fry to fingerlings or for fingerlings to market size. Any feed-taking, pond cultured fish species may be used as the primary 80% species. While the 80:20 technology system is fundamentally the same for all warmwater, feed-taking species, feed requirements and some other components of the technology will vary among species.

The guidelines for 80:20 pond fish culture presented here apply specifically to channel catfish, common carp and Nile tilapia, and generally to all feed-taking fishes raised in freshwater ponds. The guidelines are intended for use as a quick reference for persons planning or actually engaged in raising fish in ponds using 80:20 or similar technology. The basic stages of applied 80:20 technology are as follows:

1. Preparation of pond for stocking fish using standard methods.
2. Stock pond with uniform-size fingerlings of a select feed-taking species (e.g. crucian carp) and relatively uniform-size fingerlings of filter fish (silver carp) that will compose approximately 80% and 20%, respectively, of total fish weight in the pond at harvest. Largemouth bass, mandarin fish, or other predaceous species may be stocked as a component of the 20%-group to control any anticipated reproduction or wild fish contamination.
3. Feed the 80%-group fish with a nutritionally complete, high physical quality feed according to prescribed schedule and methods.
4. Maintain pond water quality at non-stressing levels during the entire culture period. Otherwise manage the pond using standard methods, expecting relatively less incidence of disease and reduced need for aeration or water flushing than for traditional polyculture systems.
5. Harvest the entire fish crop all at once ending the culture period. All individual fish composing the primary (80%) species population should be marketable and of relative uniform size. Cropping is a management option during mid-season where market prices are highly favorable.

ENVIRONMENTAL CRITERIA

Proper management of pond environments is critical to 80:20 fish culture. The objective of environmental management is to maintain a stress-free environment so that normal fish production performance, in terms of growth, feed efficiency, health and yield, is unaffected. The following are pond, water and site preparation criteria for 80:20 fish production.

Physical Pond

1. Pond water area should be 2,000 m² or greater.
2. Water depth should be between 1.2 and 1.7 m; dike height about 30 to 50 cm above water line.
3. Water level should stay constant without significant water loss.
4. The pond should not be located in a deep, narrow valley or protected from gentle breezes by trees.
5. Ponds should be equipped with fill and drain facilities. Ponds with continuous water flow are acceptable.
6. Water should be plankton green (transparency 330 cm) and not predominantly silty or acid brown. The watershed must be protected from erosion.
7. Pond bottom and water should not contain accumulated tree leaves, limbs, sticks and similar debris.
8. Pond water should be free of “wild” fish or cultured fishes that are not part of the management program.
9. There should be no conflicting use of the pond.
10. The pond should be accessible for routine management purposes and security.

Pond Water Source

1. Year-round availability of water of adequate quantity and quality is a major consideration when planning and operating fish farms.
2. Total control and unrestricted use of water source are desired.
3. Well water is a good water source, primarily because it is free of wild fish and disease organisms, but quantity may be restricted and cool temperature, low oxygen, low pH and high CO₂ may be temporary quality problems.

4. Surface water may be a good source where seasonal quantity and quality are adequate.

Pre-Culture Preparation

1. Prior to refilling and stocking fish into ponds, all physical repairs should be completed on dikes, drains and bottom soils.
2. Undesirable fish should be eradicated from ponds preferably by complete draining, followed by poisoning (degradable toxins only) of residual waters immediately prior to refilling.
3. Lime (agricultural grade limestone), if needed in a pond, should be distributed evenly over the dry pond bottom or evenly over the surface after the pond is refilled.
4. Before obtaining stock, check all facilities and equipment needed for transporting, handling and stocking of fish. Assure feed supply and markets.

FISH STOCK CRITERIA

Suitability of fish species for aquaculture is dependent on many criteria related to marketability, availability, culturability and ability to withstand stress. A species with good suitability for 80:20 aquaculture will remain healthy and stress-free in a properly managed pond environment, and will be readily available in the proper stocking size, demonstrate good production performance with pelleted feeds, and have high market demand and value.

Species Quality

1. Use only stress-free, healthy stock that meets high quality standards for primary and secondary species.
2. A primary (80% component) fish species must have high consumer demand, readily take pelleted feed and meet other marketability, culturability, availability and stress tolerance criteria. Select primary species include channel catfish, common carp, Nile tilapia, crucian carp, wuchang carp and other feed-taking species.
3. A secondary (20% component) species should have a specific food habit, such as filtering or feeding on small fish, not take pelleted feed, and generally meet all other criteria as the primary species. Select secondary species include silver carp as a plankton filterer and largemouth bass as a predator.
4. Stock quality primarily refers to a fish's genetic potential for culture, including its species and strain characteristics. Genetic quality factors are among several criteria for choosing a species, strain or a specific group of fish for farming.
5. Stock quality also refers to general health, relative size and other physical and physiological characteristics of a given group of fish being stocked.

Fingerling Quality

1. Fingerlings for stocking should be of relatively uniform size and large enough to reach market able size within the growing season.
2. Fingerlings must be unstressed and disease free. Inspection by a certified fish disease specialist is recommended. Some key indicators of good health are uniformity of skin color among the group, absence of spots and frayed fins on individuals, and vigorous capture avoidance by all fish.

Number of Fingerlings to Stock

1. Do not stock above recommended numbers per hectare of water surface area. Numbers to stock are dependent upon total and average individual weights expected at harvest and anticipated optimum carrying capacity of the pond.
2. Stock by numbers of fish per hectare regardless of size - do not stock by weight.
3. Stock primary and secondary species based on their anticipated respective total weights equaling 80% and 20% of total fish weight at harvest.
4. For first-time 80:20 technology users, suggested harvest weights of primary, feed-taking fish per hectare of water should not exceed:
 - a. 2,500 kg with limited aeration and no flushing,
 - b. 4,000 kg with unlimited aeration and limited flushing,
 - c. 6,000 kg with unlimited aeration and flushing

Collective harvest weight of secondary species would increase total harvest by an anticipated 20% to about 3,000; 5,000; and 7,500 kg/ha, respectively, for a, b and c.

5. Maximum stock density will vary with environmental quality, but a recommended maximum stock density of feed-taking fish for a first-time 80:20 farmer is the number of primary fish that will total optimum carrying capacity at harvest. For example, if the farmer using situation "b" (preceding paragraph) wants to harvest fish averaging 500 g, and expected total weight of primary fish at harvest is 4,000 kg/ha (80% of total fish yield of 5,000 kg/ha), then:

$$\text{number to stock} = \frac{4,000 \text{ kg/ha (primary fish weight at harvest)}}{0.5 \text{ kg (desired average weight at harvest)}} = 8,000 \text{ fish/ha}$$

Secondary, service species weight would be about 1,000 kg/ha (20% of total yield of 5,000 kg/ha), and the stocking density would be determined the same way for each secondary species as for the primary species.

Stocking Conditions

1. Fingerlings may be stocked at any time of year, but the process of stocking stresses fish and may adversely affect fish health. Stocking fish during the warmest part of the day is especially stressing. The warmer the water, the greater the stress.
2. Stocking is preferred during the non-growing season when water temperatures are $\leq 16^{\circ}\text{C}$ for catfish and carp and $20\text{-}22^{\circ}\text{C}$ for tilapia.
3. During the culture season, early morning and cloudy, rainy days, when water temperatures are at their lowest, are the best times to stock.

Instructions for Handling Fish

1. The fundamental objective of every activity where fish are handled is to effectively and efficiently accomplish the activity with minimum stress to the fish. The component parts of the objective, effectiveness, efficiency and minimum stress, are interrelated. For example, techniques that improve efficiency will likely result in improved effectiveness and reduced stress to the fish.
2. Techniques and procedures for achieving specific fish handling objectives related to transporting, stocking, sampling and harvesting are subject to the same four-stage process:
 - a. Plan the materials and methods of the procedure based on specific objectives
 - b. Prepare the materials and methods, including all personnel, before beginning
 - c. Implement the procedure specifically following the plan
 - d. Evaluate the results of the technique relative to achieving both the fundamental and specific objectives and the efficiency and effectiveness of the process.
3. During all handling activities, avoid or minimize all stressors of fish such as:
 - a. Working with fish that have consumed feed within 24 hours
 - b. Taking fish out of water for more than a few seconds
 - c. Working with fish during warm temperatures, especially when water temperatures are above 24°C
 - d. Exposing fish to temperature differences of more than 3°C without adequate acclimation
 - e. Exposing fish to LODOS conditions, especially to DO levels below 65% saturation
 - f. Exposing fish to chemicals and pollutants
 - g. Holding fish in tanks or transporting facilities for longer than absolutely necessary.
4. No drugs or chemicals other than salt (NaCl) should be used on healthy fish before they are stocked. Only use drugs and chemicals to treat fish when the fish are obviously diseased or infected by specifically identified pathogens, such as anchor worm (*Argulus*) or *Aeromonas* bacterium and then only use the prescribed medication and dosage specified for the identified pathogen.

FEED CRITERIA

The objective of feeding fish is to provide the nutritional requirements for good health, optimum growth, optimum yield, and minimum waste, and at reasonable cost for maximum profit. Good feed nutritional and physical qualities are the key to achieving production and economic objectives of 80:20 pond fish culture. Nutritional quality means the feed meets all the nutritional requirements of the fish through the inclusion of quality ingredients in proper proportions. Physical quality means the feed is fresh and in the form of a clean, firm pellet with water stability of 310 minutes.

Feed Quality for Pond Fishes

1. Feed should be in pelleted form prepared to either float or sink.
2. Use only feeds that meet nutritional and physical quality standards.
3. The feed used must be nutritionally complete, including complete vitamin and mineral premixes and supplemented vitamin C and phosphorus. The feed must be water stable for 310 minutes. Be suspicious of a bargain feed from a feed manufacturer that is not established.
4. Feed protein levels should generally be 32 to 36%. Higher protein feeds are more expensive, but are usually worth the extra cost, especially until fish average 350 g.
5. Feeds lose quality with age. Feeds should be used within 6 weeks after manufacturing, primarily because of loss of vitamins and other nutrients, and contamination from molds and other microorganisms.

Feeding Pond Fish

1. The objective for the physical act of feeding fish is to provide quality feed in the amount and frequency for optimum production performance and efficiency.
2. The optimum feed allowance per each feeding time and per day to balance growth and FCR is about 90% satiation; 80% satiation gives lower FCR but also slower growth; 100% satiation gives maximum growth but higher FCR; feeding at >100% contributes excessively to pollution and is costly for water management as well as for unused feed.
3. The amount of feed pond fish will consume is primarily related to water temperature and average weight of the fish.
4. Feeding practices may vary greatly but the following are basic recommendations:
 - a. Begin feeding (first few days) at a 3% rate (3 kg feed/100 kg of fish); after fish are actively eating, feed all they will consume within 2 to 5 minutes.
 - b. Some fishes, especially catfishes, normally feed at night but they should be trained to

feed during the day. The preferred feeding time(s) is between 8:00 a.m. and 4:00 p.m., or 2 hours after dawn and 2 hours before dusk.

- c. Feeding twice or more per day is not necessary. However, feeding 2 or 3 times/day 6 to 8 hours apart will result in somewhat faster growth and better feed efficiency, especially for smaller fish and for tilapia and carp.
- c. Overfeeding, which is indicated by feed left uneaten 10 minutes or longer after feeding, should be strictly avoided. This becomes increasingly more important as standing crops approach carrying capacity.
- e. At each feeding distribute the full ration all at once; do not sprinkle feed in small amounts over several minutes.
- f. Daily feed allowances are limited in part because of the negative effects of resulting metabolic wastes on water quality. Do not exceed maximum daily feed allowances recommended in the following table for the three basic water quality management levels:

Level	Water management		Feed maximum (kg/ha/day)	Fish yield optimum (kg/ha/ fange)
	Aerate	Flush		
A	Limited	No	30 - 60	2,500-4,000
B	Yes	Limited	60 - 90	4,000-6,000
C	Yes	Yes	90 - 120	6,000-8,000

Feed Purchase and Storage

1. Purchase only the amount of feed that will be used within 4 to 6 weeks.
2. Store feed in a dry, ventilated, shaded and cool location protected from animals and insects.

Feed Conversion Ratio (FCR)

1. FCR is a measure of nutrient efficiency of producing fish from feed and is influenced by several factors, including feed quality, feed quantity, fish species, fish size and water quality.
2. FCR for a high quality pelleted feed for Nile tilapia, channel catfish and common carp raised from 15 g to 500 g should be about 1.2 to 1.7 kg feed per 1.0 kg fish growth. Higher FCR will result if fish are grown to larger size.

Other Considerations Regarding Feed and Feeding

1. Nutrition (feed) has long been considered a major factor in fish management. Feed quality cannot be taken for granted. Exercise caution in purchasing and handling of feed, because feed and feeding are the highest single management cost in fish production.

2. Fish feeding behavior is the best index to fish health. If fish feed actively, conditions are good and vice versa.
3. Automatic and demand feeders are not recommended because of the added equipment cost, usually higher feed conversion, and the need for the farmer to observe fish condition, fish feeding behavior and general water environment at least once every day.
4. Feed weights should be measured and recorded each time the fish are fed. If weighing each day's ration is not practical, then a volume-weight method to measure feed weight may be used. However, volume-weight measurements must be determined anew every time feed brands or types are changed.
5. Sinking feed is less expensive than floating feed and may be used in ponds, but floating feed is preferred, because it is more profitable and it allows direct observation of the fish.
6. Feed costs to raise a crop of fish may be greater for a lower priced feed than a higher priced feed if the difference in prices is directly related to feed quality. Judge a feed for its production performance and economic efficiency rather than only its purchase price.

WATER QUALITY CRITERIA AND MANAGEMENT

1. Water quality is usually the first, or most important, limiting factor in pond fish management, and it is the most difficult to understand, predict and manage. Most fish kills, disease epizootics, poor growth, poor feed efficiency and similar management problems are directly related to poor water quality.
2. The objective of water quality management is to provide a relatively stress-free environment that meets at least minimum physical, chemical and biological standards for normal health and production performance of the fish.
3. Water quality within a pond is the product of:
 - a. Water quality of the water source supplying the pond
 - b. Quality of the pond soils and immediate environment
 - c. Production technology and management procedures employed, especially those associated with feeding and maintenance of adequate dissolved oxygen.

Oxygen and Low Dissolved Oxygen Syndrome (LODOS)

1. Low dissolved oxygen syndrome (LODOS) is a complex syndrome of numerous accompanying biological, chemical and physical factors that collectively are the most important water quality factor affecting fish health and production performance.
2. While LODOS is the most common and complex water quality problem, it is the easiest to observe, because the fish must surface to breathe.

3. Any concentration of oxygen frequently or chronically below saturation will affect fish production performance. When DO levels are:
 - a. Moderately low, at concentrations below 100% saturation but above 65% saturation, fish
 - b. Critically low, at concentrations between 35 and 65% saturation, fish will take little or no feed, growth will cease and if the condition is prolonged the fish will likely become diseased.
 - c. Severely low, at concentrations below 35%, the fish will become diseased and death to part or all of the population will be likely.
4. Normally in nutrient-rich fish ponds, oxygen is plentiful in mid-afternoon and limited in early morning. However, there are deviations from the normal pattern. These deviations are "overtorns," plankton "die-offs," and periods (2+ days) of reduced sunlight. Either will cause lower than normal oxygen levels for one to several days. When these situations occur in mid-summer, they usually cause partial or total fish kills or, at the least, disease problems, unless timely, emergency aeration is used to maintain oxygen levels above 35% saturation of about 3 mg/l.
5. Low DO and most other water quality problems are best managed by limiting feeding, which means limiting stocking density and yield.
5. Oxygen concentration in pond water may be measured by one of several devices greatly ranging in accuracy and price. Chemical analysis kits are sufficiently accurate and relatively inexpensive, especially when compared to electronic instruments. However, an electronic dissolved oxygen meter should be a priority whenever affordable.
6. Oxygen management in ponds is either biological or physical. Biological management is accomplished by maintaining a healthy phytoplankton population, indicated by a depth visibility of ≥ 30 cm. Physical management involves the employment of some form of mechanical aerator or by adding oxygen-laden water, preferably while discharging oxygen deficient water.
8. Aeration and water exchange are management options when water quality becomes critically low. These should be used when necessary to prevent DO levels from dropping below about 50% saturation of about 4 mg/l, and certainly before the fish are forced to the surface to breathe.
9. The following are causes of LODOS with indicators they have occurred, are occurring or may occur:
 - a. Cloudy weather: Sunshine and phytoplankton, through photosynthesis, are responsible for almost all of the oxygen dissolved in pond water. Therefore, even a few consecutive days with little or no sunshine will restrict photosynthesis, resulting in LODOS conditions;

- b. Thunderstorms: Winds and hard rains are notorious for creating "overturns" in ponds, and some causing LODOS conditions by mixing "bad" quality bottom water with "good" quality top water. The net effect is "bad" LODOS quality water;
- c. Plankton die-offs: Dense phytoplankton populations will sometimes die all at once. Causes of plankton die-offs are not fully understood but severe LODOS conditions follow. Die-offs are not predictable, but they occur more often when algal scum have developed on the water surface, or when depth visibilities are limited to about 15 cm. An indication that die-off has recently occurred is the abrupt clearing of the water within hours. Visibility increases two to several times, followed by changing of water color from green to a dilute coffee-brown color often streaked with black. This condition is usually accompanied by a distinct odor. By this time LODOS conditions are critical. Corrective measures in ponds are generally limited to supplemental aeration until the condition corrects itself, usually in 2-3 days.

Temperature

1. Optimum water temperature for carp, catfish, and tilapia growth is from 26° to 30°C. Growth is poor below 20°C and no growth occurs below about 12°C (lethal temperature for Nile tilapia). Growth and feed efficiency decline steeply above 31°C, and growth ceases at about 33°C, followed by disease and death.
2. Management techniques for controlling pond water temperature are generally impractical and unreliable. Addition of water from a cooler or warmer source may be a practical option in limited situations. Mechanically aerating and mixing pond waters may temporarily change temperatures, but with little benefit, especially compared to cost. Shading of ponds should not be used, because it would reduce oxygen production and would have little effect on water temperature.

Nitrogenous Wastes

1. Ammonia and nitrite are forms of nitrogenous wastes resulting from protein digestion. These wastes may become problems in intensive fish production systems, but should not be problems at the recommended stocking and production levels for 80:20 pond fish culture.
2. The most practical management technique for controlling nitrogenous wastes is prevention by limiting feed inputs through limited production intensity.

Water Visibility

1. An index to healthy pond water is a distinctly green phytoplankton color, no surface scum and a depth visibility of ≥ 30 cm. Less visibility indicates potential trouble with LODOS. Visibility of ≤ 15 cm is critical.
2. Low visibilities in ponds due to dense phytoplankton are associated with high feeding levels.

Liming

1. Properly limed ponds have fewer LODOS and related problems and less extreme pH swings in a day-night cycle. Normally, pond water pH is acidic at night, especially at dawn, and alkaline during daylight, especially at mid-afternoon. Ideal pH range would be from about pH 6.5 to pH 8.5.
2. Lime is needed when total alkalinity of pond water is ≤ 20 mg/l. When applying lime, spread it evenly over the dry pond bottom or apply it evenly over the water surface so it will fall evenly over the bottom mud.

FISH PRODUCTION

Yields and Carrying Capacities

1. There are always limits to weight yields of fish that can be produced per area of pond water. The maximum yield that can be produced is called carrying capacity. However, the maximum yield is usually not practical because stress factors begin to negatively affect production before maximum weight is achieved. The weight that is more technologically practical and economical to produce is the optimum carrying capacity or optimum yield.
2. Optimum yields vary greatly because of many factors, including species and their life stages cultured, quality and quantity of feed, biological, chemical, and physical characteristics of the water environment, market price and production cost. Therefore, there are no standard optimum yield numbers, only approximations.
3. Maximum yields in ponds of 330 mt/ha and optimum yields of 310 mt/ha have been reported, but sustainable optimum yields of feed-taking (80% component) species are more likely to be about 3 mt/ha in ponds without reliable aeration and no flushing, about 5 mt/ha with aeration and no flushing, and about 7 mt/ha with aeration and unlimited flushing.

FARM MANAGEMENT

The purpose of 80:20 pond fish farming is to raise fish in ponds for profit. Successful fish farm management that achieves the sustained profit objective involves the application of sound business and production practices to maximize profits by matching market situations with optimized production options. Management decisions are centered around what quality and quantity of fish to produce and how to produce them. What quality and quantity of fish to produce is directly dictated by market demand, which indirectly dictates market prices that farm managers must accept with little or no control. How to produce fish for a market is directly controlled by farm management but influenced by demand and prices. Production management is always optimum based. Optimum production performance is achieved by maintaining a cost-conscious balance between stock quality and quantity, nutrient input quality and quantity and environmental quality.

1. Marketing is the first thing a fish producer should think about when planning production.

2. Preferred markets are those that provide the highest profits; however, market limits, resource limits, the need to spread risks and the need to spread cash flow are considerations in choosing the fish species to produce.
3. Farm managers must stay competitive by staying current on ever changing technological advancements and market opportunities.
4. Record keeping is essential. Keep complete records of all production and economic factors relative to purchases, practices and sales, and make notes of important observations. Do not depend on memory for records and observations.
5. Make at least one visit every day to observe the fish, their feeding behavior, the color and general appearance of the water, and to look for signs of problems. Get to know the fish and their total water environment to know what is and what is not normal.
6. Fish farming is "crisis management." Plan ahead and know what to do in case of emergency, such as if:
 - a. The fish stop eating
 - b. The fish show disease symptoms
 - c. The fish are "gasping" at the water surface
 - d. A heavy thunderstorm occurs with strong wind and hard rain, potentially creating conditions for "overturn".