Initial Evaluation of Fishery Resources in Panamanian Small Impoundments

A report to

The Direction of Aquaculture in Panama

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Table of Contents

		Page
	Definition of special forms used in text	i
1.0	Introduction	1
2.0	Materials and Methods	2
2.1	Sampling equipment	2
2.2	Sampling	3
3.0	Results and Management Recommendations	4
3.1	Reservoir #1, La Orange.	5
3.11	Management Recommendations for La Orange	6
3.12	General Considerations for stocking fish in ponds	9
3.13	Survey periodicity	10
3.14	Tabulated Results of La Orange experimental catfish data	12
3.2	Reservoir #2, La Mata de Santiago	14
3.21	Results and Recommendations for the Mata de Santiago	14
3.22	Tabulated Results of La Mata de Santiago experimental catch data	16
3.3	Reservoir #3, La Mata de San Francisco	17
3.31	Results and Recommendations for La Mata de San Francisco	17
3.32	Tabulated Results of La Mata de San Francisco experimental catch data	20
3.4	Results #4, La Raya de Santa Maria	21
3.41	Results and Recommendations for La Raya de Santa Maria	21
3.42	Length-weight relationship and physical condition of the predators, Pez Perro and Sargento in the studied reservoirs	23

3.43 Tabulated results of La Raya de Santa Maria experimental catch data 25

3.5 Reservoir #5, La Yeguada 29

3.51 Results and Recommendations for La Yeguada 29

3.52 Tabulated results of La Yeguada experimental catch data 37

3.6 Reservoir #6, Volcan Chica 38

3.61 Results and Recommendations for Volcan Chica 38

3.62 Tabulated results of Volcan Chica experimental catch data 41

4.0 Discussion 42

4.1 Potential for fishery management in reservoir 42

4.2 Harvest potential 46

4.3 General management recommendations 48

4.4 Monitoring of fish stock development

5.0 Literature Cited 54

6.0 Appendices 55

6.1 Sample data recording form 55

6.2 Discussion of the physical and chemical parameters measured 58

6.3 List of scientific and common names of fishes mentioned in this report 61

6.4 Information on stomach contents and maturity of fishes sampled during the present survey 63

6.5 Generalized classification of maturity stages in fishes 65

6.6 Recommended equipment list for small impoundment management 66

I. Definition of special terms used in the text.

Large fingerling. A fish at least 15 cm in total length.

Estimated catch in 100 m^2 of gillnet. We fished gillnets with surface areas (height x width) of $25m^2$, $18.25m^2$ and $250.8m^2$. In order to compare the catches in each of these nets we estimated what the catch from anyone of these gears would be if the actual area of the net was 100 m^2, for example a net 40 m long and 2.5 m in height. To make this conversion of weight or numbers of fish actually caught in a particular net to one with 100 m^2 surface area we used the following formula.

$$\text{Estimate} = \begin{array}{l}\text{weight (or numbers)}\\ \text{of fish actually}\\ \text{caught}\end{array} \times \frac{100}{\begin{array}{l}\text{actual area}\\ \text{of experimental}\\ \text{net}\end{array}}$$

Initial Evaluation of Fishery Resources in Panamanian Small Impoundments

1.0 Introduction

R. J. Scully, a fisheries biologist from Auburn University's Department of Fisheries and Allied Aquacultures, was in the Republic of Panama March 7-20, 1982 at the request of the National Director of Aquaculture. The purpose of the trip was to evaluate fishery potential in existing small irrigation and hydroelectirc reservoirs and formulate recommendations for research and management of small reservoir fisheries.

Efraim Rodriguez, Rigoberto Gonzales and Cevero from the National Direction of Aquaculture and the author worked together during most of the data collection and initial analysis. Dr. Richard Pretto and environmentally concerned residents of Volcan, Chiriqui, participated in data collection of Volcan Chica.

In the province of Veraguas we studied four of an estimated 50 small irrigation reservoirs which average larger than 5 hectares in surface area. Such aquatic resources should be capable of yielding at least 50 kg/ha/yr of fish and with minimal management this quantity could be doubled easily. Other parts of Panama also have small impoundments, such as the 100 ha hydroelectric reservoir at La Yeguada and the natural lake, Volcan Chica in Chiriqui, both of which were also studied during the present investigation period.

By fishing variable mesh gillnets and beach seines and measuring pertinent physical-chemical parameters, we were able to estimate which fish species were present, how their populations were structured and which exotic fish species should do well if introduced. A plan for fish stocking and harvest could then be determined.

Sampling and analysis methodology are defined within this report for a continuing program to monitor the development of food fish populations. Changes in fish community structures and catch rates will be interpreted in light of ecological and population dynamics principles and this information will serve as the basis for management recommendations. Six reservoirs have been selected for investigation and management and once a successful management program has been developed for the studied reservoirs, the methods will be extended to all small reservoirs in Panama where fish culture would be appropriate.

2.0 Materials and Methods

At each of six reservoirs we set four gillnets overnight (two extra gillnets were fished at one lake, La Yeguada) and fished two types of seines at least three times each.

2.1 Sampling Equipment

Gillnets

1. Monofilament nylon 150 feet long by 8 feet deep divided into six panels each 25 feet long; Each panel is a different stretched mesh size and line diameter [1 1/2" (.28mm), 2" (.33mm), 3" (.40mm), 4" (.40mm), 5" (.52mm), 6" (.52mm)]. This is a sinking gillnet, i.e. it fishes from the pond bottom up 8 feet in the water column. The surface and bottom lines contain cores of foam and lead, respectively, which eliminate problems associated with external bouys and leads when setting gillnets.
2. Multifilament nylon, 50 meters long by 2.5 meters deep divided into five panels, each 10 meters long. Each panel is of different stretched mesh size and material diameter [2" (.33mm), 3" (.40mm), 4" (.40mm), 5" (.52mm), 6" (.52mm).] The netting is mounted on a top nylon twine with no floats and there is no bottom line. The net must be pulled taught from each end to suspend it in the water column.

3. Monofilament nylon, 300 feet long by 9 feet deep, three (3) inch stretched mesh. The surface line contains plastic floats and the bottom line contains lead weights. The net fishes up from the bottom of the water column.
4. The same as 3 above, but with 5" mesh rather than 3" mesh.

Beach seines

1. Multifilament nylon, 15' x 4' x 1/8" mesh (Ace style) minnow seine with floats and leads on the upper and lower lines respectively.
2. Multifilament nylon, 45' x 6' x 1/2" square mesh with a 6' x 6' x 6' bag. Floats and leads are attached to surface and bottom lines.

Water quality analysis

We used a Hach Water Ecology Test Kit [model AL-36B] to measure important parameters for production and wellbeing of fish. These include alkalinity, carbon dioxide, dissolved oxygen, hardness and pH. Additional water quality sampling equipment used include a dissolved gas sampler (Hach model 1962), centigrade thermometer and a 20 cm Secchi disc.

Lake surface area information was available from the Direction of Aquaculture files. A standard form for recording data was designed and modified to improve its applicability and all data were recorded on these forms. A sample form is presented as appendix 1.

2.2 Sampling

Gillnets were set from the bank or from partially inundated trees. Water depth was always less than 7 meters and generally less than 5 meters at netting locations. Gillnets were set between 3:00 and 5:00 pm and fished during the following morning generally after 8:00 am. Catches were recorded separately for each mesh size in each net and by species for each centimeter group. Fish were

measured to the nearest centimeter using a specially constructed fish-measuring board. Small fish were weighed on a 400 gram x 2 gram pan balance. Larger fish were weighed on a 20 pound x 1 ounce spring balance and weights were later converted to metric units. Each fish taken from the nets was dissected to determine stomach contents and stage of sexual development.

Beach seines were fished in an arc from the bank. Seining areas were selected where the depth was shallow enough to ensure that the leadline always drug the bottom to prevent escapement of fish. Seining sites were also limited to areas without large rocks, stumps or excessive macrophytes which would interfere with seining. aptured fish were separated by species, sorted by centimeter group, counted and recorded. Weights were recorded from seine captured fish only when used for calculating length-weight relationships and condition factors.

Water samples for dissolved oxygen, CO_2, pH, hardness, alkalinity and temperature were taken from one meter depth with a dissolved gas water sampler. Temperature was also measured at the water surface. A Secchi disc was lowered into the water until it dissappeared, then raised until it become visible. The average depth between these two points is the Secchi discvisability. A discussion of the need to record the above variables in pond analysis is given in appendix 2.

3.0 Results and management recommendations

We evaluated fish populations in six ponds and lakes, four of which were water storage ponds for irrigation of the sugar cane plantations "Victoria" and "Santa Rosa", in the province of Veraguas; all within 15-20 km of Divisa.

A fifth system was a hydroelectric power reservoir and the sixth was a small natural springfed lake. The period of this project was late into the dry season, so the manmade lakes had been drawn down, well below maximum normal

height and surface area. There had been no significant inflow of water to dilute and flush out previously standing water. Plankton concentration was probably near maximum for the year and turbidity contained little or no settlable material. Any turbidity at this time resulted from plankton or suspended colloidal matter. Cloud cover was minimal and days were generally hot and dry with windy (15-30 km/hr) afternoons. Wind probably caused significant mixing of the water mass although we did not verify this by recording temperature and oxygen profiles.

3.1 Reservoir #1

1. La Orange, Santa Rosa Sugar Plantation, March 8-9, 1982

   Physical and chemical conditions

   Surface area when full = 250 ha., presently about 100 ha

   Water quality sampled at 8:30 am at one meter depth

   pH = 7.5, Alkalinity = 48 mg/L, Hardness 51 mg/L.

   Dissolved oxygen = 7 mg/L, Co_2 = 10 mg/L., Surface water temperature = 27°C. Secchi Disc visibility = 100 cm, water color = green. No fish have been stocked in this reservoir.

Seven species of native fish were captured in experimental gill nets. These were Pez Perro, Torito, Curimata, Aguja, Chupapiedra, Chogorro and Barbudo. Common and scientific names are presented in appendix 3. Of these only the Torito was sufficiently abundant for a potential fishery. An estimated 8.3 kg of Torito would be caught in 100 m^2 (40 m x 2.5 m) of 2 inch stretched mesh monofilament gillnet. However only 1.85 kg of fish (46% Torito) was estimated for a 100m^2 of 2" stretched mesh multifilament gillnet catch. Unless the monofilament gillnet is really 10 times more efficient for Torito than is the multifilament net, then we may expect considerable variation in the catch rate of Torito in La Orange. These fish were marginally harvestable, having an average weight and length of 73 grams and 18 cm respectively.

Many small fish were captured in the 15' long seine. These were mostly algae and macrophyte feeding Astyanax and to a lesser extent the insectivorous Roeboides, both of which are generally less than 5 cm long and are collectively called Sardines. These fish do not grow to harvestable sizes.

The 45' seine captured Roeboides, Torito, Shrimp, Pez Perro and Aguja. The latter two species are piscivorous and are probably the main predators on small littoral fishes such as were captured in the 15' seine. We were unable to catch sufficient shrimp with seine or castnet to indicate that an economically exploitable population existed. Possibly baited traps would successfully catch shrimp. Of the seine catch only Pez Perro and Torito grow to harvestable sizes.

The fish biomass of La Orange is largely of unharvestable size fish. Possibly a harvest of 50 kg/ha/yr of Torito and Pez Perro could be expected but the average catch rate would be low and the fish would be only marginally large enough for harvest. With management, this lake should produce at least 100 kg/hectare of quality food fish.

3.11 Management recommendations for La Orange

Our goals are to enhance the fish community such that most fish are of species which grow to harvestable size, to ensure that most of the available food sources are utilized and that most of the fish feed low on the food chain thus increasing the efficiency of fish production. Broodstock of many tropical freshwater food fish species are available at the Divisa aquaculature station in Panama and these will form the initial seed for the pond stocking program. Several of these species should be stocked in La Orange and their contribution to the community production of pond fish is discussed below.

Tilapia nilotica is an aggressive, highly competitive African Cichlid. It feeds on phytoplankton and to a lesser extent on detritus and macrophytes. It grows quickly to harvestable size and is generally accepted in fish markets. T.

nilotica was accidently introduced into Lake Victoria, Africa and purposfuly into several Brazilian reservoirs. In both areas it has become a dominant component of the commercial catch, thus, this species is capable of making a place for itself in waters already saturated by other species.

Tilapia nilotica should be introduced to La Orange reservoir to utilize periphyton on submerged trees, phytoplankton and benthic detritus. Introduce adults since the Pez Perro and Aguja would probably eliminate introduced Tilapia fingerlings 5 adults per hectare should be stocked at the beginning of the rainy (rising water) season. They should spawn immediately and the young should have a good chance of survival as they disperse over newly inundated lands. Native predatory fish should prevent overpopulation and stunting of Tilapia.

The abundance of "Sardines" in the 15' seine catch indicates that increased predation is warrented. Sargento is a good food and sport fish and an efficient predator. Its addition to the La Orange fish community would further assure that the Tilapia population would not stunt. Only adults or large fingerlings (large fingerlings are here defined as $\geq$ 150 mm is total length) should be stocked. Availability of Sargento may be a limiting factor; possibly Sargentocould be collected from La Mata de San Francisco (See reservoir #3 below) for stocking. At least 50 Sargento should be stocked in La Orange and about 400, (2/ha) would be most desirable. Once establish, restocking of T. nilotica and Sargento will not be necessary as these species will reproduce adequately with pond.

The large seasonally inundated, vegetated plain of La Orange should provide excellent forage for the Common Carp which should be stocked at about 50 per hectare of large fingerlings. This species may or may not form naturally substaining populations. Thus repeated annual stocking may be necessary.

Marginal submersed vegetation would provide good forage for Grass Carp. Assuming that less than 5% of La Orange contains such forage, and that 100 Grass Carp/ha will control vegetation then stock (.05) (200 ha) (100 carp/ha) = 1000 grass carp as large fingerlings

Israeli stocking rates for Silver Carp in reservoirs of moderate productivity is 400/ha. 400 x 200 ha (as an annual average) = 80000 Silver Carp. To insure that Silver Carp do not suffer from intraspecific competition I would suggest an initial stocking rate of 50/ha or 10000 large fingerlings. Israeli stocking rates for Bighead carp are 15/ha; again we should start with a lower rate possibly 5/Ha. If future sampling indicates excellent physical condition and growth rate, than stocking density can be increased.

Initial stocking program for La Orange based on 200 HA average surface area

Species	Quantity	When	Size
Tilapia nilotica	1000	beginning of rains	Adults
Sargento	≥50	mid dry season	Adults
Common Carp	10000	beginning of rains	large fingerlings
*Grass Carp	1000	beginning of rains	large fingerlings
*Silver Carp	10000	early dry season	large fingerlings
*Bighead Carp	1000	early dry season	large fingerlings

3.12 General considerations for stocking fish in ponds

Listed stocking rates are only educated guesses. Their utility should be determined by the physical condition and occurance of stocked fish in the experimental and fishermen's catch. Very fat fish indicate that a stocking rate can be increased and thin fish indicate that the stocking rate was too high. Biomass of fish in unfertilized ponds probably will be between 50-200 kilograms/ha depending on basic productivity and the availability of appropriate species to utilize available foods. If too many fish are stocked, competition for food will be excessive and poor growth will result. If few or no introduced fish enter the experimental catch in the following one to two years then the following problems should be considered.

1. Insufficient food supply and fish died of starvation.
2. Predators are consuming introduced fish. If this is determined than larger fish must be introduced.
3. Pesticides carried in by rains from the watershed are killing the fish or their food organisms.

*These species will not spawn in ponds and repeated annual or biannual stocking will be necessary. The frequency of stocking depends on the rate of depletion by harvest and natural mortality.

4. Fish escape downstream with excessive overflow of the spillway during heavy rains. Solution: widen the spillway such that even with the heaviest rains, water on the spillway will always be $\leq$ 4" deep. This will prevent escape of most harvestable sized fish. Necessary width of spillway depends on watershed area, rainfall intensity, permiability of soils, etc.
5. Water quality variables, especially dissolved oxygen, may reach lethal low concentrations during such occurrances as water overturns during excessively windy days or at the initiation of the rainy season when much organic matter is washed into the pond, greatly increasing the dissolved oxygen demand.
6. Fish may die immediately or soon after introduction to the pond due to handling stress. Silver Carp are especially sensitive to handling and should only be transported early in the morning when temperature is coolest. Other precautions such as not feeding fish for several hours prior to handling and adding salt at one to five percent to transport water to minimize ion inbalance should be considered. There will probably be litle or no temperature differences between hatchery and pond surface water, but this possibility should be recognized as temperature change is very stressful to fish.

3.13 Survey periodicity

This report contains information on the catch rates and species compositions in various experimental nets. A second such survey should be done before or at the time of stocking to verify the information of the first survey. Preferably four surveys will occur annually; 1st, mid dry season (already completed); 2nd beginning of rains, 3rd; mid-rainy (high water) season; 4th; at the end of the rainy season. Fish activity, distribution and density will likely differ

between these seasons, and results of future surveys, after fish stocking or other management activities, should be compared with pre-management survey data, on a seasonal basis.

Gillnets, probably of 3" or 4" stretched mesh will be the most efficient gears to exploit the new fish community. However, it is best to wait until the fish community develops and sample with multimesh experimental gillnets before making this recommendation.

Gillnet catch summaries from La Orange at the Santa Rosa Sugar Plantation

Species	Net material	stretched mesh (inches)	Net area m^2	# of individ.	% #	wt (kg)	% wt	Average weight (grams)	*#Est. in 100^2	*Wt(kg) Est in 100^2	total length and standard error (cms)
		Multimesh flagnet									
orito	Multifilament	2"	25	3	50	.214	46	71	12	.856	16.7±0.88
urimato	"	"	"	3	50	.248	54	83	12	.992	17.3±0.33
				6		.462			24	1.848	
	"	3	25	-NO CATCH-							
guja	"	4	"	1	100	.095	100	95	4	0.380	17
	"	5	"	-NO CATCH-							
	"	6	"	-NO CATCH-							
		Multimesh gillnet									
orito	Monofilament	1 1/2	18.58	1	50	.024	.55	24	5.4	0.129	13
hogorro	"	"	"	1	50	.020	.45	24	5.4	0.108	9
				2		.044			10.8	0.237	
orito	"	2	"	21	100	1.535	100	73	113	8.261	18.0±0.23 cm
	"	3	"	-NO CATCH-							
	"	4	"	-NO CATCH-							
	"	5	"	-NO CATCH-							
	"	6	"	-NO CATCH-							

ez Perro	monofilament	3	250.8	8	80	3.511	87	439	3.2	1.400	33.4±0.56
hupapiedra	"	"	"	1	10	0.130	3	130	0.4	0.052	24
rbudo	"	"	"	1	10	0.400	10	400	0.4	0.159	31
				10		4.041			4.0	1.611	
hupapiedro	monofilament	5	250.8	1	100	0.568	100	0.568	0.4	0.226	38

based on the surface area of each net, we estimated the number and weight of fish that would have been caught in a pothetical net of 100 m^2 (40m long x 2.5m deep, for example) so that catch rates could easily be compared between nets. The nversion formula is

$$\text{timated} = \frac{(X)\ 100m2}{\text{area of actual net in } m^2}$$

where x equals the number of fish or weight of fish actually caught.

3.2 Reservoir #2

La Mata de Santiago, Victoria Sugar Plantation

March 9-10, 1982

Surface area 16 ha full, less than 5 ha at present. Water quality sampling time 8:30 am, depth of sample was one meter.

pH = 7.5, Alkalinity = 27 mg/L, Hardness = 21 mg/L.

Dissolved oxygen = 7 mg/L, CO_2 = 5 mg/L, surface water temperature = 28°C.

Secchi disc visibility = 110 cm, water color = green.

Previously Introduced fish:

species	year	quantity	size
Grass carp	1980	83	4.5 inches
Silver carp	1980	1066	3 inches

3.21 Results and Recommendations for La Mata de Santiago

Only two species were caught in experimental gillnets, Pez Perro, a predator and Chogorro an insectivorous cichlid. The density of Pez Perro is only marginal to support fishing as our best estimated catch rate was 1.9 kg per 100 m^2 of 3 inch stetched mesh gillnet. Several small species were caught in seines; the insectivorous Roeboides, herbivorous Astyanax ruberrimus and A. coeruleopuntatus, detritus feeding Curimata magdalenae and a planktivorous poecilid. Young Chogorro and Pez Perro were also inthe seine catches. We caught none of the introduced carps.

A fringe of submersed vegetation, possibly Ceratophyllum, Hydrilla or Chara extended out several meters from shore. As the water level receded, the exposed shore was covered with a carpet at dead decomposing vegetation. The relatively transparent water may be a result of macrophyic vegetation successfully competing with phytoplankton for limited available nutrients.

An obvious candidate for stocking in the pond is Grass Carp. However, 83 were stocked here two years ago, with no apparent affect on vegetation and none were caught in our nets. Possibly our sample was too small, but more likely, the Carp left the pond over the spillway during the rainy seasons. If possible, the spillway should be widened or on additional spillway constructed and larger fingerling Grass Carp should be stocked at a rate of 100 per hectare.

Tilapia nilotica should be stocked as they would probably compete well with other herbivovous and omnivovous species and improve the community for food fish production. Adult Tilapia stocked at 5-10 per hectare should result in abundant young Tilapia appearing in the 15' seine catches within 6 months. Some 3 inch to 5 inch long Tilapia i.e, 10-40 intermediate sized Tilapia should be captured in the average 45' seine haul and narvestable sized Tilapia should occur in the 3" and 4" stretched mesh gillnets if predation by Hoplias is adequate to prevent excessive Tilapia survival.

If populations grow well, the majority of the catch will be of Tilapia with lesser catches of Grass Carp. 3" and 4" stretched mesh gillnets will probably be the best gear for harvest. 100 kg/ha/yr, based on an average of 10 hectares would be a reasonable harvest after the new community is established. The catch should average 20 kg/week which should provide a welcome supplement to the food of sugarcane workers.

Silver and Bighead Carp require plankton production which may or may not be adequate in this pond. If the spillway problem is solved and Grass Carp are successful, then Silver and Bighead Carp could be stocked at the same density as recommended for La Orange, ie 50/ha and 5/ha, respectively.

Gillnet catch data from La Mata de Santiago

ecies	Net material	mesh (inches)	Net area m^2	# of indivd.	% #	wt (kg)	% wt	Average weight (grams)	*#Est. in 100^2	*Wt(kg) Est in 100^2	Total length and standard error (CMS)
		Multimesh Gillnet									
: Perro	monofilament	1 1/2	18.25	1	35	.040	38	40	5.4	0.215	16
ogorro	"	"	"	3	75	.065	62	21.7	16.1	0.350	10.3±0.33
				4		.105			21.5	0.565	
: Perro	"	2	"	3	75	.326	98	109	16.1	1.755	23.3±0.67
ogorro	"	"	"	1	25	.008	2	8	5.4	0.043	8
				4		.334			21.5	1.798	
: Perro	"	3	"	1	100	.350	100	350	5.4	1.884	33
	"	4	"	- NO CATCH -							
	"	5	"	- NO CATCH -							
	"	6	"	- NO CATCH -							
		Single mesh gillnet									
z Perro	monofilament	3	250.8	1	100	.417	100	417	0.4	0.166	36
		Single mesh gillnet									
z Perro	monofilament	5	250.8	1	100	.380	100	380	0.4	0.152	33

the multifilament flagnet was not fished

3.3 Reservoir #3

La Mata de San Francisco - Victoria Sugar Plantation

March 10-11, 1982

Surface area full = 11 ha., surface area at present about 7 ha. Water quality sampling time 9:00 AM, depth of sample one meter. pH = 7.0, Alkalinity = 14 mg/L, Hardness = 7 mg/L. Dissolved oxygen = 7 mg/L, CO_2 = < 5 mg/L, water temperature at surface = 28°C, at one meter = 26.5°C. Secchi disc visibility = .38 cm. Water color is grey-white and appears to be colloidal clay turbidity.

Previously introduced fish

species	year	quantity	size
Sargento	?	?	?
Tilapia sp.	?	?	?
Silver Carp	1980	400	3"
Grass Carp	1980	41	4"

3.31 Results and Recommendations for La Mata de San Francisco

Seven species were captured in experimental gillnets. Macana (a Gymnotid), *Curimata*, Torito, Sardine, Sargento, Pez Perro and *Tilapia sp.* *Curimata*, *Tilapia* and Sardine are probably important prey species and Sargento and Pez Perro the major predators. Macana and Torito occupy intermediate trophic levels. Torito stomachs often contain shrimp remains.

The largest estimated catches would occur in $100m^2$ of 4" monofilament (9.8 kg) and 2" multifilament (9.5 kg) stretched mesh gillnets. Nearly the entire catch, by weight, from these two nets is of Sargento.

Sargento appears to have been the most successful introduction. The only other introduced fish in the catch were two large *Tilapia* of uncertain speces, probably *T. mossambica*.

A combination of very efficient predation by Cichla and Hoplias and of low primary production due to clay turbidity has resulted in a predator dominated fish community. Clay turbidity also inhibits macrophytic growth, thus minimizing hiding areas for prey. We seined 11 times with the 15' seine and 7 times with the 45' seine and only two fish, both juvenile Cichla of 8 and 14 cm were captured.

An ephemeral river enters this pond, bringing colloidal clay, thus clay removal, which is expensive, would bring only short-lived results, as new water enters the pond. The only possible solution to the turbidity problem would be to enhance the vegetative cover on the erroding watershed.

Although our catch rate for Sargento was good, it is doubtful that regular fishing would continue to produce well. Annual harvest of predators can not be expected to be more than 15-20% of the possible harvest of fishes from all tropic levels. If the lake averages near 10 ha of water surface, then annual Cichla harvest should not exceed 150-200 kg. If catch values averaged 4 kg/100m^2 net of 4" stretched mesh gillnet (about half of our catch rate) then 40-50 net nights/year would catch the harvestable surplus. That would be one net set every 7-9 days. An adaptive forage fish such as T. nilotica might form a population in this lake even though its prefered food, phytoplankton is minimal. If such occurred, and simultaneously the Cichla population was reduced by fishing, then productive predator and prey populations could result and an increased harvest expected.

Clay turbidity and the resultant inhibition of macrophytes and plankton, make this pond unsuitable for Grass, Silver and Bighead Carps. Common Carp, because of their digging habit would only increase the turbidity problem.

Suggested Fish Stocking:

species	size	quantity	when
Tilapia nilotica	adults	200	Beginning of rains

Simultaneously, weekly fishing with about $100m^2$ of 3" and 4" mesh gillnet should begin to reduce the density of adult Sargento. These same nets should effectively catch *Tilapia nilotica*, once this population develops. Although we caught two large *Tilapia sp* in 5" mesh, since we caught no smaller *Tilapia* in gillnets or seines, the *Tilapia* population is probably dying out. *T. nilotica* should be more successful in colonizing this pond.

Experimental Gillnet data

La Mata de San Francisco - Victoria Sugar Plantation

Species	Net material	stretched mesh (inches)	Net area m^2	# of indivd.	% #	wt (kg)	% wt	Average weight (grams)	*#Est. in 100^2	*Wt(kg) Est in 100^2	Mean total length and standard error (CMS)
		Multimesh Flagnet									
Sargento	multifilament	2	25	3	50	2.100	88.2	700	12	8.400	37.2±1.86
Surimato	"	"	"	2	25	0.058	2.4	29	8	0.232	17
Sorito	"	"	"	2	25	0.226	9.4	113	8	0.904	19.5±1.5cm
				7		2.386			28	9.536	
	"	3	"	1	100	.316	100	316	4	1.264	29
	"	4	"	- NO CATCH -							
	"	5	"	- NO CATCH -							
	"	6	"	- NO CATCH -							
		Multimesh Gillnet									
Macana	monofilament	1 1/2	18.25	1	12.5	.080	19	80	5.4	0.431	42
Surimato	"	"	"	5	62.5	.266	65	53	26.9	1.432	15.4±0.51
Sorito	"	"	"	1	12.5	.049	12	49	5.4	0.264	15
Sardina	"	"	"	1	12.5	.016	4	16	5.4	0.086	11
				8		.411			43.1	2.213	
Surimato	"	2	"	6	60	.469	64	78	32.3	2.524	16.7±0.33
Sorito		"		4	40	.262	36	66	21.5	1.410	16.8±0.48
				10		.731			53.8	3.934	
	"	3	"	- NO CATCH -							
Sargento	"	4	"		100	1.829	100	610	16.1	9.844	35.0±0.89
	"	5	"	- NO CATCH -							
	"	6	"	- NO CATCH -							
		Single mesh gillnet									
Sargento	monofilament	3	250.8	7	78	2.441	85	349	2.8	0.973	29.3±0.89
Pez Perro	"	"	"	1	11	0.365	13	365	0.4	0.146	34
Sorito	"	"	"	1	11	0.063	2	63	0.4	0.026	17
				9		2.859			3.6	1.145	
		Single mesh gillnet									
Tilapia	monofilament	5	250.8	2	100	2.441	100	1220	0.8	0.973	37.5±1.5

3.4 Reservoir #4

La Raya de Santa Maria - Victoria Sugar Plantation

Near the Village 'La Guaca'

March 12-13, 1982

Surface area when full = 9 Ha, present area about 7 Ha. Water quality sampling time = 4:00 PM, depth of sample = one meter. pH = 7, Alkalinity = 14 mg/L, Hardness = 14 mg/L.

Water temperature at surface = 28°C, at one meter depth = 26°C, Secchi disc visibility = 95 cm, water color = green.

Previously Introduced Fish

species	year	quantity	size
Grass Carp	1980	41	4 inches
Silver Carp	1980	400	3 inches

3.41 Results and Recommendations for La Raya de Santa Maria

The population of large fish is small or non-existent in this lake, i.e., we had no catch in the stretched meshes of 4, 5 and 6 inches, and very little in the 3 inch mesh. No introduced fish were recovered. The small characin, Curimat[illegible] [illegible]nated the experimental catch. In a 2" mesh Curimata averaged 17.5 cm and 91 grams (0.2 pounds), a size considered harvestable by the investigators. The 2" mesh monofilament gillnet caught Curimata at a rate of 168 fish (17.23 Kg) per 100m^2 of netting. However the multifilament nylon 2" mesh caught Curimata at a low rate, i.e., 4 fish (0.40 kg) per 100m^2 of netting. These two catches may indicate the large variation in catch to expect between net sets and in part the relative efficiency of monofilament and multifilament nylon.

The food source for Curimata is generally bacteria and decaying organic matter in bottom muds. There is probably an abundance of dead organisms (plankton, etc.) in tropical pond mud, thus the Curimata population may be large.

Due to the small adult size, the fish is probably short lived (2-3 years) and a relatively large harvest could be expected annually.

(1) At a harvest rate of 50-100 kg/Ha/year, 450-900 kg could be harvested from this 9 ha reservoir.

Using a conservative average catch rate of 1/4 our high catch rate, a $100m^2$ 2" stretched mesh gillnet would catch, on the average, $\frac{17.228}{4}$ kg = 4.3 kg per set.

450-900/kg/yr ÷ 4.3 kg/set = 105-210 net sets which would be needed to harvest the available surplus on a yearly basis. One 40m x 2.5m or two 20m x 2.5m 2" mesh (fine filament, monofilament) nets would suitably harvest the Curimata in the lake. The nets should be fished 2-4 times per week and if the catch per unit effort drops by more than 50%, then the frequency of fishing should be reduced. Curimata caught in 2" mesh gillnets are sexually mature so the problem of recruitment overharvest should not occur.

(2) The color of the lake (green) and the (fair-good) density of phytoplankton (secchi disc visability = 95cm) indicates that there is food for planktivorous fish such as Silver Carp and Tilapia nilotica. Although Silver Carp did not succeed in this lake from the 1980 introduction they should be tried again at a lower density and larger size than before to minimize intraspecific competition for food and predation by Pez Perro. Try introducing 20 Silver Carp per hectare at 5" length (as compared to 44/Ha at 3" in 1980).

Tilapia nilotica should form a population once the introduced adults have spawned. The unknown density and voracity of Pez Perro or other predators leave uncertain the possibility for quick extinction of introduced Tilapia fingerlings. Assuming that indigenous predators can control excess Tilapia reproduction, 5-10 adult Tilapia nilotica should be stocked per hectare. Three months after introduction, abundant Tilapia fry should be present in the 15' seine catches. Soon afterward the 45' seine and the 2" mesh gillnets should reveal the

expansion of the Tilapia population. If Tilapia do well, a 3" mesh gillnet will probably be the best gear for their harvest.

The 15 and 45 feet seines captured only herbivorous Astyanax and a few of the insectivorous Roeboides (sardines). No young of exploitable species were represented.

Suggested Fish Stocking

species	when	quantity	size
Tilapia nilotica	beginning of rains	45	adults
Silver Carp	Dry season	180	large fingerlings

3.42 Length-weight relationship and physical conditions of the predators, Pez Perro and Sargento in the studied reservoir.

The four canefield reservoirs which we evaluated all contained the native predator, Pez Perro. We constructed a length- weight relationship for this species from the combined data in the experimental catch (figure 1). Most of the data came from La Orange and La Mata de Santiago. It can be seen in figure 2 that most of the Pez Perro caught in La Orange had observed weights greater than weights predicted from the general formula. The opposite is true for Pez Perro from La Mata de Santiago. This indicates that there is more available prey in the former reservoir than in the latter and that the introduction of an additional predator, Sargento would have the best chance of successfully colonizing La Orange.

The only Pez Perro captured in La Mata de San Francisco had a low weight as would be expected do to the large poulation of a competing predator, Sargento and to the lack of available prey as indicated by the seine catches.

A length-weight relationship was calculated from a sample of 12 Sargento caught in La Mata de San Francisco, where all the fish appeared very thin. This figure should be used to compare future physical condition of Sargento in this reservoir if a forage base of Tilapia nilotica is initiated.

Two Sargento from La Yeguada (Reservoir #5, below) were weighed, measured and located on figure 3. La Yeguada has a good forage base of cichlids for Sargento of the size captured and this is reflected in the increased weight relateive to Sargento of the same length from La Mata de San Francisco.

Experimental Gillnet Data

Raya de Santa Maria

Cerca al Pueblo "La Guaca"

Species	Net material	stretched mesh (inches)	Net area m^2	# of indivd.	% #	wt (kg)	% wt	Average weight (grams)	*#Est. in 100^2	*Wt(kg) Est in 100^2	Mean total length and standard error (CMS)
			Multimesh flagnet								
Pez Perro	Multifilament	2"	25	1	50	.118	54	118	4	.472	12
Curimata	"	"	"	1	50	.100	46	100	4	.400	18
				2		.218			8	.872	
Pez Perro	"	3	"	1	50	.426	66	426	4	1.704	33
				1	50	.224	34	224	4	.896	
				2		.650			8	2.600	
	"	4	"	- NO CATCH -							
	"	5	"	- NO CATCH -							
	"	6	"	- NO CATCH -							
			Multimesh Gillnet								
Curimata	monofilament	1 1/2	18.25	25	100	1.552	100	62	135	8.353	14.3±0.38
Curimata	"	2	"	35	100	3.201	100	91	188	17.228	17.5±0.16
	"	3	"	- NO CATCH -							
	"	4	"	- NO CATCH -							
	"	5	"	- NO CATCH -							
	"	6	"	- NO CATCH -							
			Singlemesh gillnet								
	monofilament	3	250.8	- NO CATCH -							
			Singlemesh gillnet								
	monofilament	5	250.8	- NO CATCH -							

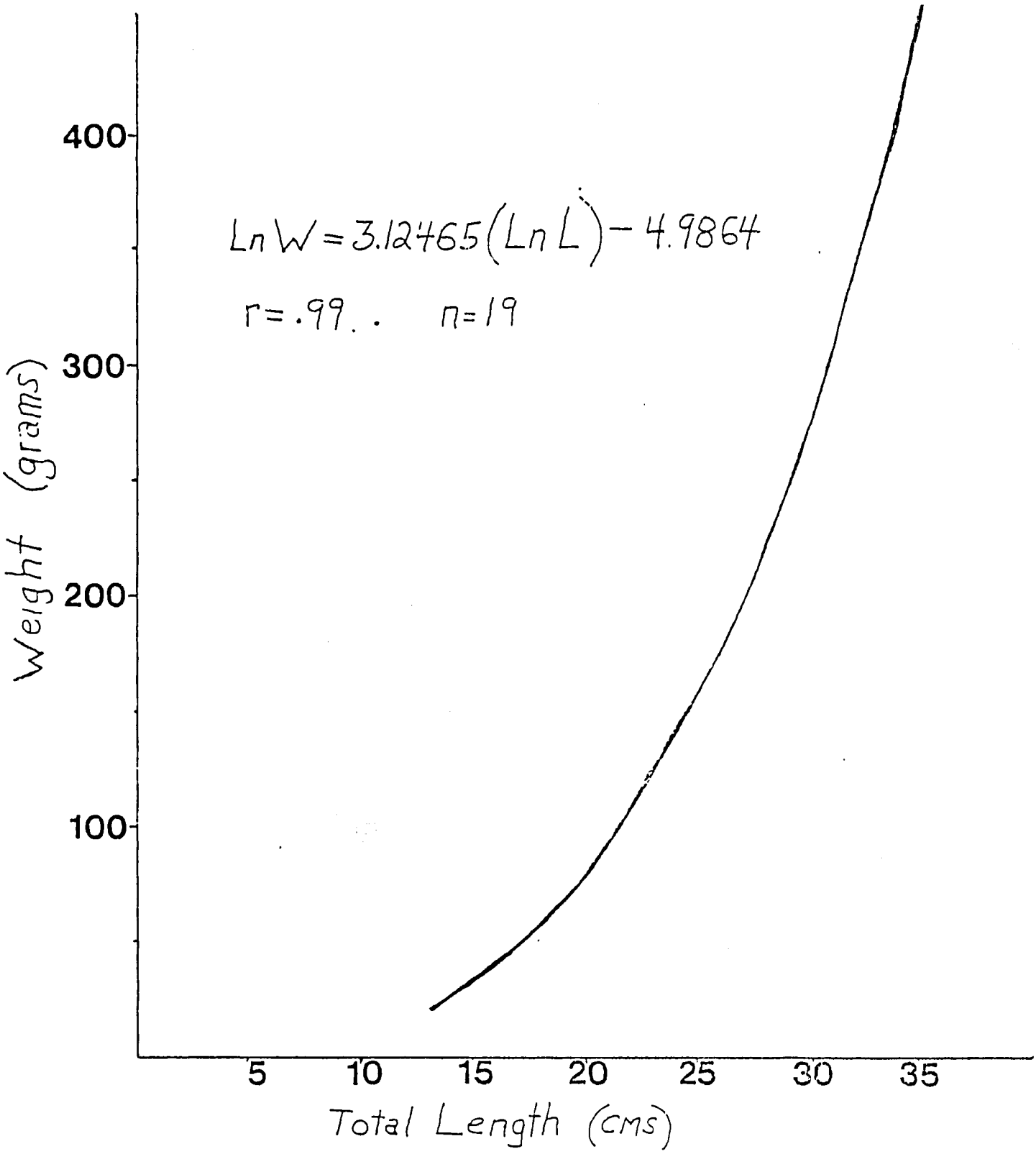

FIGURE 1. LENGTH-WEIGHT RELATIONSHIP FOR PEZ PERRO. DATA ARE COMBINED FROM FOUR SUGARCANE PLANTATION RESERVOIRS. MOST FISH CAME FROM LA ORANGE.

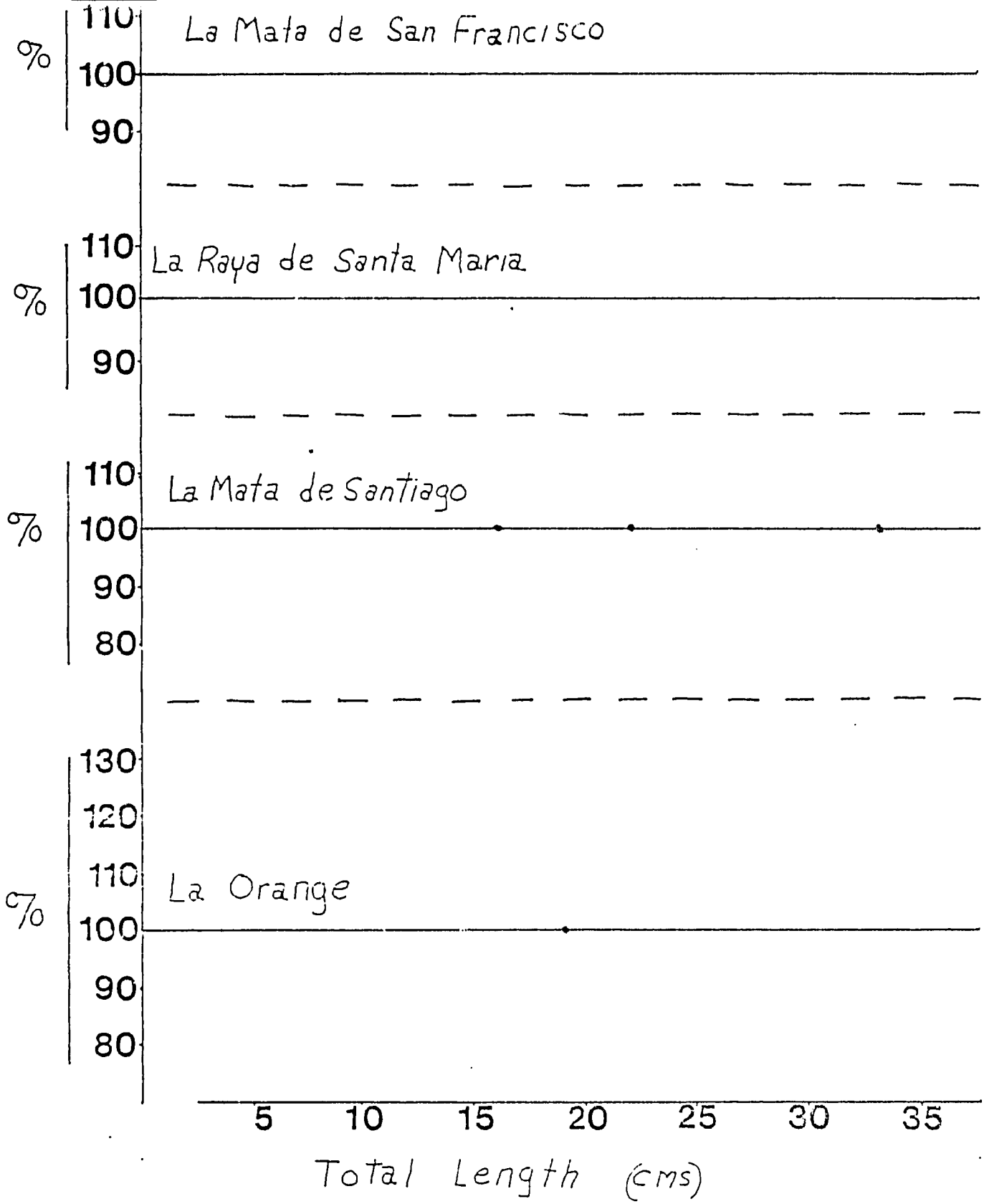

FIGURE 2. PEZ PERRO RELATIVE WEIGHTS, I.E., OBSERVED WEIGHT AS A PERCENTAGE OF PREDICTED WEIGHT (PREDICTED FROM THE LENGTH-WEIGHT RELATIONSHIP OF FIGURE 1). THE HORIZONTAL DASHED LINES (---) SEPARATE THE RELATIONSHIPS FOR EACH RESERVOIR.

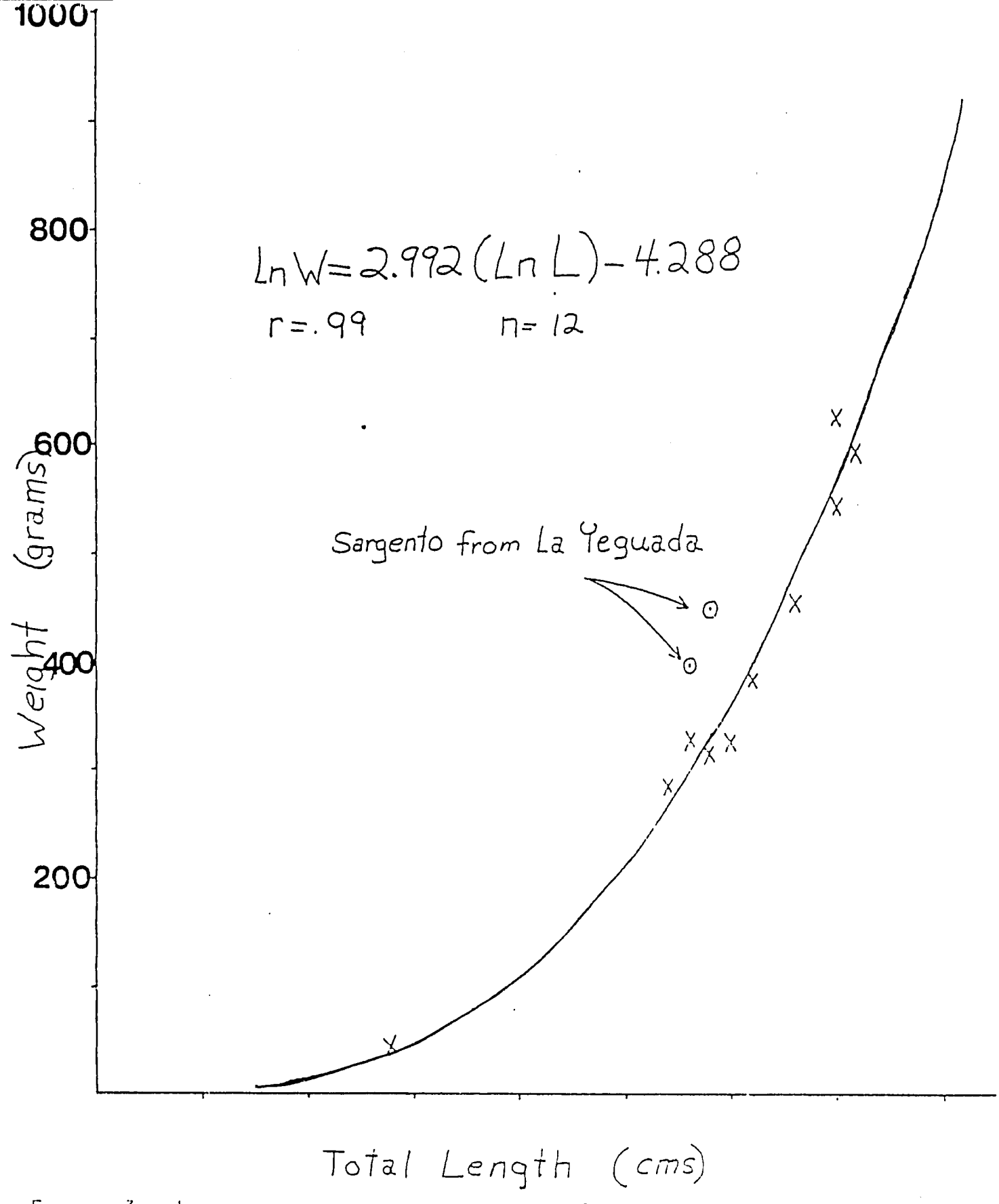

FIGURE 3. LENGTH-WEIGHT RELATIONSHIP OF SARGENTO (*CICHLA OCELLARIS*) FROM LA MATA DE SAN FRANCISCO, I.E., THE PREDICTED RELATIONSHIP, THE OBSERVED POINTS (X) AND TWO OBSERVATIONS FROM LA YEGUADA (•).

3.5 Reservoir #5

La Yeguada - An I.R.H.E. Hydroelectric reservoir

Elevation 600 meters, March 15-16

Surface area full = 100 ha, presently about 60-70 Ha. Water quality sampling time 7:30 AM, depth of sample = one meter. pH = 7, Alkalinity = 14 mg/L, Hardness = 7 mg/L. Dissolved oxygen = 8 mg/L., Co_2 = 10 mg/L. Water temperature at surface 24°C, at one meter of depth = 23°C Secchi Disc visability =.65 cm, water color = green.

Previously Introduced Fish

Species	Year	Quantity	Size
Common Carp	1978	2085	5 1/2 inches
Tilapia nilotica	1976	200	7 1/2 inches
Silver Carp	1978, 1979	>10000	4 inches
Sargento	1967	?	?

3.51 Results and Recommendations for La Yeguada

Three species were captured in experimental gillnets, all of which were introduced. Extra nets of large mesh, 3" and 5", were fished to improve the chance of catching specimens of all introduced species. However, only *Tilapia nilotica*, Common Carp and Sargento were caught. The *Tilapia* population appears to be large, to the point that growth is inhibited. Harvestable size *Tilapia* (about 20 cm, 160 grams) are abundant but there was no evidence that *Tilapia* continued to grow after reaching this size (figure 4). Very few sexually mature *Tilapia* females were in our sample, indicating that reproduction may be suppressed by excessive population density. Large numbers of intermediate *Tilapia* and *Aequidens* were captured in the 45' seine and no *Tilapia* fry (< 1 1/2") were captured in the 15' seine. The latter situation further supports the hypothesis that reproduction of *Tilapia* is being suppressed.

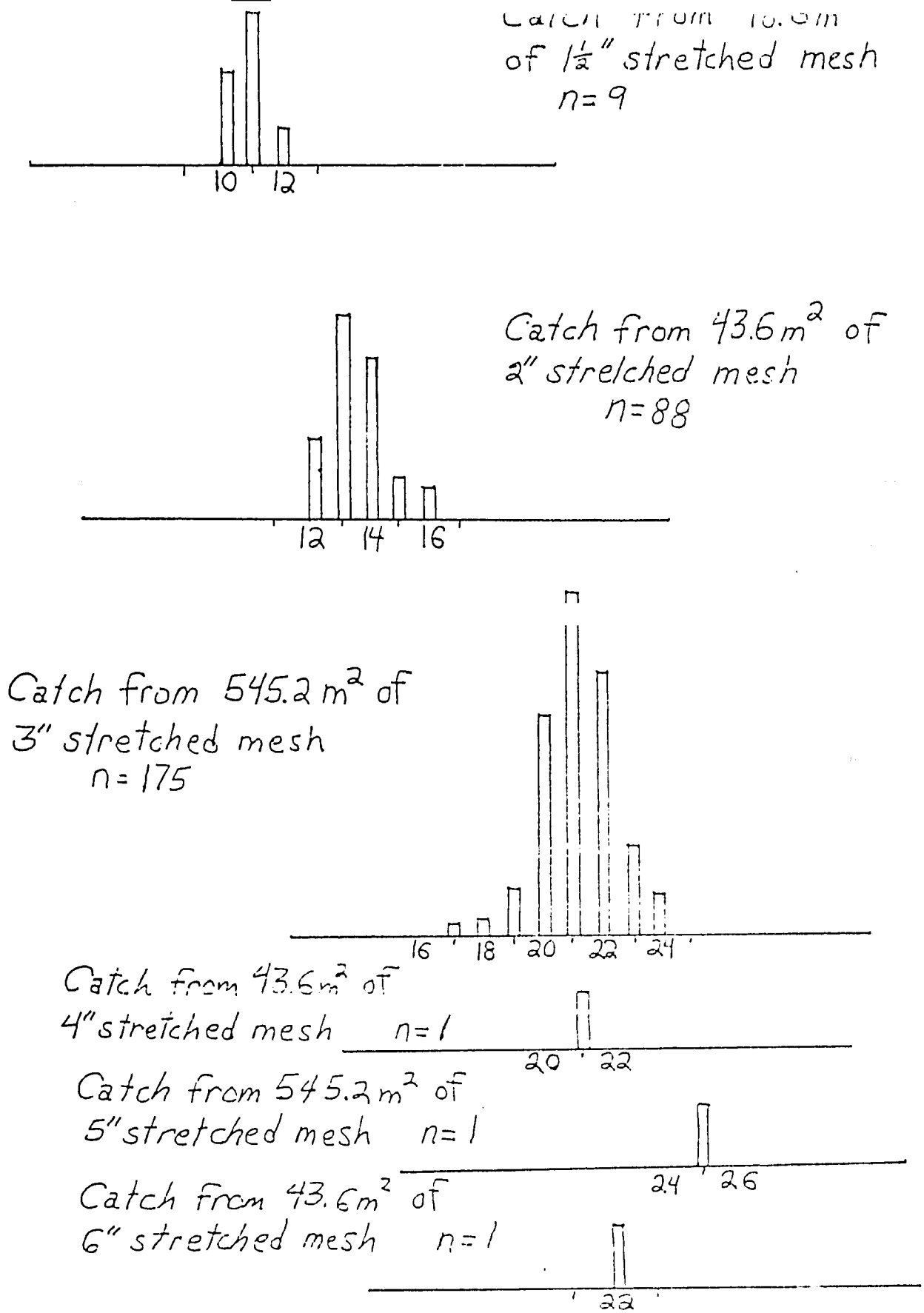

FIGURE 4. THE OVERNIGHT CATCH OF *TILAPIA NILOTICA* IN GILLNETS FISHED IN LA YEGUADA RESERVOIR. LENGTHS ARE IN CENTIMETERS OF TOTAL LENGTH.

The large number of intermediate sized (2" to 5") Cichlids in the 45' seine catch (54 per haul) indicates that there is insufficient predation of fry and small fingerlings (figure 5). Our nets captured only two individuals of the predator Sargento, species of 28 and 30 cm total length. These fish were in excellent condition as would be expected with such an abundance of forage fish (figure 3). However the dynamic interrelationship between Tilapia and Sargento seems to be restricted. Over abundant intermediate Tilapia and Aequidens probably prey on Sargento eggs and fry and compete with Sargento fry and small fingerling for zooplankton and insects. Thus there are insufficient young sargento to eat the excess Tilapia fry. Poor growth and inhibited reproduction of Tilapia result; it is a deteriorating cycle.

Also, there appears to be very little (possibly none) gillnet fishing, thus adult Tilapia are not being thinned to allow space and food for growth of the abundant intermediate sized Tilapia. By thinning adult Tilapia, those that survive grow better and their improved physical condition leads to increased reproduction, providing food for juvenile Sargento. Also when Tilapia are thinned they will refrain from egg and fry eating, thus the community will become more dynamic, more productive and result in better fishing. A managed year around gillnet fishery for Tilapia should be initiated to facilitate improved fish community structure and dynamics. Better growth and physical condition of Tilapia will result. In the future, after implementation of management recommendations, a quantitative comparison of relative weight per centimeter group of Tilapia can be done based on the 1982 length-weight relationships (figure 6).

We captured eleven Common Carp in La Yaguada; average weight was near 1.7 kg and the largest carp weighed near 5 kg. These fish were captured in 5" stretched mesh monofilament gillnets. No small Carp were caught, indicating

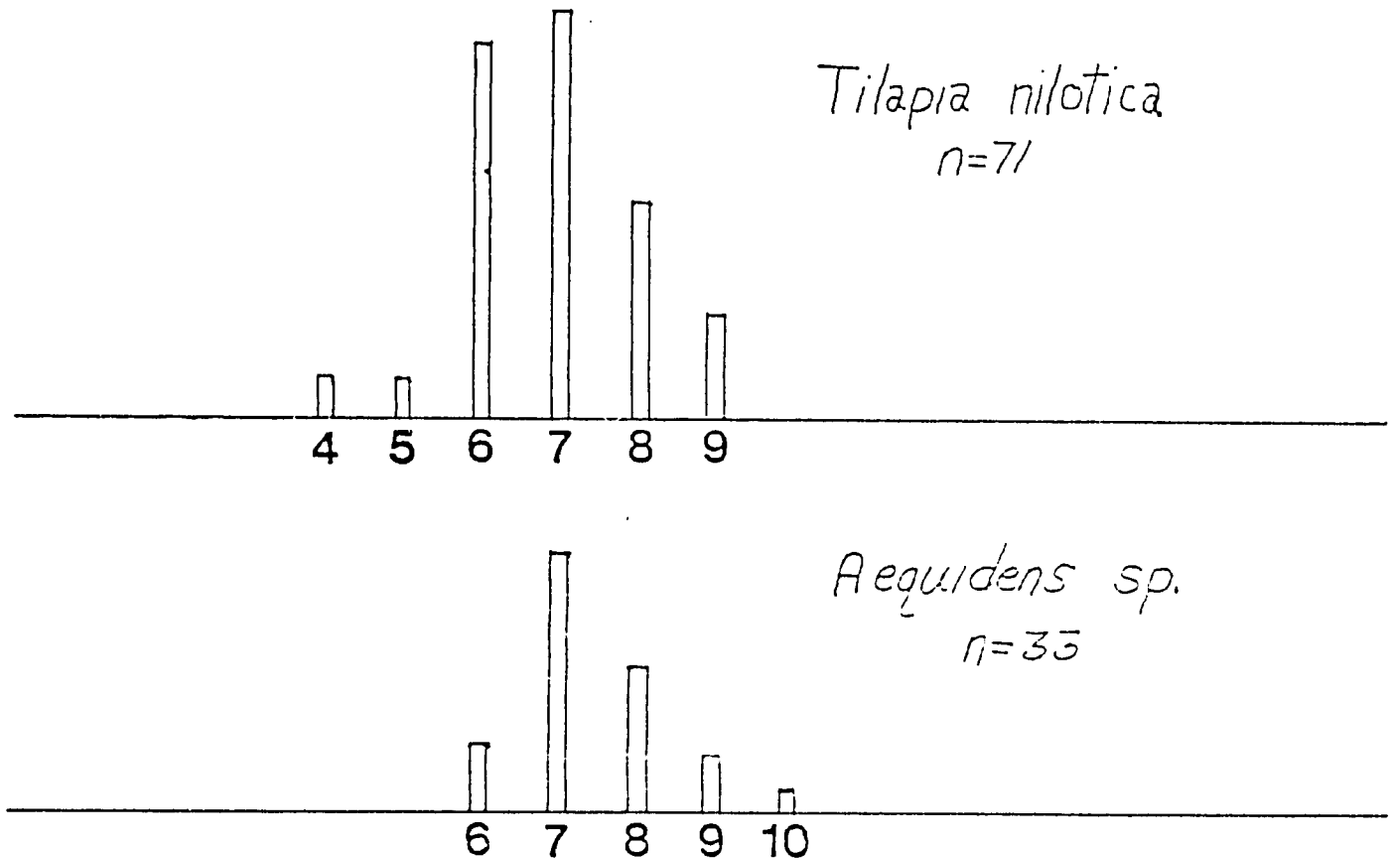

FIGURE 5. LENGTH FREQUENCY DISTRIBUTION AND SAMPLE SIZE OF TWO SPECIES OF FISH CAPTURED IN TWO PULLS OF A 40' X 6' X 1/2" MESH BAG SEINE AT LA YEGUADA RESERVOIR. THIS LARGE NUMBER (52/PULL) INDICATES THAT PREDATION IS INSUFFICIENT, THUS TOO MANY FRY ARE SURVIVING TO FINGERLING (INTERMEDIATE) SIZE. THIS WILL RESULT IN SLOW GROWTH AND REDUCED REPRODUCTION OF TILAPIA AND POSSIBLY IN PREDATION OF TILAPIA AND AEQUIDENS ON EGGS AND FRY OF THE PREDATOR, SARGENTO. INCREASED HARVEST OF TILAPIA IS NEEDED.

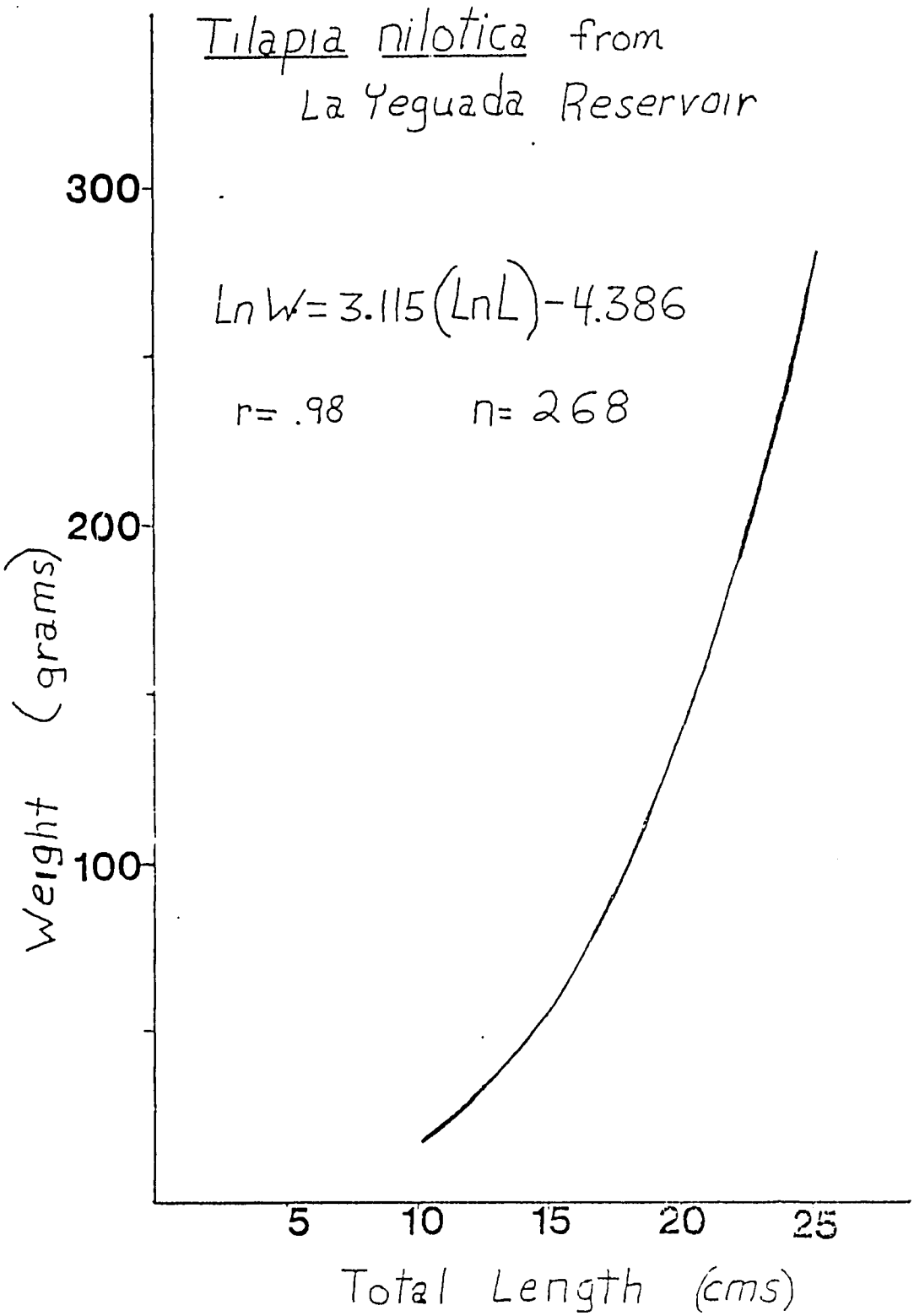

FIGURE 6. LENGTH-WEIGHT RELATIONSHIP. LN = NATURAL LOGARITHM, W = WEIGHT IN GRAMS, L = TOTAL LENGTH IN CENTIMETERS.

that predation or unsuccessful reproduction is preventing natural recruitment of Common Carp. The environment appears suitable for Carp reproduction, especially when wet season rains flood the upper terrace which is covered with vegetation. Common Carp do grow well in La Yeguada, and if natural reproduction or recruitment is not dependable, then an annual stocking program of large fingerlings should be planned.

No Silver Carp were caught in our set of experimental nets(see table below) and it is not known what has happened to this population which produced some harvest in the first year after stocking (as reported by Chang in a Direction of Aquaculture report). It is doubtful that a reservoir of this size, designed for hydro-electric power production, would lose all of the Silver Carp from spillway or power generation discharge. Relative to Israeli reservoir water, La Yaguada contains adequate phytoplankton for Silver Carp growth, based on its Secchi Disc transparency of 65 cm. Also the 1000 stocked Silver Carp are about 1/4 of the density used by the Israelis thus, survival should have been enhanced.

Stretched mesh	area of nets(m^2)
1 1/2	19
2	44
3	502
4	44
5	502
6	44

Mesh sizes and area of netting of experimental gillnets fished overnight at La Yaguada March 15-16, 1982.

Silver Carp should be stocked again, with reduced numbers, but at a larger size; possibly 5000 (60-80/ha) large fingerlings should be stocked. Seasonal sampling following introduction of these fish should reveal growth rates of Silver Carp and whether or not the population survives well in the lake.

The harvest composition from La Yeguada should be approximately:

80% Tilapia

15% Common Carp

5% Sargento

The lake has a surface area when full of 100 ha and possibly an average area of 80 ha. Under year around growing conditions we should be able to harvest 100% of the production. With a community largly dominated by herbivores we should expect a biomass of at least 150 Kg/Ha.

150 Kg/Ha/Yr x 80 ha = 12000 kg expected annual harvest.

Tilapia	12000 Kg	x	.80	= 9600 Kg
Carp	12000 Kg	x	.15	= 1800 Kg
Sargento	12000 Kg	x	.05	= 600 Kg

Using the 3" mesh gillnets, the average weight of Tilapia will be $\geq$ 160 grams since the average weight in this mesh size may increase i.e., fish of the same length will be heavier as the population is thinned and more food becomes available per individual.

The average catch per $100m^2$ gillnet will probably be about 4 Kg or 25 individuals, nearly 100% Tilapia, probably 1-2% Sargento.

9600 Kg ÷ 4 Kg = 2400 Sets

If nets are set 5 days/week we would need 2400 ÷ (5 days/wk x 52 wks/yr) = 9 or 10 nets for the fishery.

Common Carp were best caught in 5" mesh gillnets although they may be equally well caught in the 3" nets if smaller Carp were available. Annual or bi-annual stocking of Common Carp may be necessary and this could result in good catches of Carp in 3" mesh nets. Based on our experimental data, catch per $100m^2$ of 5" mesh is 5.1 Kg of nearly 100% Common Carp. Thus to catch 1800 Kg of Common Carp per year:

$$1800 \div 5.1 \text{ Kg/net} = 353 \text{ sets/year}$$

this assumes continued abundance of large common carp. More conservatively we could set one $100m^2$ 5" net 5 days/wk for a year and catch 5.1 kg x 5 days/wk x 52 weeks/yr = 1326 Kg of large carp, again assuming a continued catch rate of 5.1 kg/set.

The catch of Sargento will come incidental to the catch of *Tilapia* and Carp. Hook and line and cast net fishing should continue and be encouraged as these gears are a means of providing frequent small catches for home consumsption. Also this helps control intermediate sized *Tilapia*.

Experimental Gillnet data

La Yeguada Reservoir

Species	Net material	stretched mesh (inches)	Net area m^2	# of indivd.	% #	wt (kg)	% wt	Average weight (grams)	*#Est. in 100^2	*Wt(kg) Est in 100^2	Mean total length and standard error (CMS)
			Multimesh Flagnet								
Tilapia	multifilament	2	25	69	100	2.480	100	36	276	9.92	13.3±0.11
Tilapia	"	3	"	10	100	1.387	100	139	40	5.55	19.1±1.33
	"	4	"								
	"	5	"								
	"	6	"								
			Multimesh Gillnet								
Tilapia	monofilament	1 1/2	18.25	9	100	0.158	100	17.6	48	0.85	9.8±0.22
Tilapia	"	2	"	19	100	0.893	100	47	102	4.81	14.4±0.41
Tilapia	"	3	"	10	100	1.65	100	165	54	8.88	19.9±1.51
Tilapia	"	4	"	1	100	0.156	100	156	5	0.84	21
	"	5	"	-NO CATCH -							
Tilapia	"	6	"	1	100	0.160	100	160	5	0.860	22
			Singlemesh Gillnet								
Tilapia	monofilament	3	250.8	72	100	12.23	100	170	29	4.88	21.2±0.14
			Singlemesh Gillnet								
Tilapia	monofilament	3	250.8	90	100	14.69	95	163	36	5.86	20.8±0.25
				2	2	0.85	5	425	0.8	0.34	28.5±0.5
				92		15.54			3.68	6.20	
			Singlemesh Gillnet								
Common carp	monofilament	5	250.8	3	100	9.676	100	2419	1.2	3.86	55±4.04

3.6 Reservoir #6

Volcan Chica - a natural lake in Chiriqui at about 2000m elevation. March 17-18, 1982

The lake level was full at the time of sampling and surface area appeared to be more than 10 ha. Water source is in part from springs and probably very little water level fluxuation occurs. There appeared to be no surface waters outlet. Water quality parameters were sampled at 9:00 AM at one meter depth. pH = 6.5, Alkalinity = 12 mg/L, Hardness = 6 mg/L. Dissolved oxygen = 7 mg/L, CO_2 = 5 mg/L. Water surface temperature = 24°C, Secchi disc transparency > 3 meters, water color, slightly brown (from tannins).

3.61 Results and Recommendations for Volcan Chica

The lake has a 50-100 ft wide band of submersed weeds, possibly Ceratophyllum and a central open area. Total depth was not measurable with the depth meter as weeds come within three meters of the surface in the center of the lake.

The shallow areas appeared to be overcrowded with 3-5" long Bluegill. We could only pull the 45' long seine at one place (at a boat launching site) and 220 intermediate sized Bluegill were caught in the initial haul.

It is impossible to directly apply the community ratios (F/C, Y/C, A_T) of Swingle (1949, 1950) to a Bass-Bluegill community in the tropics due to longer growing season, and in the case of Volcan Chica, marginally low temperature for BlueGill spawning, but continually good temperature for Bass spawning.

However it is obvious that the dense populations of aquatic weeds prevents adequate predation of Bluegill by Bass which results in slow growth of young Bass (not enough available food) and slow growth of Bluegill due to too much intra-specific competition for limited food. Thus the Volcan Chica F/C ratio, i.e., wt of forage fish ÷ wt of carnivorous fish is probably too large due to an

over abundance at intermediate sized bluegill, the Y/C ratio i.e., the weight of edible (for Bass $\leq$ the average sized Bass) forage fish ÷ weight of carnivorous fish is also too large, and the A_T value i.e., the percentage of total weight of harvestable size fish, is too small. This indicates that the Bass and Bluegill populations are not very productive and not much of the production goes to harvestable sized fish.

Also, aquatic weeds compete with plankton and periphyton for available minerals and nutrients, thus greatly reducing food for zooplankton and aquatic insects which are essential foods for Bluegill and young Bass.

Grass Carp should be introduced to Volcan Chica at 100-200 ha. These fish will live for several ($\geq$ 6-8) years in the lake and may consume nearly all the aquatic weeds - thus indirectly reducing competition for nutrients by phytoplankton and macrophytes and directly producing nutrients as feces for plankton growth. Predation will become more efficient with reduced weeds, thus Bass and Bluegill growth will increase. Also the Grass Carp is an excellent food fish which grows rapidly ($\geq$ 2 Kg/year). It is difficult to catch on a hook, and gillnets (and possibly castnets) may be the best method to harvest Grass Carp. The desirability of harvest will depend on the degree of success achieved in weed reduction, the size attained by Grass Carp and especially on the continued availability of Grass Carp fingerlings for successive introductions to the lake.

Bass will consume unspined fusiform fish (like a Grass Carp) which are up o one half of their own length. In our fish population samples we captured three large Bass of 44, 46 and 47 cm. This size class is probably fairly abundant in the lake and to ensure minimum loss of stocked Grass Carp through Bass predation, introduced Grass Carp should be $\geq$ 25 cm. Grass carp are not adapted to spawn in lakes so no natural reproduction will occur.

The size of Grass Carp will be more important than the number. Fewer (less than 100-200/Ha) Grass Carp will take longer to reduce the weed problem, however a large number of small < 20 cm grass carp will most likely only serve as Bass food.

Possibly, fingerling Grass Carp could be reared near Volcan in weedy seasonal ponds containing no predators and when pond volume is minimal, and the Carp have attained a size large enough to escape predation, they could be seined and taken to Volcan Chica.

Bass-Bluegill communities in unfertilized ponds will have a carrying capacity of about 100 Kg/Ha. In a tropical environment production of fish biomass is rapid and about 100% of the standing crop can be harvested annually with no appreciable decrease in standing crop. This requires that fish are harvested a little at a time, i.e., about 1/12 of the annual harvest is removed each month. The reproductive capacity and balance between predator and prey species can be negatively affected by intense harvest during a short time interval.

Also, Bass are predators of Bluegill, thus it is reasonable to assume that the biomass of harvestable size Bluegills is at least 5 times greater than the biomass of harvestable size Bass and the annual harvest in Kg should be in about the same ratio i.e., 84 Kg/ha Bluegill and 16 Kg/ha Bass. Bass sport fishermen should be encouraged to release Bass which are of a size efficient for predation on overabundant intermediate sized Bluegill, i.e. Bass less than 16" (40 cm) in total length. Heavy fishing of Bluegill should be encouraged, even of very small bluegill 3 to 5 inches (7-12 cm) in length, as these small size Bluegill tend to overpopulate resulting in very slow growth, thus few large Bluegills are produced. Severely overpopulated Bluegills will eat Bass eggs, further increasing the Bluegill overpopulation problem by reducing the population of small predators.

Experimental Gillnet data

Volcan Chica - near Volcan in Chiriqui

Species	Net material	stretched mesh (inches)	Net area m^2	# of individ.	% #	wt (kg)	% wt	Average weight (grams)	*#Est. in 100^2	*Wt(kg) Est in 100^2	Mean total length and standard error (CMS)
			Multimesh Flagnet								
Bluegill	multifilament	2	25	7	100	0.273	39	100	28	1.092	12.86±0.40
Bluegill	"	3	"	3	100	0.362	121	100	12	1.448	19.0±0.58
Bluegill	"	4	"	4	100	0.820	205	100	16	3.280	22.5±0.65
	"	5	"	- NO CATCH -							
	"	6	"	- NO CATCH -							
			Multimesh Gillnet								
	monofilament	1 1/2	18.58	- NO CATCH -							
	"	2	"	- NO CATCH -							
Bass	"	3	"	1	100	0.388	100	388	5.4	2.088	31
Bluegill	"	4	"	1	100	0.040	100	40	5.4	0.215	15
Bass	"	5	"	1	100	1.674	100	1674	5.4	9.010	47
	"	6	"	- NO CATCH -							
			Singlemesh Gillnet								
Bluegill	monofilament	3	250.8	12	67	1.498	36	125	4.8	0.597	19.75±0.45
Bass	"	"	"	6	33	2.696	64	449	2.4	1.075	32.5±0.67
				18		4.194			7.2	1.672	
			Singlemesh Gillnet								
Bass	monofilament	5	250.8	2	100	2.866	100	1433	0.8	1.143	45.0+1.0

Since there is a significant interest in rod and reel fishing at Volcan Chica, I would not recommend that gillnets be used to harvest fish, especially not monofilament gillnets as they appear to efficiently catch Bass which we do not wish to overharvest.

With some reservation I would suggest that a 2" mesh nylon multifilament gillnet may be a possible way to reduce the stunted population of intermediate sized Bluegill. At least in our sample, no Bass were caught in the multifilament type netting.

Harvest

Rod and reel fishing: Hooks baited with earthworms or insects (crickets, etc) is probably the best way to harvest Bluegill. Bass will be best harvested with small live fish or with artificial lures.

4.0 Discussion

4.1 Potential for fishery management in reservoirs

Management of farm ponds for fish production has been studied in detail since the 1940's especially in the Southeastern United States. Quantitative levels of alkalinity and fertilization have been determined which will consistently produce increased fish production. Proven fish species are stocked at tested rates which will maximize production of harvestable size fish and standard pond construction methods are used which minimize cost while maximizing strength and water retention ability of the dam, pond bottom and walls. This incudes a spillway wide enough to ensure that deep water (> 4") will not pass across the spillway during peak floods, thus ensuring that few harvestable sized fish will escape downstream.

Panamanian ponds examined during the present investigation had primary functions of irrigation and hydro-electric power production; development of fish populations for harvest is presently only a minor consideration. Total harvest

by draining will not be possible as this conflicts with primary functions of the reservoirs.

Our goal in Panama is to enhance the existing fish community with complementing species which would form populations of harvestable sized individuals. When communities are heavily populated with predators we wish to add prey species, and simultaneously fish the predator population, to reduce it and better enable the prey populations to develop.

Where the community is heavily dominated by prey species then predators may be needed to enhance growth of the prey by thinning their numbers. Frequently the native species do not grow to harvestable size, so we wish to displace these with food fish. Thus we must use species which are appropriate for available niches and ones which can compete well with native species. Wherever possible we wish to initiate populations of herbivorous food fish, as these are the most efficient converters of the pond's available food to fish flesh.

One option is to use non-reproducing (in ponds) species stocked at a known rate, based on an estimate of available nutrients. These species are generally Chinese Carps which feed low on the food chain.

Partial or total poisoning of undesirable species, before introductions of food fish may be desirable to reduce competition with native fishes.

If large predators naturally populate a pond, then introduced fish must be too large to be preyed upon by these predators.

Introduced fish, in an environment that already contains a biomass near carrying capacity have much less chance of achieving good growth and survival than do fish introduced into a pond that is refilling after being recently drained and the fish removed (or a pond where all fish have been killed by a toxicant such as rotenone). However draining generally is not possible and population renovation with rotenone is very expensive.

Viable methods to restructure and augment the existing fish community.

1. Introduce adults rather than fingerlings of fish which will spawn naturally in the pond such as the predators Sargento (Cichla) and Cichlasoma (Guopoto tigre is of this genus) and the prey species, Tilapia and Cyprinus (Common Carp). A few adults which spawn successfully in the pond will have a greater ability to populate a pond than many vulnerable hatchery reared fingerlings.

2. Introduce non-reproducing pond species as large fingerlings to reduce or eliminate their loss to native predators. Also, fishing effort directed towards predators should be towards large individuals to reduce their density.

Successful stocking rates for Israeli reservoirs are given below and may be considered a staring point for determining appropriate stocking rates for Panamanian reservoirs.

Species	Initial Stocking Rate	Primary Food
silvercarp	400 HA (1 fish/25m^2)	phytoplankton
bighead carp	15/Ha (1 fish/667m^2)	zooplankton
grass carp	80/HA (1 fish/125^2)	macrophytes
common carp	200/HA (1 fish/50m^2)	Benthis invertabrates and plants
Tilapia nilotica	(only one initial intro-	algae; detritus
or Tilapia aurea	duction is necessary)	algae; detritus

Reduced rates should be used initially to ensure that an adequate food supply is available for the introduced fish. If fish grow well and appear "fat" then higher stocking rates are warrented in later years.

Not all species may be appropriate in any given reservoir, depending on particular pond conditions and on the pre-existing fish community. When Silver, Bighead and Grass Carp are employed they should be restocked each year and most of the fish from the prevoius stockings should be harvested.

Tilapia and the predator species of Sargento and possibly Cichlasoma should require only one stocking as they will form naturally reproducing populations. Common carp also spawn naturally in ponds but if predation is heavy there will be no recruitment to the fishable stock.

Experience in Brazil of introducing T. nilotica on to native fish communities has shown consistently that stunting of Tilapia does not occur, but rather that Tilapia assume a population structure dominated by harvestable size fish and they successfully compete with fishes of similar niches such that T. nilotica generally become the dominant fish in the community catch.

Panama receives heavy rains resulting in sudden large overflows across pond spillways. Many typically riverine species such as the Chinese carps may move downstream with flood water when possible. The best solution to this problem is to widen the spillway such that the depth of water crossing it will rarely exceed 10 cm in depth. The larger the fish, the less likely that it will cross the spillway. Thus carp fingerlings should be stocked at the beginning of the dry season, to allow them time to grow before the next rainy season. A less plausable solution is to screen a narrow spillway. However, when flooding occurs someone must attend the screen to remove leaves, etc. which would otherwise block the free flow of water and result in destruction of the screen (and possibly the dam) and loss to fish.

The purpose of developing desirable fish populations in the canefield ponds is to provide a protein source for the owner and workers. Assuming the owner wants harvestable fish populations, he will cooperate with fisheries personnel. It is essential that we learn from pond owners when, where, what quantity, and method of application of poisons have been used in the watershed. Likely poisons will include herbicides and possibly insecticides. Knowledge of the short and long term effects of these poisons on fish and fish food organisms can

be obtained from their manufacturers. If frequent poisoning of pond water occur there is no justification for a fisheries development program unless alternate weed and insect control methods can be considered.

Presently, Panama and the USAID are engaged in the development of inegrated aquacultura systems i.e., the cycling of scarce nutrienets, first through pigs, cattle or poultry, second through pond raised fish and finally to garden crops. Twenty of these integrated aquaculture "modules" have been initiated at widely separated sites in central Panama. The project goal is self-sufficiency at the village level in all aspects of Tilapia nilotica production.

These aquaculture modules should generate widespread interest in utilizing freshwater fish which logically should extend to the utilization of all available including canefield irrigation ponds. Some harvest methods used in the modules, such as gillnetting, will be the same as needed to harvest fish in reservoirs. Additionally the modules may produce excess Tilapia fingerlings which could be sold to irrigation pond owners or given to them in return for a share of the resulting harvest. Module operators may also extend methods of harvest and maintenance of fish harvesting gear for the canefield pond fisheries. Simultaneous development of the intensively managed modules and the extensively managed farm ponds will increase the probability that management and utilization of freshwater fish populations will become a permanant part of resource utilization in Panama's central provinces.

4.2 Harvest Potential

Tropical freshwater systems do not necessarily support larger stocks of fish, eg. kg/ha, than do temperate systems (Lowe McConnell, 1975). However year around warm water temperature and intense solar radiation in the tropics do increase the potential for production of fish, eg. kg/ha/yr.

Once the carrying capacity of a pond is reached, which in Panama would likely occur within 6 months to a year after stocking, only the removal of fish through natural mortality and fishing will leave food and space for expansion of the population and then only to an extent equal to that which has been removed. Thompson (in Bennet 1970) therorized that the maximum potential annual yield as a percent of carrying capacity increases from higher to lower latitude, eg. 20% can be removed at 45° latitude, 50% at 40°, 85% at 35°, 120% at 30°. Central Panama is at about 9° of latitude, thus we could expect a harvest potential of possibly 150% or more of the pond carrying capacity.

However the annual production of a Bass-Bluegill community in Cuban lagoon was shown to be 70-85% at a latitude of about 20° (Holcik, in Lowe McConnel, 1975). Although there is not strong agreement between these two studies, I believe that the harvestable production in Panamanian ponds should be at least 100% of carrying capacity.

Carrying capacity or standing crop estimates are not readily available from tropical, unmanaged (unfertilized) ponds, but we should be able to draw conclusions concerning probable carrying capacity from the following table.

Source	unfertilized ponds	carrying capacity (kg/ha)
Bennet, 1970	Alabama ponds	335
	USA natural lakes	55-170
	USA artificial impoundments	225-450
	Kentucky onds	225-1100
Jensen, 1973	El Salvador ponds	500-1300
Lowe-McConnel,	Zaire ponds	100-1000

Many factors affect the carrying capacity of a pond, such as the natural fertility of the water, pond bottom and watershed, the species of fish in the pond and the rate of flow of water through the pond. Ponds with significant development of agriculture or pasture in the watershed will obtain a greater nutrient load from runoff water than will a pond in a heavily forested watershed. Highest production will be obtained by the use of species with the shortest food chains (plant-feeding fishes). Excessive flow of water can lead to at least two major problems. (1) The plankton community which is the most important source of primary production in a pond will be continually flushed out of the pond and (2) large volumes of water passing over the spillway in a short time interval will often carry out a large part of the pond fish. This latter problem can be reduced if a wide enough spillway is built to ensure that the height of water passing the spillway is always less than 4 inches.

4.3 General management recommendations

Our goal for fisheries management in multiple use small impoundments is to produce and harvest a large biomass of acceptable size fish on a continuous basis. This will be done by introducing several species to utilize the varied fish food available with emphasis on maximizing production of fishes that are primary consumers.

Recommended speices include:

Tilapia nilotica - a very competitive, omnivore, highly tolerant of poor water quality, omnivorous but prefering algae, a lacustrive species that will not be lost in significant numbers over flooded spillways. *T. nilotica* spawn naturally in ponds, form large populations quickly and generally is the major species in the community catch.

2. Common Carp - an omnivorous benthic feeder, it may reproduce and recruit successfully in ponds. Its digging habit while feeding inhances cycling of nutrients, but also increases soil turbidity.
3. Sargento (Peacock Bass). An efficient predator of excess Tilapia reproduction.
4. Grass Carp. An efficient forager of macrophytic vegetation. species will improve water quality and growth of other fish species.
5. Silver Carp. Generally feeds on phytoplankton, but uses small zooplankton and detritus. This species utilizes the open water (limnetic) area of a pond.
6. Bighead carp. This species feeds mainly on zooplankton. Like the Silver Carp, the bighead carp occupies the openwater area.

A seventh species, the Guapote Tigre a speices of Cichlasoma is an efficient predator of Tilapia fry, however it is also a very prolife spawner. Females begin spawning at 13 cm long, laying 1500-2000 egg every 40-50 days. Experiments in fertilized ponds in Colombia (Popma et al. 1980 and Phelps and Popma, unpublished) demonstrated that a community of Tilapia and Cichlasoma, after only a few months of development, would be nearly all Cichlasoma as no Tilapia fry would escape predation. Further experimentation, however, indicated that a dynamic community could be obtained if Sargento was stocked along with the Tilapia and Cichlasoma, the funtion of the Sargento being to inhibit excessive Cichlasoma recruitment. Cichlasoma would be very useful in a Tilapia growout pond that would be drained and restocked with fingerlings every few months, but as part of a permanent community I am unsure of the net affect of a Guapote Tigre introduction.

Tilapia nilotica should be stocked in all the low elevation sugarcane ponds. It should produce a large standing crop of harvestable sized fish and will not tend to escape over spillways. A few adults, 5-10/ha should produce a harvestable population within a year. The large populatons of Tilapia in La Yeguada was reported to have been initiated by 200 adults (2/ha) even after the predator Sargento had already been established.

The Chinese Carp (Grass, Silver and Bighead) are riverive species and given the opportunity they will migrate out of a pond. A hydrologist would be able to obtain an estimate of spillway width necessary for a given pond to prevent excessive depth across a spillway. If this problem is first solved, then Chinese Carps could be stocked with the following precautions (1) stock large fingerlings since large predators already exist in the ponds (2) stock less fish/ha than were recommended for Israeli reservoirs. This latter precaution should insure increased survival. If physical condition is very good then a higher stocking rate can be used in later year.

Sargento should be stocked where insufficient predation is apparent. A small number of adults should be sufficient to begin a population (2-5/ha).

Common carp should be stocked at 50-100 large fingerling/ha. Although they may spawn successfully, the young may suffer nearly 100% mortality due to predation, thus necessitating annual stockings.

Once populations of Tilapia and Sargento are observed (fish which are not part of the original stocking) no more stocking is necessary.

Grass, Silver and Bighead Carp should be stocked annually to replace those removed by harvest and natural mortality.

Management of ponds will mostly involve stocking and harvesting. Harvesting in most part will be with gillnets, although cast nets and hook-and-line fishing should be encouraged additionally, baited traps should be tried for Tilapia.

Stocking rates are based on reservoir surface area. Transit survey measurements of area are the only reliable estimates. This information should be obtained before any stocking program begins.

4.4 Monitoring of fish stock development

We have preposed particular management practices for each of the six reservoirs which we evaluated (Section 2). The four sugarcane plantation ponds present the greatest challenge since previous introduction of herbivorous food fishes to these ponds have not resulted in populations of harvestable fish. This observation is based on the data in this report; a second evaluation would increase the data base and reliability on which conclusions are drawn. If future surveys the same sampling methods and gears should be used as during the initial survey and the same analysis of data should be done. This consistency will enhance the utility of the data for documenting changes which occur in the fish populations. These surveys should be continued on a seasonal (four per year, possibly in March, June, September and December) basis at times which coincide with mid-dry season, the beginning of rainy season, mid-rainy season and the beginning of dry season. This schedule assumes that some fish stocking will begin with the initiation of the 1982 rainy season. Thus, the consecutive seasonal sampling will provide documentation for development of introduced populations. Relative growth rate of introduced fish can be observed as the modal lengths of fish caught in the multimesh gillnets increase seasonally. Spawning success and timing will be seen as fish fry and fingerlings are captured in the 15' long seine. The 50' seine will catch intermediate size fish and indicate the intensity of predation. A recommended list of equipment necessary to carry out a seasonal survey of selected small impoundments is given in appendix 5.

Once populations of harvestable size fish are developed, a fishery can begin, using a fishing gear recommended by the investigators. The gear will most likely be a gillnet of 3 or 4 inch stretched mesh which should catch fish of harvestable size, fish which have already passed through much of their rapid growth phase.

Changes in the abundance and size composition of native species should also be noted. Small herbivorous species may become less abundant as Tilapia, etc. begin competing with them.

The physical condition of predators may improve after the successful establishment of a Tilapia population. This can be quantitatively evaluated by comparing the average weight for a given centimeter group in future samples (new weight) with those from before fish stocking began (old weight) as follows.

$$\text{Relative condition} = \frac{\text{New weight}}{\text{Old weight}} \times 100$$

Whenever possible, such weight comparisons between years should be made during the same season of each year since seasonal availability of food, spawning periodicity, etc. often result in fish having different relative conditions during different seasons of the same year.

Grass Carp function to reduce nuisance aquatic vegetation as well as to produce harvestable food fish. Successful vegetation control by Grass Carp should be documented to determine rate of weed removal relative to Grass Carp stocking density. Samples of aquatic weeds should be identified and delineated weeded and unweeded areas marked with corner stakes and photographed, and the abundance, condition and species composition of weeds recorded at each successive season until control is achieved. The most valid comparision, as a documentation of aquatic vegetation control by Grass Carp would be between years, but within the same season.

Dissection of fish captured in seasonal samples should continue until enough data are available to describe spawning season and size of fish at maturity. Knowledge of these parameters provides the greatest utility for Sargento. Since it may be possible to overharvest Sargento if they are frequently captured as juveniles.

Stomach contents of native predators and all introduced species should continue to be examined until it is determined what food sources are being utilized (and not utilized) and the extent of predation on introduced fish. Information collected during the initial survey on stomach content and sexual maturity are in appendix 4.

Water quality parameters should continue to be monitored at each survey to increase the possibility of documenting any short term deficiency in the environment. Also, one day after the first heavy rain of the new rainy season, water quality parameters should be measured. At this time turbidity is increased and decaying terrestrial organic matter is carried into the reservoir. Dissolved oxygen may become very low and deleterious changes in pH and CO_2 may also occur.

If a gillnet fishery begins at La Yeguada then seasonal sampling of fish populations with the survey as described above should be initiated. Also an appropriate catch assessment survey should be initiated to provide estimates of fishing effort, catch per unit effort, catch, relative species composition and length frequency distribution of the exploited stocks.

Volcan Chica needs Grass Carp and time for them to eliminate the submersed weeds. When this occurs further management steps can be considered. This will probably be at least two years in the future.

5.0 Literature cited

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6.0 Appendices

6.1 Appendix I Sample data recording form

Sumario de poblaciones de peces

localidad_____ Fecha_____

HORA:_____

Metodo de Colecta:_____

*pH_____ AICALINIDAD_____ DUREZA_____ Oxigento Disuelto_____ CO_2_____

Area de superficie del agua_____ Profundidad de visibilidad_____

Temperatura del agua (superficic_____, 1 matro_____)

color de agua_____

Fecha cuando los peces fueron introducidos

A. especics: _____ _____ _____

B. numero _____ _____ _____

C. tamano _____ _____ _____

NUMERO Y PESO POR CADA ESPECIE

intervalo por centimetro										
	No.	Kgs	No.	Kgs	No.	Kgs	No.	Kgs	No.	Kgs
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										

*Aqua muestrada de 1 metro de profundidad

	No.	Kgs	No.	Kgs	No.	Kgs	No.	Kgs	No.	Kgs
18										
19										
20										
21										
22										
23										
24										
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35										
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38										
39										
40										
41										
42										

	No.	Kgs	No.	Kgs	No.	Kgs	No.	Kgs	No.	Kgs
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Appendix 2 Discussion of the physical and chemical parameters measured

We attempted to describe important physical and chemical characteristics of each studied pond to assist in our understanding of the fish production potential.

Dissolved oxygen (D.O.): Fish extract dissolved oxygen from water for respiration. At 27°C and at an altitude near sea level, water is saturated with oxygen at 7.9 mg/L. Any reduction in D.O., resulting from insufficient photosynthesis or excessive oxidation of organic matter by bacteria decreases efficiency of respiration for fish. When D.O. < 4 Mg/l most fish can only maintain life and will have little or no growth. D.O. less than 1 Mg/L stresses fish, and over an extended time will result in death either directly or by increased incidence of disease. pH; Alkalinity, Hardness and CO_2: These factors are so interrelated that they will be discussed together.

Alkalinity (HCO_3 - and CO_3=) is in equilibrium with the acid substance CO_2 in water. pH is a measure of acidity (and basicity) of water. Alkalinity cations are generally in combination with the bivalent anions of Ca^{++} and Mg^{++} which are the hardness in water. During daylight hours photosynthesis uses much if not all the available CO_2, thus reducing acidity this increasing pH. If pH gets very high, i.e., > 9 it will irritate fish and above pH 10 fish will die. However, as CO_2 is reduced, CO_3= increases. If the alkalinity is in combination with hardness Ca^{++} and Mg^{++}, $CaCO_3$ forms. Since this compound is only sightly soluable in water, it will precipitate out of solution, thus preventing any further increase in pH (no higher than 9). If alkalinity is combined with alkaline earth metals (K^+, Na^+) i.e., not with hardness ions, then soluable 2 $NaCo_3$ ionic bonds will allow pH to rise to toxic levels.

Thus ample alkalinity is important to allow sufficient CO_2 for photosynthesis and ample hardness is important to prevent toxic levels of pH during times of excessive photosynthesis.

Both day and night bacterial oxidation and respiration create CO_2 which reduces pH. However at night there is no photosynthetic activity to produce O_2 and utilize CO_2 to offset respiration. Thus, pH is lowest at dawn after the night of uncontrolled CO_2 production. Very low pH is toxic to fish, with pH 4 being the acid lethal point. Generally pond water quality is satisfactory if the water pH $\geq$ 6.5 at first daylight and the water pH $\leq$ 9 during the late afternoon.

Fish can tolerate CO_2 levels to 60 mg/L but may avoid them at levels as low as 5 mg/L. Low concentrations of dissolved oxygen usually occur simultaneously with high CO_2 levels. Also, CO_2 interferes with oxygen absorption, especially when oxygen is minimal. Thus early morning is the critical time for dissolved oxygen and CO_2 problems.

Alkalinity and hardness should be of similar magnitude and the alkalinity should be at least 15 mg/L to 20 mg/L to ensure ample CO_2 for maximum photosynthesis. Also, this level of HCO_3^- and CA^{++} facilitates the solution of phosphates, which can then be used in primary production.

The <u>Secchi disc transparency</u> is a measure of light penetration. Approximately twice the depth of the Secchi disc transparency is the maximum depth that sufficient sunlight penetrates to permit net production of oxygen by photosynthesis. If turbidity is caused by phytoplankton, then the lower the transparency the denser the plankton, at least in the uppermost part of the water column.

Water Temperature is a measurement for comparison between ponds and seasons: 20°C and 32°C is the range of temperatures to allow good fish growth of warmwater species as long as dissolved oxygen is sufficient (saturation of D.O. decreases as temperature decreases). Temperatures below 20°C will reduce production of all warm water species compared with waters at higher temperature. Some species require higher temperatures for spawning, e.g. Blue Gill (at least in Alabama) only spawn when water temperatuare $\geq$ 26°C.

Water surface area. This value is directly proportional to production in a water body. Estimated harvest and stocking rates will depend on an accurate estimate of surface area. Maximum, minimum and average values over a year would be even more meaningful especially in reservoirs with predictable seasonal draw downs.

Water Color: Water turbidity can have a positive affect on fish production if it is caused primarily by phytoplankton and is not excessive. However if turbidity is caused by colloidal clay, the light penetration will be reduced inhibiting primary production. Green water color is caused by plankton. White or grey color is generally soil turbidity. Red or brown color may be plankton or soil turbidity.

6.3 Appendix 3. List of scientific and common names of fishes mentioned in this report

Scientific name	Family	Common Name
Native Species		
Astyanax ruberrimus	Characidae	Sardina comun, common sardine
Roeboides guatemalensis	Characidae	Sardina
Hoplias malabaricus	Erythrinidae	Pez Perro
	Ctenoluciidae	Aguja
Curimata magdalenae	Curimatidae	Sardina mana
?	Gymotiformes (order)	Macana
Trachycoristes amblops	Auchenipteridae	Torito
?	Loricariidae	Clupalaja
?	Poeciliidae	purivivous
Aequidens coeruleopuntatus	Cichlidae	Chogorro
Introduced Species		
Cyprinus Carpio	Cyprinidae	Common carp, Carpa comun
Hypophthalmichthys molitrix	Cyprinidae	Carpa Plaleada, Silver Carp
Aristichthys nobilis	Cyprinidae	Carpa Cabezona, Bighead Carp
Ctenopharyngodon idella	Cyprinidae	Carp Herbivora, Grass Carp

Cichla ocellaris	Cichlidae	Sargento, Peacock Bass
Cichlasoma managuensis	Cichlidae	Guapote tigre
Tilapia mossambica, *T. nilotica*	Cichlidae	Tilapia
?	Ariidae	Barbudo
Micropterus salmoides	Centrarchidae	Lobina, Bass, (Largemouth)
Lepomis macrochirus	Centrarchidae	Mojarra de agalla azul, Bluegill

6.4 Appendix 4 Information on stomach content and size at sexual maturity of fishes sampled during the present survey.

Species	Stomach Contents	Minimum Sizes at sexual maturity in the sample
Astyanax ruberrimus	algae, some seeds	
Aequidens coeruleopuncatus	seeds	
Roeboides guatemalensis	insects, mainly diptera	
Poecilidae (species?)	zooplankton	
Trachycoristes amblops	mostly shirmp, some insects* and fish	F-4 @ 16-18 cm
Curimata magdalena	detritus	F-5 and M-5 @ 16-18 cm
Hoplias malabaricus	fish prey size = 0.06-0.41 pred. length	F-4 @ 34 cm
Cichla ocellaris	Fish prey size = 0.16 pred. length	F-4 @ 35 cm
Tilapia mossambica	algae, detritus	F-5 @ 36 cm
T. nilotica	algae	F-4 @ 14 cm M-5 @ 22 cm
Cyprinus carpio	all stomachs empty	F-5 @ 45 cm M-5 @ 42 cm

The above table contains data on species for which data were available on stomach contents and size at sexual maturity. The ratio of prey to predator length shows what size fish a predator of any length is likely to eat. Deep bodied, spiney fish are preyed upon at smaller sizes than are narrow fusiform fish. Sexual development stages 4-6 indicate that a fish will spawn within a few months. F= female, M= male.

*See attached scale of sexual development on the following page from (Ricker).

Appendix 6.5

BLE 7.1. Two generalized classifications of maturity stages in fishes, with approximate correspondence between them.

From Kesteven (1960)	From Nikolsky (1963a)
Virgin y small sexual organs close under the tebral column. Testes and ovaries trans-ent, colourless to grey. Eggs invisible to ed eye.	I. Immature Young individuals which have not yet engaged in reproduction; gonads of very small size.
Maturing virgin stes and ovaries translucent, grey-red. ngth half, or slightly more than half, the gth of ventral cavity. Single eggs can be n with magnifying glass.	II. Resting stage Sexual products have not yet begun to develop; gonads of very small size; eggs not distinguishable to the naked eye.
. Developing stes and ovaries opaque, reddish with ood capillaries. Occupy about half of . ntral cavity. Eggs visible to the eye as nitish granular.	III. Maturation Eggs distinguishable to the naked eye; a very rapid increase in weight of the gonad is in progress; testes change from transparent to a pale rose colour.
. Developing estes reddish-white. No milt-drops appear nder pressure. Ovaries orange reddish. ggs clearly discernible; opaque. Testes nd ovaries occupy about two-thirds of entral cavity.	
. Gravid exual organs filling ventral cavity. Testes hite, drops of milt fall with pressure. Eggs ompletely round, some already translucent nd ripe.	IV. Maturity Sexual products ripe; gonads have achieved their maximum weight, but the sexual products are still not extruded when light pressure is applied.
I. Spawning Roe and milt run with slight pressure. Most ggs translucent with few opaque eggs left n ovary.	V. Reproduction Sexual products are extruded in response to very light pressure on the belly; weight of the gonads decreases rapidly from the start of spawning to its completion.
VII. Spawning/spent Not yet fully empty. No opaque eggs left in ovary.	

From: IBP Handbook #3, Methods for Assessment of Fish Production in Fresh Waters, edited by W. E. Ricker, Blackwell Sci. Publ. Oxford, 1968 306p

TABLE 7.1 *continued.*

From Kesteven (1960)	From Nikolsky (1963a)
VIII. Spent Testes and ovaries empty, red. A few eggs in the state of reabsorption.	VI. Spent condition The sexual products have been discharged; genital aperture inflamed; gonads have the appearance of deflated sacs, the ovaries usually containing a few left-over eggs, and the testes some residual sperm.
II. Recovering spent Testes and ovaries translucent, grey-red. Length half, or slightly more than half, the length of ventral cavity. Single eggs can be seen with magnifying glass.	II. Resting stage Sexual products have been discharged; inflammation around the genital aperture has subsided; gonads of very small size, eggs not distinguishable to the naked eye.

should be kept for each individual separately: the fish's length, body weight, gonad weight, and age as determined from scales or otoliths (see Chapter 5). In some cases fecundity may have to be determined by stripping the eggs from the fish so that neither fish nor eggs are killed, but it is more satisfactory to dissect out the ovary and estimate the number of either fresh or preserved eggs.

Counting fresh eggs. With valuable fish such as salmon it may only be possible to work with fresh eggs that will later be used for hatching. Pope *et al.* (1961) used a variety of methods in their work on Atlantic salmon. With some of the fish the eggs were stripped from ripe females, fertilized, washed and allowed to harden. They were then estimated by the ratio method described by Burrows (1951). This involves finding the total volume of water displaced by all the eggs and also the known number of eggs that displaces a unit volume of water. They also used a hatchery method of counting eggs (Lindroth, 1956) in which the eggs are allowed to fall into 100 small holes in a plastic plate. In this case all the eggs are counted and not just a sample. However, some of the salmon were dead and the ovaries were preserved by Simpson's (1951) method. From these counts the authors were able to learn whether bias was introduced through retention of some of the eggs in the stripped fish. Results from the Scottish River Blackwater in 1957, 1958 and 1959 showed no evidence of differences in the methods of obtaining the

6.6 Appendix 6 Recommended Equipment list for Small Impoundment Management

Gillnets

(A) two, multimesh monofilament, containing eight panels of stretched mesh sizes 1 1/2", 2", 2 1/2", 3", 3 1/2", 4", 5", 6". Each panel is 8m x 2.5m in area. These are sinking containing net weight and float material should be continuous lines within nylon rope.

(B) two, multifilament flagnets containing seven panels of stretched mesh sizes 2", 2 1/2", 3", 3 1/2", 4", 5, 6". Each panel is 5 x 2.5 m in area. These nets are suspended in the water column by pulling the ends of the top line tight. There are no floats and no bottom line.

(C) Four, single mesh monofilament, each 80m x 2 1/2m in area, two each of 3" and 5" stretched mesh. Weight and float material should be continuous lines within nylon ropes. These nets will sink.

20 anchors for gillnet supports require a bag of cement, 20-two liter plastic bags, and 20-10" long pieces of 1/16" diameter wire. Cemet after mixed with water is poured into bags. A length of wire is bent and inbedded in the cement allowing a wire loop to extend above the cement.

Quantity	Item
1	14 foot long aluminum flat-battomed "John Boat"
4	Fiberglass paddles
100 meters	1/8" diameter nylon rope
1	One 50' x 6' x 1/2" square mesh seine with a 6'x6'x6' central bag This net should be treated with tar and mounted on lead and float lines.
1	One 15'x4'1/8" ace mesh seine treated with tar and mounted on lead and float lines.

1	Electronic depth meter.
1	20 cm diameter Secchi disc
2	Fish measuring board
2	Pan balance 500 gram by 2 gram increments
1	Spring balance 5 Kg by 10 gr. increments
1	Water quality kit for measuring: hardness, alkalinity, pH, CO_2 and dissolved oxygen
2	Thermometer
1	Hach water sampler
10	Three gallon plastic buckets, with sealing lids
5	Gallons of formaldahyde
2	Dissection Kits
200	2 liter plastic bags
20	High rag content paper for labeling preserved specimens
400	Rubber bands
50	Data forms to be made up and modified as needed
4	Life jackets or cushions
1	3 gallon Thermos for drinking water
2	Clipboards
1	Long bed 1/2 ton pickup - 4 wheel drive may be necessary in rainy season
1	High lift pickup jack
1	Storage box in pickup (mounted high enough so the boat can slide under the box)