

FINAL REPORT

FRESHWATER SPORT FISH COMMUNITY ASSESSMENTS

State : Puerto Rico
Grant Title : Freshwater Sport Fish Community Assessments
in Puerto Rico Reservoirs and Lagoons.
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INTRODUCTION

Puerto Rico is a tropical island in the Caribbean. It has a limited fresh water fishery in terms of species diversity and reservoir size. However, recreational fishing in Puerto Rico has boomed in the last years, as people have more leisure time and disposable income. The DNER and FWS-SFR, have invested money and time to improve this activity. Access to the most frequented fishing areas has been facilitated, and ramps and docks for boats have been built, an Education Program in Aquatic Resources has been implemented, and fish stockings are periodically carried out in the reservoirs, to increase or enhance sport fish populations. Because sport fish populations are subject to rapid fluctuation in Puerto Rico (e.g., Ashe et al. 1998), regular assessment is needed to make management decisions. Electrofishing assessments had originally been performed only on reservoirs with Puerto Rico Department of Natural and Environmental Resources (DNER) access areas or field stations, however, Corujo (1991) indicated that other reservoirs and lagoons are also subject to recreational fishing pressure.

In September 2004, Project F-52 "Freshwater Sport Fish Community Assessments in Puerto Rico Reservoirs and Lagoons" was approved to perform electrofishing assessments on the Puerto Rico reservoirs that were not administered by the Puerto Rico Department of Natural and Environmental Resources (Guajataca, Lucchetti, La Plata and Cerrillos).

Fish population assessment in five reservoirs

Objective 1: To derive indices of sport fish populations and community well being in selected Puerto Rico reservoirs (Carite, Cidra, Patillas, Loiza, Toa Vaca, Guayabal, Guayo, Caonillas, and Dos Bocas).

Remarks: Five reservoirs were monitored twice per year during Spring (May-August) and Fall (October-November) for years 2006 to 2008. For year 2009 the monitoring was performed during each six months period (semester 1: January - June and semester 2: July - December) due to the fact that seasonality was not a determinant factor for this sampling. Among the reservoirs monitored were Carite (133 ha), Cidra (170.8 ha), Patillas (137 ha) Loiza (388 ha), Toa Vaca (321 ha), Guayabal (131 ha), Guayo (118 ha), Caonillas (280 ha), and Dos Bocas (254 ha). These reservoirs were selected taking in consideration the following criteria: 1) the lack of information regarding the sportfish community where recreational fishing was conducted at a significant level, 2) where creel surveys were programmed, 3) where an access ramp existed adequate to launch and retrieve the electrofishing boat and 4) the size in surface area was greater than 100 ha.

During the past four years, we performed some broodstock capture as requested by Maricao Fish Hatchery biologists (Project F-35). Also, we collaborated in electrofishing with Cerrillos, Guajataca and La Plata personnel when they had problems with their electrofishing boats.

Method: The fish community assessment was performed using boat-mounted electrofishing equipment (Smith Root SR-16 EB, 5.0 GPR boat). Six sampling sites per reservoir were chosen based on their type of habitat and location. Each site was sampled for 10 minutes. Fish were collected and placed in a boat live well. Although the largemouth bass (LMB) (*Micropterus salmoides*) and peacock bass (*Cichla ocellaris*) are the major target species in

Puerto Rico, we collected all species encountered during the sampling period. Once the electrofishing was completed at each station, the fish were identified, measured (mm), weighed (g) and then released alive. A photographic record was made of some fish specimens as well as invasive invertebrates.

Data analysis and report preparation

Objective 2: To analyze data for annual and final reports

Remarks: After several years without electrofishing monitoring of fish communities in the majority of P.R. reservoirs (only Guajataca, Lucchetti, La Plata and Cerrillos are routinely monitored) nine reservoirs were monitored between January 2006 and December 2009.

Method: Data was collected in the field on data sheets, and later entered into a computer database in JMP. Data analysis was performed using JMP® (SAS Corporation) on an Apple Macintosh microcomputer.

PATILLAS

In this reservoir, a total of eleven fish species were found during electrofishing samplings for years 2006 and 2007. The most abundant species was redbreast tilapia (*Tilapia rendalli*) followed by blue tilapia, redear sunfish and armored catfish. The bigmouth sleeper (*Gobiomorus dormitor*) was detected in Patillas reservoir during 2006 but not during 2007 sampling (Table 1). Also, the peacock bass (*Cichla ocellaris*) was present in an average composition of 11.75% which is relatively high. Similar to Carite, in Patillas reservoir, the forage species threadfin shad (*Dorosoma petenense*) was absent.

Table 1. Species present in electrofishing samples at Patillas reservoir during 2006 and 2007. (n=83 for Spring 2006, n=112 for Fall 2006, n=88 for Spring 2007 and n=114 for Fall 2008).

Species	%Composition 2006	%Composition 2007	%Composition 2008	%Composition 2009	%Average Composition
	S / F	S / F	S / F	S1 / S2	
armored catfish	2 / 16	14 / 17	--	--	12.25
bigmouth sleeper	5 / 2	0 / 0	--	--	1.75
bluegill	16 / 8	9 / 0	--	--	8.25
blue tilapia	17 / 11	9 / 0	--	--	9.25
brown bullhead	0 / 1	0 / 0	--	--	0.25
channel catfish	11 / 9	20 / 5	--	--	11.25
largemouth bass	5 / 5	13 / 10	--	--	8.25
mozambique tilapia	0 / 0	1 / 11	--	--	3.00
peacock bass	3 / 10	6 / 28	--	--	11.75
redbreast sunfish	0 / 0	0 / 1	--	--	0.25
redbreast tilapia	22 / 30	19 / 10	--	--	20.25
redeer sunfish	19 / 8	9 / 18	--	--	13.50
Total	100 / 100	100 / 100	--	--	100.00

LMB (largemouth bass) CPUE was 11 fish/hour for Spring and Fall 2007, meaning this increased compared with the previous year (4 for Spring and 6 for Fall 2006). In the same way, LMB condition factor was 101 and 100 for Spring and Fall 2007 respectively, and 91 and 87 for Spring and Fall 2006, which is an improvement in largemouth bass relative weight (Table 2).

Table 2. Total CPUE, LMB CPUE and LMB relative weight for Patillas reservoir for 2006 and 2007.

Sample	TOTAL CATCH	LMB CPUE	MEAN
	CPUE (fish/hour)	(fish/hour)	LMB Wr
Spring 2006	*83	*8	93
Fall 2006	112	6	87
Spring 2007	88	11	101
Fall 2007	114	11	100

*During Spring electrofishing only 3 sampling stations were done due to mechanical problems with the boat generator.

Length frequency distribution of largemouth bass for both sampling periods is shown in Figures 1, 2, 3 and 4. No largemouth bass at fingerling sizes were sampled during Spring electrofishing, however we did find them during Fall. As in the Spring 2006 electrofishing, no largemouth bass at fingerling sizes were sampled during the 2007 sampling.

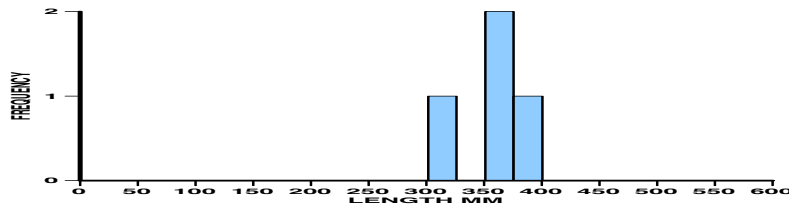


Figure 1. Length frequency distribution of largemouth bass at Patillas reservoir during Spring electrofishing (2006).

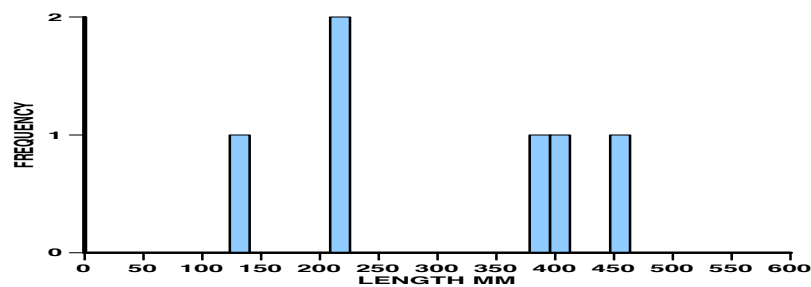


Figure 2. Length frequency distribution of largemouth bass at Patillas reservoir during Fall electrofishing (2006).

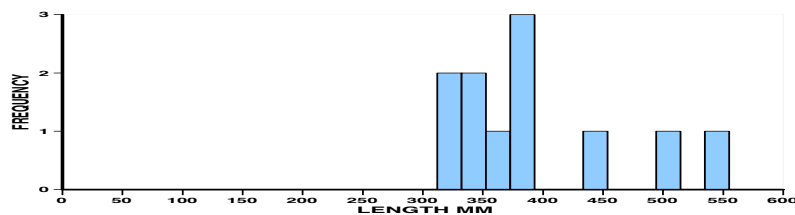


Figure 3. Length frequency distribution of largemouth bass at Patillas reservoir during Spring electrofishing (2007).

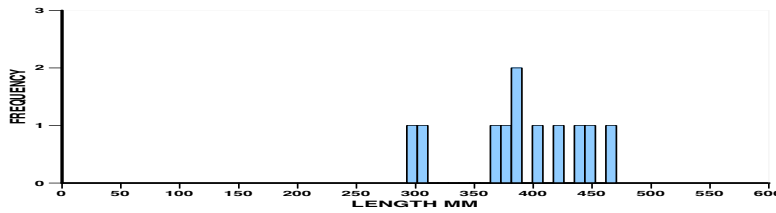


Figure 4. Length frequency distribution of largemouth bass at Patillas reservoir during Fall electrofishing (2007).

CARITE

This reservoir was monitored in years 2006 and 2008. In this reservoir, a total of nine fish species were found. In Carite reservoir there exist the 3 top-level predators (largemouth bass, peacock bass and bigmouth sleepers). During this sampling period, it wasn't different, with the native bigmouth sleeper (*Gobiomorus dormitor*) the most abundant species (average composition of 35.25%), followed by largemouth bass *Micropterus salmoides* (21.0%) and the less abundant, peacock bass (7.75%).

Table 3. Species present in electrofishing samples at Carite reservoir during 2006 and 2008. (n=28 for Spring 2006, n=41 for Fall 2006, n=196 for Spring 2008 and n=54 for Fall 2008).

Species	%Composition 2006		%Composition 2007		%Composition 2008		%Composition 2009		%Average Composition
	S	F	S	F	S	F	S1	S2	
bigmouth sleeper	43	37	--	--	31	30	--	--	35.25
bluegill	0	5	--	--	0	0	--	--	1.25
blue tilapia	0	5	--	--	0	0	--	--	1.25
channel catfish	21	7	--	--	3	4	--	--	8.75
largemouth bass	18	7	--	--	44	15	--	--	21.0
mozambique tilapia	0	0	--	--	0	2	--	--	0.5
peacock bass	4	7	--	--	0	20	--	--	7.75
redbreast sunfish	0	5	--	--	1	2	--	--	2.0
redbreast tilapia	0	15	--	--	2	5	--	--	5.5
redear sunfish	14	12	--	--	19	22	--	--	16.75
Total	100 / 100				100 / 100				100.00

In this reservoir, no threadfin shad were detected which is an important forage species. However, the redear sunfish (*Lepomis microlophus*) population was relatively high with an average composition of 16.75%. This fish species is also used as forage by predatory species.

The highest LMB (largemouth bass) CPUE was 87 fish/hour for Spring 2008. For the same period, LMB condition factor (Wr) was 102, which is very good (Table 4).

Table 4. Total CPUE, LMB CPUE and LMB relative weight for Carite reservoir for 2006 and 2008.

Sample	TOTAL CATCH CPUE (fish/hour)	LMB CPUE (fish/hour)	MEAN LMB Wr
Spring 2006	28	5	91
Fall 2006	41	3	83
Spring 2008	196	87	102
Fall 2008	54	8	84

During these samplings (2006 and 2008) the majority of the largemouth bass were at fingerling sizes (approximately 50 mm TL – 203 mm TL) Figure 5, 6, 7, and 8.

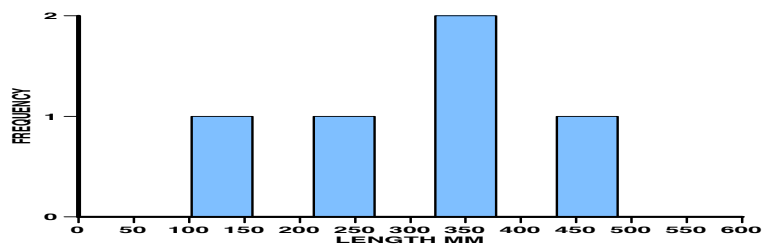


Figure 5. Length frequency distribution of largemouth bass at Carite reservoir during Spring electrofishing (2006).

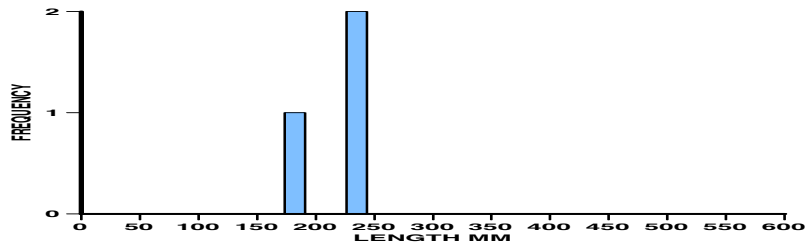


Figure 6. Length frequency distribution of largemouth bass at Carite reservoir during Fall electrofishing (2006).

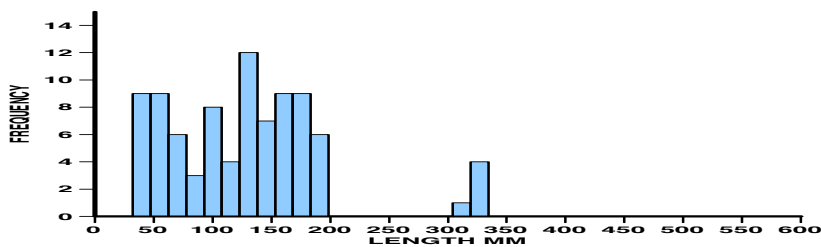


Figure 7. Length frequency distribution of largemouth bass at Carite reservoir during Spring electrofishing (2008).

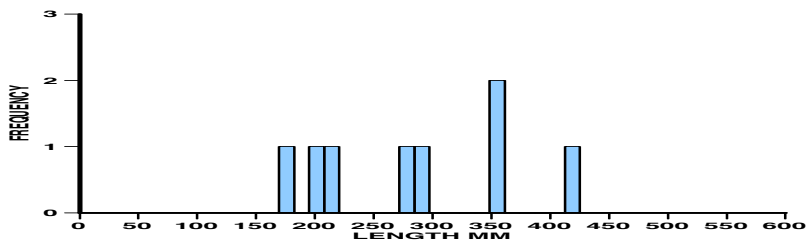


Figure 8. Length frequency distribution of largemouth bass at Carite reservoir during Fall electrofishing (2008).

LOIZA

Loiza reservoir was monitored in years 2006 and 2008 (Table 5). Historically, this reservoir has been one of Puerto Rico's more diverse reservoirs, principally because of the presence of several tropical aquarium species. Eighteen fish species were found in Loiza reservoir including threadfin shad, guppy, rosy barb, green swordtail and mosquito fish. These species were not

included in the fish species composition analysis. For the first time, the guapote tigre *Parachromis managuensis* was caught in a reservoir during Fall 2008 electrofishing sampling, although it is known to have been introduced before 2003 to control the tilapia populations in an experimental aquaculture farm in Lajas, Puerto Rico. This cichlid, native to Costa Rica, is considered highly piscivorous and aggressive (Infobase). Also, during Spring 2008 sampling, the native shrimp *Xiphocaris elongata* was present. This shrimp had been observed previously only in Guayabal reservoir. In addition, one specimen of the Australian redclaw *Cherax quadricarinatus* was found. This crayfish was accidentally introduced to this reservoir after escape from earthen aquaculture ponds on a farm in northeastern Puerto Rico as a result of Hurricane Georges in 1998 (Williams et al., 2001).

Table 5. Species present in electrofishing samples at Loiza reservoir during 2006 and 2008. (n=210 for Spring 2006, n=212 for Fall 2006, n=289 for Spring 2008 and n=219 for Fall 2008).

Species	%Composition 2006		%Composition 2007		%Composition 2008		%Composition 2009		%Average Composition
	S	F	S	F	S	F	S1	S2	
armored catfish	4	16	--		24	33	--		19.25
blue tilapia	0	0	--		1	13	--		3.50
channel catfish	5	6	--		1	1	--		3.25
convict cichlid*	0	2	--		11	0	--		3.25
firemouth cichlid**	0	0	--		7	1	--		2.00
guapote tigre**	0	0	--		0	2	--		0.50
largemouth bass	1	4	--		0	0	--		1.25
mozambique tilapia	55	24	--		3	11	--		23.25
peacock bass	4	1	--		6	9	--		5.00
redbreast sunfish	0	0	--		0	0	--		0.00
redbreast tilapia	10	17	--		5	7	--		9.75
red devil*	11	27	--		42	23	--		25.75
redear sunfish	10	3	--		0	0	--		3.25
Total	100	100			100	100			100.00

* These cichlids were found during 2006 sampling. ** First time reported during electrofishing.

In Loiza reservoir, the largemouth bass, one of our target fish, showed low relative abundance. The red devil (*Amphilophus spp.*) relative abundance for Spring 2008 was quite high (122 individuals), taking in consideration that this cichlid has been

recently introduced to Puerto Rico's reservoirs, probably from aquarium related sources.

CPUE information and LMB Relative Weights in Loiza reservoir for Spring and Fall 2006 and 2008 are presented in Table 6.

Table 6. Total CPUE, LMB CPUE and LMB Relative Weight for Loiza reservoir for 206 and 2008.

Sample	TOTAL CATCH CPUE (fish/hour)	LMB CPUE (fish/hour)	MEAN LMB Wr
Spring 2006	212	3	114
Fall 2006	289	8	115
Spring 2008	289	0	*
Fall 2008	219	1	100

*No individual was captured.

It has to be mentioned that a significant part of the Loiza reservoir is covered with *Eichhornia crassipes* water hyacinth, which makes sampling difficult and sometimes impedes reaching largemouth shoreline habitat with the electrofishing boat.

Figures 9 and 10 present the LMB Length Frequency for Spring and Fall 2006.

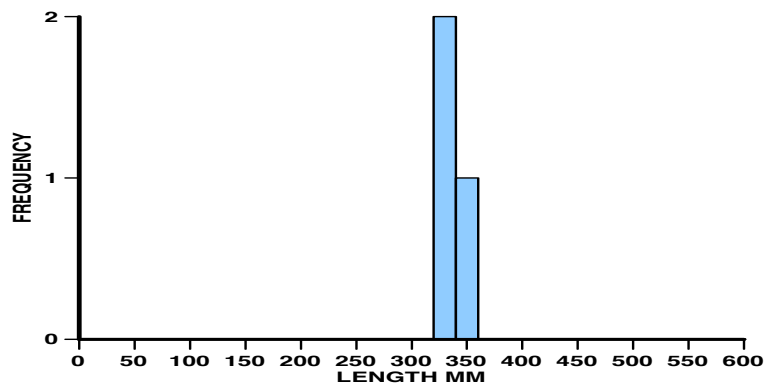


Figure 9. Length frequency distribution of largemouth bass at Loiza reservoir during Spring electrofishing (2006).

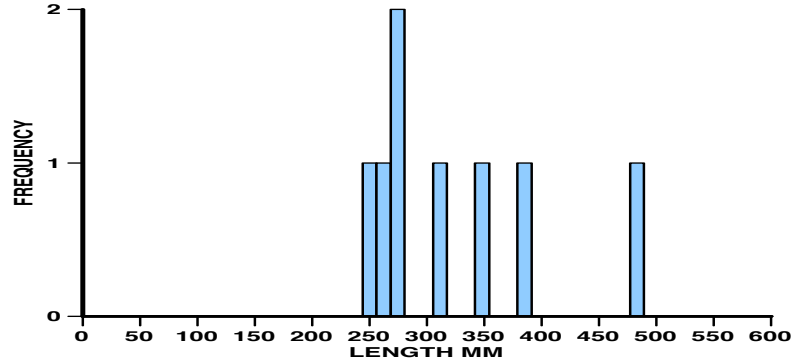


Figure 10. Length frequency distribution of largemouth bass at Loiza reservoir during Fall electrofishing (2006).

DOS BOCAS

The 2006 to 2009 electrofishing at Dos Bocas reservoir was represented by 15 species (Table 7). The mosquito fish were present and hundreds of threadfin shad were observed during both samplings. The dominant species was the armored catfish (24.75%), followed by tilapia mozambique (16.50%) and red devil (15.00%).

Table 7. Species present in electrofishing samples at Dos Bocas reservoir during 2006 and 2008. (n=243 for Spring 2006, n=388 for Fall 2006, n=65 for Spring 2008 and n=153 for Fall 2008).

Species	%Composition	%Composition	%Composition	%Composition	%Average Composition
	2006	2007	2008	2009	
	S / F	S / F	S / F	S1 / S2	
armored catfish	6 / 20	--	48 / 25	--	24.75
blue tilapia	0 / 0	--	0 / 7	--	1.75
brown bullhead	1 / 0	--	0 / 0	--	0.25
channel catfish	13 / 5	--	5 / 6	--	7.25
firemouth cichlid	0 / 0	--	18 / 14	--	8.00
largemouth bass	2 / 18	--	1 / 11	--	8.00
mozambique tilapia	27 / 27	--	2 / 10	--	16.50
peacock bass	1 / 2	--	0 / 2	--	1.25
redbreast sunfish	4 / 3	--	0 / 0	--	1.75
redbreast tilapia	5 / 5	--	6 / 0	--	4.00

red devil	9 / 9	--	20 / 22	--	15.00
redeer sunfish	32 / 11	--	0 / 3	--	11.50
white catfish	0 / 0	--	0 / 0	--	0.00
Total	100 / 100		100 / 100		100.00

Table 8. Total CPUE, LMB CPUE and LMB Relative Weight for Dos Bocas reservoir for 2006 and 2008.

Sample	TOTAL CATCH CPUE (fish/hour)	LMB CPUE (fish/hour)	MEAN LMB Wr
Spring 2006	243	6	106
Fall 2006	388	72	113
Spring 2008*	65	2	117
Fall 2008*	153	34	121

*For each sampling (Spring and Fall 2008) only 3 stations were sampled due to mechanical problems with the boat generator and the trailer.

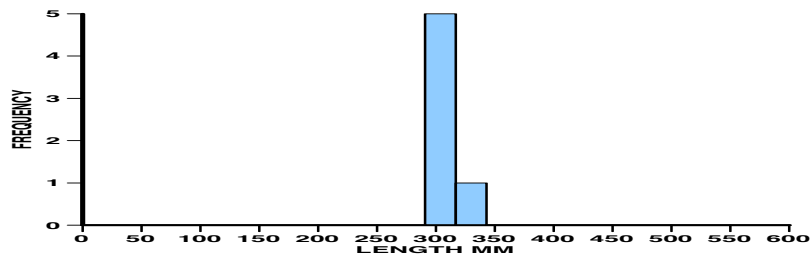


Figure 11. Length frequency distribution of largemouth bass at Dos Bocas reservoir during Spring electrofishing (2006).

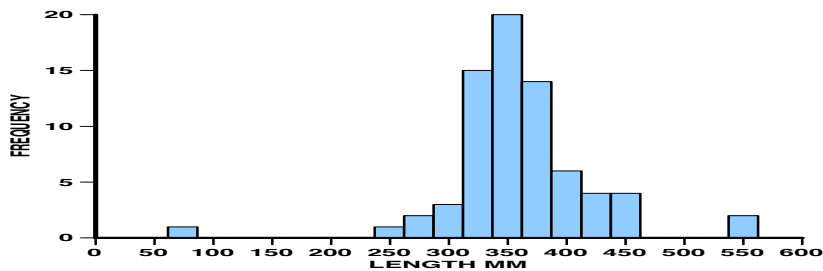


Figure 12. Length frequency distribution of largemouth bass at Dos Bocas reservoir during Fall electrofishing (2006).

LMB relative abundance was very low (1%) for Spring 2008 with only one individual. However, for Fall sampling there was a remarkable increase in the relative abundance, to 11%, with 17 individuals (Figure 13).

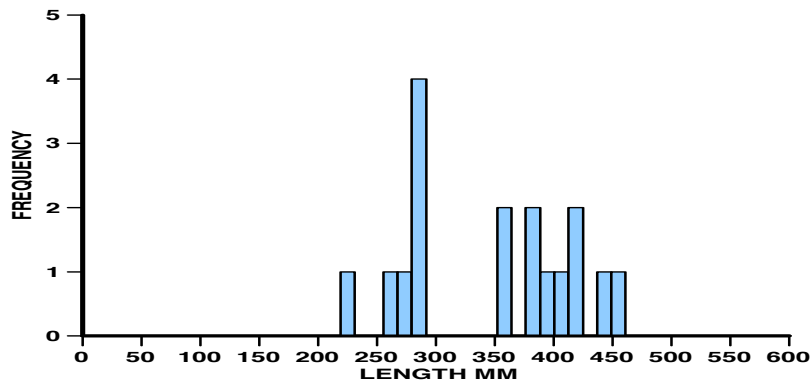


Figure 13. Length frequency distribution of largemouth bass at Dos Bocas reservoir during Fall electrofishing (2008).

CIDRA

Eleven fish species in total were represented in the electrofishing samples from Cidra reservoir for years 2007 and 2009 (Table 9). Threadfin shad (*Dorosoma petenense*) and guppy were found abundantly at Cidra reservoir but they were not included in the species composition analysis. Also, specimens of the Australian redclaw *Cherax quadricarinatus* were found (2007 and 2009) but they were not included either in the species composition analysis. This crayfish was accidentally introduced to Loiza reservoir in 1998 (Williams et al., 2001). However, it has been found in other reservoirs like Carite, where it was present during electrofishing sampling in 2006 (Olmeda et al., 2007).

Table 9. Species present in electrofishing samples at Cidra reservoir during 2007 and 2009. (n=147 for Spring 2007, n=208 for Fall 2007, n=225 for S1 2009 and n=195 for S2 2009).

Species	%Composition 2006		%Composition 2007		%Composition 2008		%Composition 2009		%Average Composition
	S	F	S	F	S	F	S1	S2	
armored catfish	--		5	14	--		8	24	12.75
blue tilapia	--		0	2	--		3	3	2.00
channel catfish	--		6	1	--		2	2	2.75
largemouth bass	--		10	4	--		15	10	9.75
mozambique tilapia	--		4	38	--		5	3	12.50
peacock bass	--		17	9	--		14	15	13.75
redbreast sunfish	--		10	1	--		3	1	3.75
redbreast tilapia	--		29	27	--		40	27	30.75
redeer sunfish	--		19	4	--		10	15	12.00
Total	--		100	100	--		100	100	100.00

In Cidra, for years 2007 and 2009, the largemouth bass, one of our target fish, showed an average composition of 9.75%. The dominant species was redbreast tilapia (*Tilapia rendalli*) (30.75% average composition) followed by peacock bass (*Cichla ocellaris*) (13.75% average composition) and armored catfish (*P. pardalis*) (12.75% average composition). These last two species increased their % composition from 2007 sampling.

LMB (largemouth bass) CPUE increased from 2007 (14 fish/hour for Spring and 9 fish/hour for Fall) to 2009 (33 fish/hour for S1 and 20 fish/hour for S2). The LMB condition factor (W_r) was excellent except for S1, which was slightly low (91) when the LMB CPUE was highest (33) (Table 10). This indicates that adequate forage was available to the bass.

Table 10. Total CPUE, LMB CPUE and LMB relative weight for Cidra reservoir for year 2007 and 2009.

Sample	TOTAL CATCH	LMB CPUE	MEAN
	CPUE (fish/hour)	(fish/hour)	LMB W_r
Spring 2007	147	14	104
Fall 2007	265	9	100

S1 2009	225	33	91
S2 2009	195	20	100

Figures 14, 15, 16 and 17, present the LMB Length Frequency for years 2007 and 2009. For S1 and S2, largemouth bass at fingerling sizes were detected.

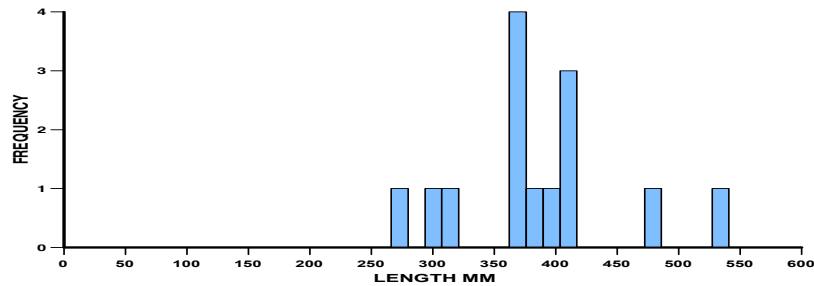


Figure 14. Length frequency distribution of largemouth bass at Cidra reservoir during Spring electrofishing (2007).

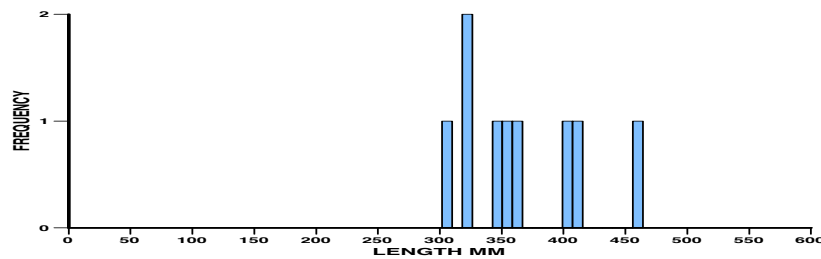


Figure 15. Length frequency distribution of largemouth bass at Cidra reservoir during Fall electrofishing (2007).

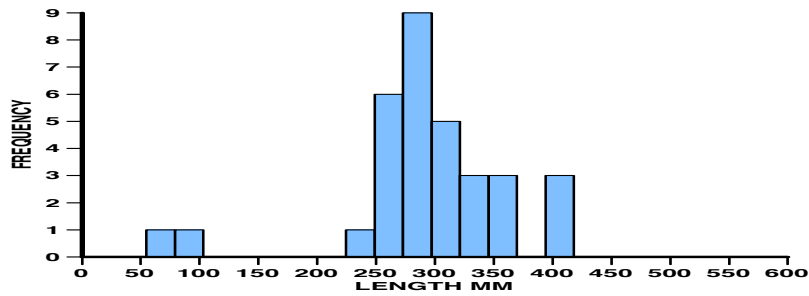


Figure 16. Length frequency distribution of largemouth bass at Cidra reservoir during S1 electrofishing (2009).

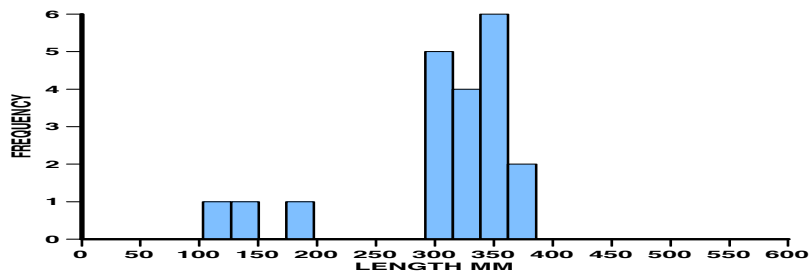


Figure 17. Length frequency distribution of largemouth bass at Cidra reservoir during S2 electrofishing (2009).

GUAYABAL

The electrofishing at Guayabal reservoir (2007 and 2009) was represented by twelve fish species (Table 11). The mosquito fish (*Gambusia affinis*), the threadfin shad and guppy, were also present but weren't included in the species composition analysis. During all sampling was noticeable, along the reservoir shore, the presence of thousands of the native shrimp *Xiphocaris elongata*.

The dominant species was the redear sunfish (59% in S1), which is the only one present in Guayabal of the three sunfish species in Puerto Rico's reservoirs. At Guayabal reservoir, the peacock bass were not detected during the 2007 and 2009 samplings.

Table 11. Species present in electrofishing samples at Guayabal reservoir during 2007 and 2009. (n=126 for Spring 2007, n=156 for Fall 2007 and n=184 for S1 2009).

Species	%Composition 2006	%Composition 2007	%Composition 2008	%Composition 2009	%Average Composition
	S / F	S / F	S / F	S1 / S2	
armored catfish	--	6 / 3	--	3 / --*	4.00
blue tilapia	--	0 / 0	--	7 / --*	2.33
brown bullhead	--	1 / 0	--	0 / --*	0.33
channel catfish	--	0 / 1	--	1 / --*	0.67
largemouth bass	--	1 / 2	--	7 / --*	3.33
mozambique tilapia	--	13 / 25	--	14 / --*	17.33
redbreast tilapia	--	28 / 10	--	9 / --*	15.67
redeer sunfish	--	51 / 59	--	59 / --*	56.33
river goby	--	0 / 0	--	0 / --*	0.00
Total	--	100 / 100	--	100 / -- *	100.00

*No sampling was done due to problems with the access ramp.

LMB condition factor was excellent as in this reservoir exist multiple forage species (threadfin shad, redear sunfish, and tilapia spp.).

Table 12. Total CPUE, LMB CPUE and LMB relative weight for Guayabal reservoir for 2007 and 2009.

Sample	TOTAL CATCH	LMB CPUE	MEAN
	CPUE (fish/hour)	(fish/hour)	LMB Wr
Spring 2007	126	1	109
Fall 2007	156	3	114
S1 2009	184	13	104
S2 2009	*	*	*

*No sampling was done due to problems with the access ramp.

Largemouth bass Length Frequency for Guayabal reservoir is presented in Figure 18 (Fall 2007) and Figure 19 (S1 2009). For Spring 2007 sampling, only one individual was captured (413 mm) and for S2 2009 it was not possible to do the electrofishing sampling.

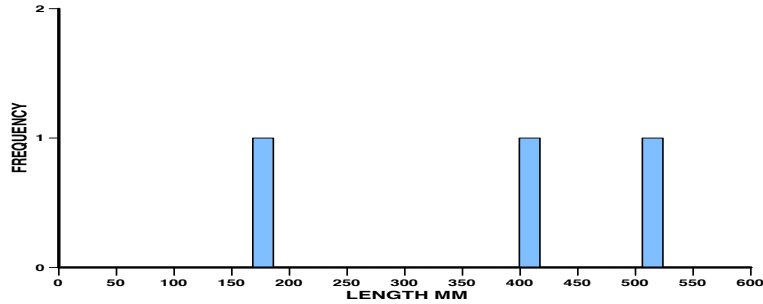


Figure 18. Length frequency distribution of largemouth bass at Guayabal reservoir during Fall electrofishing (2007).

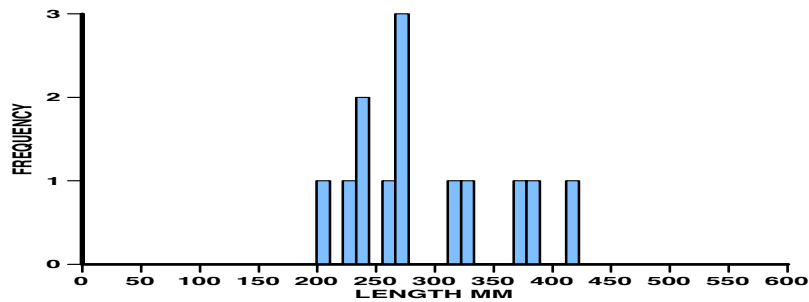


Figure 19. Length frequency distribution of largemouth bass at Guayabal reservoir during S1 electrofishing (2009).

GUAYO

A total of ten fish species were found in Guayo reservoir (Table 13). Interestingly, and contrary to the majority of the reservoirs in Puerto Rico, one of the most abundant species in this reservoir was the largemouth bass (*Micropterus salmoides*). The most abundant species was the redear sunfish (*Lepomis microlophus*). The invasive species armored catfish that in 2007 sampling was not present, was found during 2009 electrofishing sampling. Threadfin shad were present during sampling but were not included in the species composition analysis.

Table 13. Species present in electrofishing samples at Guayo reservoir during 2007 and 2009. (n=382 for Spring, n=174 for Fall, n=392 for S1 and n=261 for S2).

Species	%Composition 2006	%Composition 2007	%Composition 2008	%Composition 2009	%Average Composition
	S / F	S / F	S / F	*S1 / *S2	
armored catfish	--	0 / 0	--	4 / 5	2.25
bluegill	--	0 / 2	--	0 / 4	1.50
blue tilapia	--	0 / 0	--	0 / 1	0.25
channel catfish	--	1 / 1	--	0 / 1	0.75
largemouth bass	--	66 / 54	--	37 / 41	49.50
mozambique tilapia	--	2 / 5	--	0 / 0	1.75
redbreast sunfish	--	7 / 1	--	4 / 5	4.25
redbreast tilapia	--	13 / 19	--	15 / 11	14.50
redecor sunfish	--	11 / 18	--	40 / 32	25.25
Total	--	100 / 100	--		100/ 100

CPUE information and LMB Relative Weights in Guayo reservoir for Spring and Fall 2007 and S1 and S2 2009 are presented in Table 14. For Fall 2007 and S2 2009, it was relatively low.

Table 14. Total CPUE, LMB CPUE and LMB Relative Weight for Guayo reservoir for 2007 and 2009.

Sample	TOTAL CATCH	LMB CPUE	MEAN
	CPUE (fish/hour)	(fish/hour)	LMB Wr
Spring 2007	415	254	125
Fall 2007	188*	113	89
S1 2009	392**	217	104
S2 2009	261**	162	91

*Only five sampling station were done due to heavy rain.

**Only four sampling station were done.

LMB Length Frequency is shown in Figure 20, 21, 22 and 23. Fingerling and adult sizes were present. The presence of LMB fingerlings during all samplings, make it evident that in Guayo reservoir, natural spawning and recruitment has been occurring.

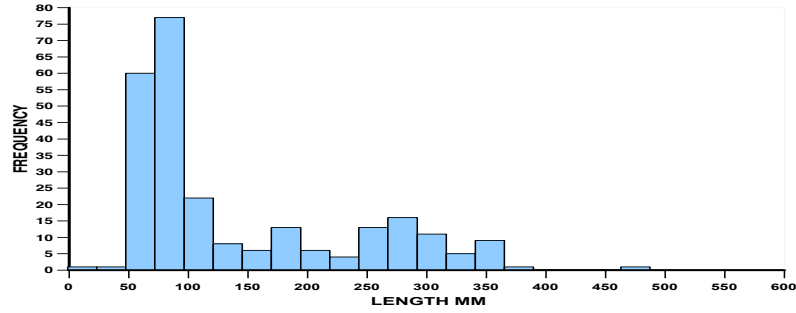


Figure 20. Length frequency distribution of largemouth bass at Guayo reservoir during Spring electrofishing (2007).

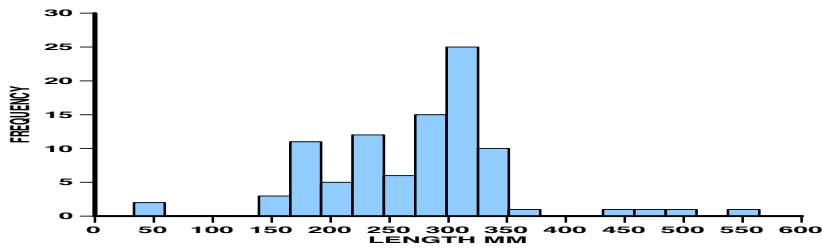


Figure 21. Length frequency distribution of largemouth bass at Guayo reservoir during Fall electrofishing (2007).

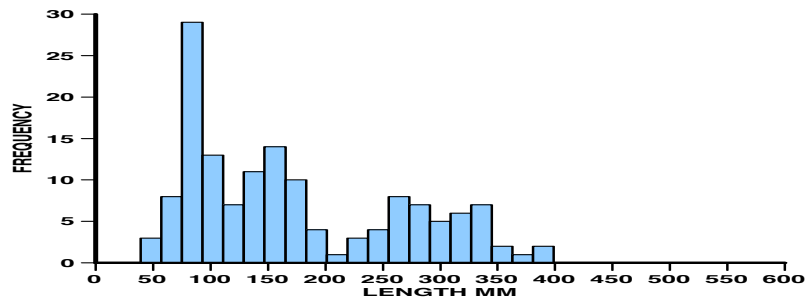


Figure 22. Length frequency distribution of largemouth bass at Guayo reservoir during S1 electrofishing (2009).

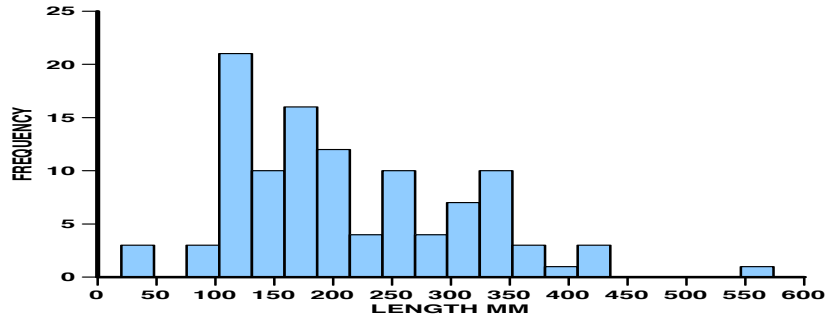


Figure 23. Length frequency distribution of largemouth bass at Guayo reservoir during S2 electrofishing (2009).

Largemouth bass condition factor, based on relative weights (W_r), is excellent for Spring (125) and S1 (104) sampling. The abundant prey, (threadfin shad, redear and redbreast sunfish and redbreast tilapia) contributes to largemouth bass good condition.

TOA VACA

Eight fish species in total were represented in the electrofishing samples (2008 and 2009) from Toa Vaca reservoir (Table 15). Also, threadfin shad and mosquito fish (*Gambusia sp.*) were found abundantly but they have not been included in the species composition analysis.

Table 15. Species present in electrofishing samples at Toa Vaca reservoir during 2008 and 2009. (n=406 for Spring 2008, n=232 for Fall 2008, n=298 for S1 2009 and n=220 for S2 2009).

Species	%Composition 2006		%Composition 2007		%Composition 2008		%Composition 2009		%Average Composition
	S	F	S	F	S	F	S1	S2	
armored catfish	--	--	--	--	5	8	2	1	4.00
bluegill	--	--	--	--	0	0	0	1	0.25
blue tilapia	--	--	--	--	0	0	0	5	1.25
brown bullhead	--	--	--	--	0	0	0	0	0.00
channel catfish	--	--	--	--	--	--	--	--	--
largemouth bass	--	--	--	--	16	18	12	13	14.75
mozambique tilapia	--	--	--	--	5	5	4	0	3.50

peacock bass	--	--	--	--	--
redbreast sunfish	--	--	--	--	--
redbreast tilapia	--	--	27 / 15	45 / 56	35.75
redear sunfish	--	--	47 / 54	37 / 24	40.50
Total	--	--	100 / 100	100 / 100	100.00

In Toa Vaca, the largemouth bass, one of our target fish, showed a species composition of 16% and 18% for Spring and Fall 2008 respectively. During S1 and S2 2009, the largemouth bass species composition was 12% and 13% respectively. The dominant species was redear sunfish followed by redbreast tilapia *Tilapia rendalli*.

Total Catch per Unit of Effort (CPUE fish/hour), LMB CPUE and LMB Relative Weight (Wr) at Toa Vaca reservoir for Spring and Fall 2008 and S1 and S2 2009 are presented in Table 16.

Table 16. Total CPUE, LMB CPUE and LMB Condition Factor for Toa Vaca reservoir for 2008 and 2009.

Sample	TOTAL CATCH CPUE (fish/hour)	LMB CPUE (fish/hour)	MEAN LMB Wr
Spring 2008	406	63	148
Fall 2008	232	41	105
S1 2009	298	35	114
S2 2009	220	29	108

The largemouth bass relative weight was very good for all electrofishing periods (2008: Spring – 148 and Fall – 105), and (2009: S1-114 and S2-108) indicating that adequate forage is available to the bass in this reservoir.

Fingerlings LMB were encountered in either sample. Figure 24 and Figure 25, present the LMB Length Frequency for Spring and Fall respectively.

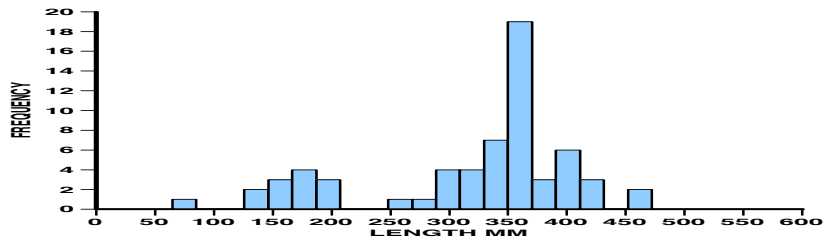


Figure 24. Length frequency distribution of largemouth bass at Toa Vaca reservoir during Spring electrofishing (2008).

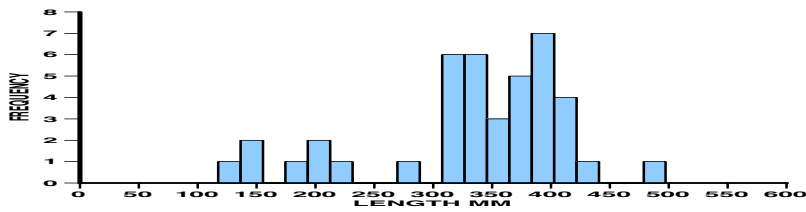


Figure 25. Length frequency distribution of largemouth bass at Toa Vaca reservoir during Fall electrofishing (2008).

During S1 and S2 2009 samplings, largemouth bass fingerlings were encountered also (Figures 26 and 27). This shows that largemouth bass natural reproduction occurred in Toa Vaca reservoir. This is one of the island reservoirs with a solid population of largemouth bass.

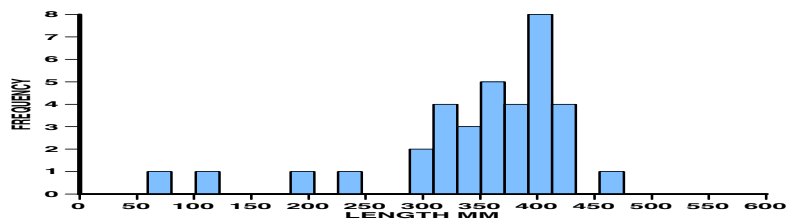


Figure 26. Length frequency distribution of largemouth bass at Toa Vaca reservoir during S1 electrofishing (2009).

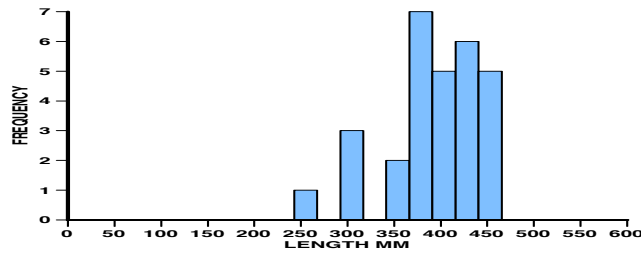


Figure 27. Length frequency distribution of largemouth bass at Toa Vaca reservoir during S2 electrofishing (2009).

CAONILLAS

In this reservoir, seventeen fish species were represented in 2006 to 2008 electrofishing samplings. Mosquito fish and threadfin shad were observed in abundance during the sampling but were not used as part of the species composition analysis (Table 17). Among the nine reservoirs sampled, Caonillas together with Loiza were the reservoirs with the greatest species diversity.

Table 17. Species present in electrofishing samples at Caonillas reservoir during 2006 and 2008. (n=187 for Spring 2006, n=383 for Fall 2006, n=189 for Spring 2007, n=242 for Fall 2007, n=299 for Spring 2008 and n=333 for Fall 2008).

Species	%Composition 2006		%Composition 2007		%Composition 2008		%Composition 2009		%Average Composition
	S	F	S	F	S	F	S1	S2	
armored catfish	39	31	22	26	34	18	47	25	30.25
bluegill	0	0	0	0	0	0	0	0	0.00
blue tilapia	0	0	0	0	8	14	4	21	5.875
brown bullhead	0	0	1	1	0	0	0	0	0.25
channel catfish	5	1	1	1	2	1	1	1	1.625
firemouth cichlid**	0	0	0	0	3	13	8	3	3.375
largemouth bass	10	1	9	8	4	1	2	10	5.625
mozambique tilapia	6	2	11	18	4	10	1	3	6.875
peacock bass	3	2	0	2	1	3	2	12	3.125
redbreast sunfish	3	4	0	2	3	0	0	0	1.50
redbreast tilapia	25	33	22	24	26	25	25	14	24.25
red devil*	0	0	0	2	4	6	2	5	2.375
redear sunfish	9	26	34	16	11	9	8	6	14.875
Total	100	100	100	100	100	100			100.00

*These cichlids were initially found during 2007 sampling.

**These cichlids were initially found during 2008 sampling.

The dominant species were the invasive armored catfish (*Pterygoplichthys pardalis*) with an average composition of 30.25%, redbreast tilapia (average composition of 24.25%), and redear sunfish (average composition of 14.875%).

The red devil (*Amphilophus spp.*) that was detected during 2007 for the first time in Caonillas reservoir, continued present at high relative abundance. It has been detected in Guajataca, Loiza, and Dos Bocas reservoirs (Olmeda et al., 2007) and in Cañaboncito and Cañas Rivers (Felix Grana). In addition, for the first time (2008), the presence of the firemouth cichlid (*Thorichthys meeki*) was detected in Caonillas reservoir. This is another cichlid that was recently introduced to the island's reservoirs, probably from aquarium related sources. It was detected also in Loiza and Dos Bocas reservoirs.

Although largemouth bass were present at Caonillas reservoir during these four years of electrofishing sampling, it can be said that this reservoir does not have an abundant largemouth bass population. The largemouth bass average composition was only 5.625%.

Total CPUE, LMB CPUE and LMB relative weight is presented in Table 18. LMB CPUE was very low for some samplings periods (2 fish/hour for Fall 2006, 4 fish/hour for Fall 2008 and 5 fish/hour for S1 2009). On the other hand, LMB CPUEs for Spring 2006 (19 fish/hour), Spring 2007 (18 fish/hour) and Fall 2007 (20 fish/hour) were fairly high. The condition factor for largemouth bass was acceptably good during all electrofishing samplings.

Table 18. Total CPUE, LMB CPUE and LMB Condition Factor for Caonillas reservoir for 2006 to 2008.

Sample	TOTAL CATCH CPUE (fish/hour)	LMB CPUE (fish/hour)	MEAN LMB Wr
Spring 2006	212	19	96
Fall 2006	422	2	97
Spring 2007	250	18	109
Fall 2007	279	20	114
Spring 2008	299	11	106
Fall 2008	333	4	120
S1 2009	278	5	99
S2 2009	95	9	113

During the 2006 electrofishing, no fingerling largemouth bass were found (Figure 28 and Figure 29).

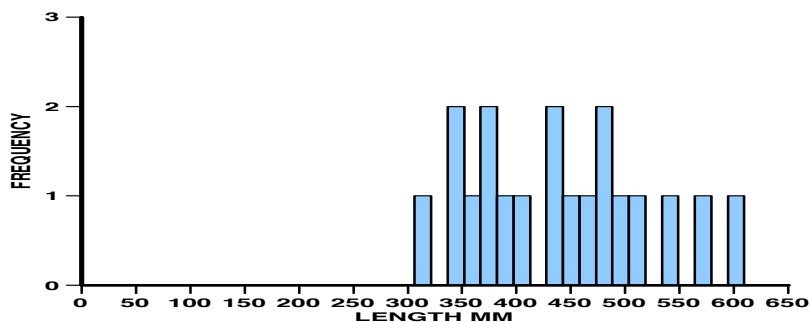


Figure 28. Length frequency distribution of largemouth bass at Caonillas reservoir during Spring electrofishing (2006).

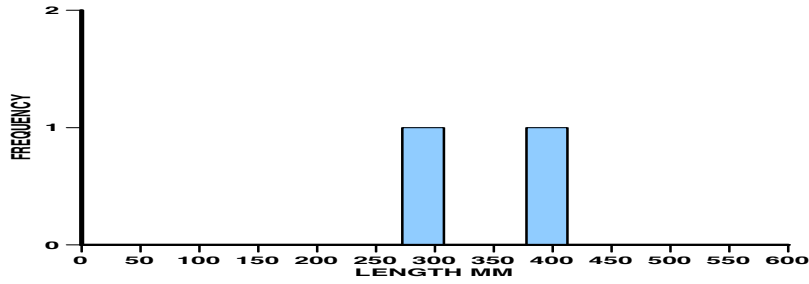


Figure 29. Length frequency distribution of largemouth bass at Caonillas reservoir during Fall electrofishing (2006).

In the Spring electrofishing sample 2007, a bimodal tendency was represented in the LMB length frequency distribution (Figure 30). The first group was composed by LMB fingerling size and the other was a group of LMB adult sizes. A fish stocking was performed during April and May 2007 at Caonillas reservoir with sizes ranging from 38.1 mm to 57.15 mm. Taking into consideration that LMB fingerlings grow approximately 1" per month, these fingerlings could be those stocked before.

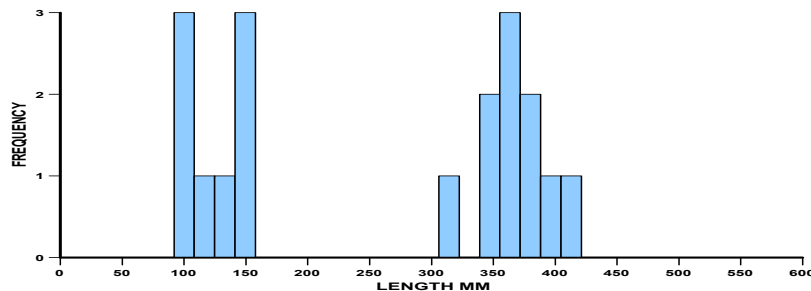


Figure 30. Length frequency distribution of largemouth bass at Caonillas reservoir during Spring electrofishing (2007).

Figure 31, shows the LMB length frequency distribution during Fall electrofishing 2007. Fingerling bass were found, probably due to a fish stocking performed in August 2007.

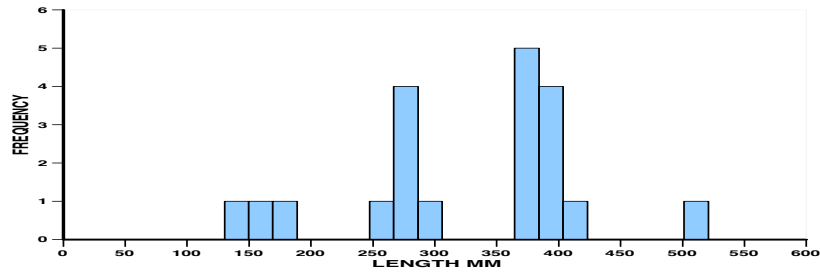


Figure 31. Length frequency distribution of largemouth bass at Caonillas reservoir during Fall electrofishing (2007).

During the Fall electrofishing, only four specimens of largemouth bass were collected, unlike the Spring when eleven specimens were collected. In the Spring sample, no fingerlings were found while in Fall only one was collected (Figure 32 and Figure 33).

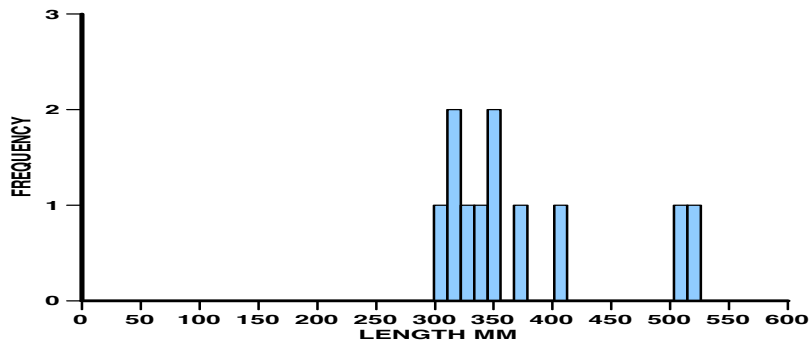


Figure 32. Length frequency distribution of largemouth bass at Caonillas reservoir during Spring electrofishing (2008).

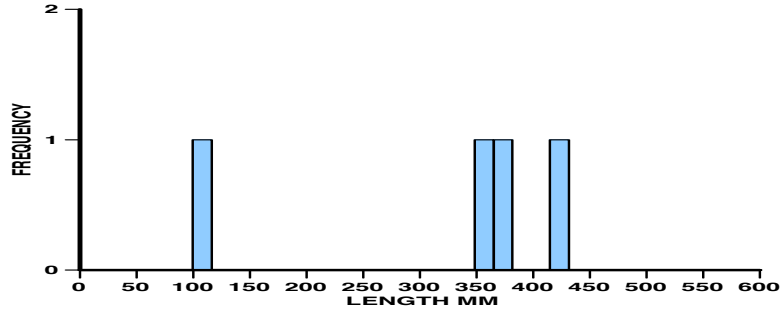


Figure 33. Length frequency distribution of largemouth bass at Caonillas reservoir during Fall electrofishing (2008).

No fingerlings were found in any of the electrofishing samplings in 2009 (Figure 34 and Figure 35).

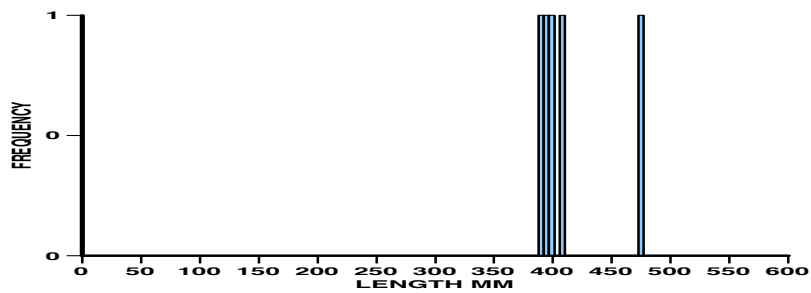


Figure 34. Length frequency distribution of largemouth bass at Caonillas reservoir during S1 electrofishing (2009).

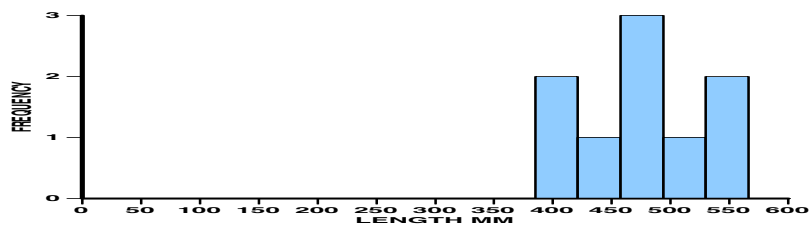


Figure 35. Length frequency distribution of largemouth bass at Caonillas reservoir during S2 electrofishing (2009).

Water Quality

Water quality parameters were monitored at each reservoir when it was possible. The parameters measured were temperature (°F), secchi disk transparency (cm) and dissolved oxygen (mg/l). Also, the reservoir depth was taken at the point where the other parameters were measured, usually close to the dam. Table 19 shows average of the water quality data for all reservoirs during years 2006 to 2009.

For 2006 sampling, in Caonillas it was not possible to monitor water quality due to very high winds (Fall electrofishing). At Loiza, dissolved oxygen was low compared with the other reservoirs (average of 4.04 mg/L). Dissolved oxygen levels below 4 mg/l are considered stressful for warmwater fish.

During electrofishing sampling 2007, in Cidra, Guayo, Caonillas and Guayabal, it was not possible to monitor water temperature and dissolve oxygen due to equipment malfunction. At Cidra, dissolved oxygen was low compared with the other reservoirs (average of 3.6 mg/l). As we mentioned before, dissolved oxygen at these levels (below 4 mg/l) are considered stressful for warmwater fish. Since we take our measurements during the day, when it can be assumed the values will be highest for dissolved oxygen, it is likely that they are considerably below 4 mg/l just before sunrise with some frequency at this reservoir.

Table 19. Water quality data for the five reservoirs sampled during 2006 to 2009.

	PATILLAS	CARITE	LOIZA	DOS BOCAS	CIDRA	GUAYABAL	GUAYO	TOA VACA	CAONILLAS
2006									
TEMP (°C)	27.4	25	27.15	26.4					26.3*
SECCHI (cm)	250	200	48.5	63					174*
O.D. (mg/L)	6.48	6.98	4.04	6.45					7.94*
Depth (feet)	31.75	†	12*	68*					12*
2007									
TEMP (°C)	26.9				25.3*	25.6*	25.7*		26.3*
SECCHI	83.0				48.5	173.0	90.5		61.2

(cm)									
O.D. (mg/L)	7.5				3.6*	8.4*	8.6*		6.7*
Depth (feet)	31.5*				12.8	32.3	24.9		51.0
2008									
TEMP (°C)		26.1	29.4	28.7				29.4	28.0
SECCHI (cm)		43.3	72.5	129.0				8.8	14.3*
O.D. (mg/L)		6.8	7.1	8.9				8.2	8.6
Depth (feet)		58.5	46.8*	46.5				117.0	98.5
2009									
TEMP (°C)					25.8	32.8*	27.4	27.4	27.1
SECCHI (cm)					96.0	140.0*	15.0	176.5	200.0
O.D. (mg/L)					6.8	7.2*	8.3	7.6	7.5
Depth (feet)					29.7	32.8*	81.6	141.5	123.0

* Data only for one sampling.

† No data collected.

Discussion:

In Patillas the three sunfish species (reardear, blugill and redbreast) were present, three tilapia species (redbreast, mozambique and blue). The threadfin shad was not present, and largemouth bass condition factor (Wr) averaged 95. In Patillas there is a healthy population of peacock bass *Cichla ocellaris* with an average composition of 11.75%. Largemouth bass average composition was 8.00%. The bigmouth sleeper *Gobiomorus dormitor*, that was present during 2006 sampling, was absent in 2007 electrofishing sampling.

Among the fish community at Carite reservoir, the most abundant fish species was the bigmouth sleeper (35.25%) followed by largemouth bass (21.0%). This reservoir has the particularity of maintaining a healthy population of bigmouth sleeper, so it is an alternative to those fishermen that prefer this fish. According to Bacheler et al. 2004, in Carite reservoir, recreational fishermen frequently target, catch, and consume bigmouth sleepers. LMB condition factor (Wr) averaged 90, which

was considerably low. In this reservoir, the threadfin shad, an important forage species, was not detected. About 500 threadfin shad were transferred from Cerrillos reservoir in 2008 by F-35 project personnel in an effort to reestablish the species. In addition, the tilapia species average composition was low (5.5% for redbreast tilapia and 0.5% for mozambique tilapia). Carite and Toa Vaca were the reservoirs with lowest fish diversity (9 and 8 species respectively).

Loiza and Caonillas reservoirs presented the highest species diversity among the five reservoirs sampled (18 and 17 fish species respectively). In Loiza some ornamental species were present that have been introduced to the island during the past years. For the first time, the guapote tigre *Parachromis managuensis*, was caught during electrofishing sampling in 2008. Even though fish stockings have been performed recently (2007 and 2008), largemouth bass relative abundance was extremely low. As in the past, this reservoir has a heavy infestation of water hyacinth and water lettuce, which cover a significant part of the lake's surface area. This situation restricts the sampling areas. Neither pacu (*Colossoma spp.*) nor Oscars (*Astronotus ocellatus*) were caught in this electrofishing sampling though they have been reported from Loiza reservoir.

In Caonillas, we sampled the red devil *Amphilophus spp.* for the first time in the 2007 sampling. In the 2008 sampling, the relative abundance increased (2% 2007 to 6% 2008). This invasive species has increased its distribution in the water bodies of the island. Another cichlid that has increased its distribution is the firemouth cichlid, which was reported for the first time at Caonillas reservoir during 2008 sampling. This species is present also in Loiza and Dos Bocas reservoirs. The armored catfish was the most abundant species although its relative abundance has fluctuated since 2006 (30.5% for 2006 / 19.5% for 2007 / 26.0% for 2008 / 36.0% for 2009). Largemouth bass relative abundance was very low (5.6%) although this

reservoir was stocked with largemouth bass fingerlings several times during 2006, 2007, 2008 and 2009. However, as we have said in the past, the presence of the armored catfish, and its spawning habits of constructing nesting burrows close to each other compromising the reservoir shore stability, together with the water levels fluctuations in the reservoir, could be affecting the largemouth bass spawning sites. It is also possible that the high rate of sedimentation, low dissolved oxygen, presence of massive amounts of floating vegetation (with all the effects this entails) and a multitude of predatory invasive cichlids contribute to a hostile environment for largemouth bass. The LMB condition factor averaged 107, which is very good.

In Dos Bocas, there are several tropical aquarium species contributing to the high fish diversity (15 fish species). The most abundant fish species were the armored catfish (average composition of 24.75%), tilapia mozambique (average composition of 16.50%) and red devil (average composition of 15.00%). Largemouth bass population has decreased from 2006 to the present ((LMB CPUE 72 fish/hour Fall (2006) /LMB CPUE 34 fish/hour Fall (2008)). Dos Bocas has been stocked with largemouth bass since 2002. Since 2006, over 40,000 largemouth bass fingerling have been stocked in this reservoir. Nonetheless, the average composition for largemouth bass is currently low (8.0%).

Among the fish community at Cidra reservoir, the most abundant fish were redbreast tilapia (*Tilapia rendalli*) and the peacock bass. This reservoir was stocked with largemouth bass fingerling during 2006 and 2007. LMB average composition was 9.75%, and apparently the abundant populations of tilapia and shad contribute to excellent largemouth bass condition, with Wr averaging 99%. Cidra reservoir is another water body with the presence of invasive species like the australian redclaw *Cherax quadricarinatus*, which was detected during 2007 sampling.

In Guayabal, we found a low relative abundance for largemouth bass (3.33% of average composition). Nevertheless, the condition factor was 109 for Spring 2007, 114 for Fall 2007 and 104 for S1 2009, which were excellent. The reason for this low relative abundance could be that in this reservoir natural recruitment is inadequate to maintain the populations over time, probably due to water level fluctuations, which interfere with spawning. This reservoir has a heavy infestation of water hyacinth and water lettuce, which cover a significant part of the reservoir's surface area. This situation may affect the primary production of phytoplankton by inhibiting light penetration and also restrict the sampling areas. It should be noted that thousands of the native shrimp *Xiphocaris elongata* were present all over the reservoir. This could be an abundant source of food for some fish species.

Of all the reservoirs sampled during these four years, Guayo had the greatest largemouth bass population (LMB CPUE 254 fish/hour for Spring 2007). This reservoir has not been stocked with largemouth bass since 2002. However, the most abundant fish was the largemouth bass with an average composition of 49.50%. The LMB condition factor averaged 102, even though the condition factor was considerably low during Fall sampling (89). In Guayo reservoir there are no peacock bass, and the armored catfish (*Pterygoplichthys pardalis*) was detected for the first time in electrofishing sampling in S1 2009. Similar to Cerrillos reservoir, Guayo has a solid largemouth bass population that makes it a very special reservoir.

Toa Vaca reservoir had a great largemouth bass abundance (average composition is 14.75% and average LMB CPUE 42 fish/hour). This reservoir has not been stocked with largemouth bass since 2003. However, it had a healthy largemouth bass population with representation of all sizes and excellent

condition (average $Wr=119$).

Recommendations:

In Carite and Patillas reservoirs where the island's three top level predators, bigmouth sleeper, peacock bass and largemouth bass co-exist, the forage species stocking should continue. Also, the threadfin shad should be stocked in order to expand the forage alternatives and prey biomass available to these species. These three predator species have now been joined by the guapote tigre cichlid, which is already considered a recreational target species at Loiza Reservoir. However, DNER does NOT recommend stocking this species into any other reservoir until it has been thoroughly researched.

In Toa Vaca, where a healthy largemouth bass population exists, forage species stocking should continue. No largemouth bass stocking should be performed in Toa Vaca at this time.

Toa Vaca reservoir should be considered to construct a public boat ramp sponsored by DNER in order to promote sport fishing. This reservoir maintains a tremendous largemouth bass population that should be available to all the sport fishermen. At the present, the Puerto Rico Electrical Power Authority administers this reservoir, so an agreement to develop this kind of project should be reached.

Guayo is another reservoir where a healthy largemouth bass population exists. In fact, of all the reservoirs sampled, this reservoir, maintains the biggest largemouth bass population with an average composition of 49.5%. It is recommended that forage species stocking should continue. No largemouth bass stocking should be performed in Guayo.

In Guayo reservoir there is no public boat ramp. This reservoir, should be considered for construction of public facilities that could be used by all the sport fishermen. Currently, the best facilities are administered by members of the fishing club. This reservoir has an excellent largemouth bass population and like Toa Vaca, should be available to all the people interested in the sport fishing activities.

The armored catfish is present in the majority of the island's reservoirs. It was present in Caonillas, Loiza, Dos Bocas, Patillas, Toa Vaca, Cidra, and Guayabal. Also, it was present in S1 and S2 2009 at Guayo reservoir. Of the sampled reservoirs this period, it was not present in Carite. It is still a matter of concern because we know about the negative impact this species causes to the reservoir shoreline. Hence it is recommended to advocate the capture and consumption of this species and to prohibit the release of this species back into the reservoir when it is caught. Also the importation of this species by aquarium organism importers should be prohibited. It is suspected that multiple introductions were caused by aquarium hobbyists discarding their pets without understanding the consequences of their actions (Williams et al., 1994). Also, an intense educational campaign should be performed to the general public in order to educate about this important matter.

A healthy and abundant largemouth bass population in these reservoirs would help to control armored catfish abundance.

The presence of other exotic invasive species in the island's reservoirs has worsened. Several cichlids have been established in some reservoirs (Loiza, Dos Bocas, Cidra, La Plata, Guajataca and Caonillas). It is recommended to investigate the impact of invasive species on fresh water habitat and sportfish populations as well as control mechanisms. Also, an intense educational campaign should be performed to the general public in order to educate about the importance of not introducing

exotic species to our water bodies and how to dispose correctly of aquatic pets, fishing bait, etc.

For many years, our sportfish management efforts have been focused on the restoration and supplementation of the largemouth bass population. Analyzing the data obtained for the past decades, we believe it is time to try different strategies or in some cases to focus on other targets in some reservoirs. We have identified reservoirs where the largemouth bass is not favored by the reservoir dynamics, for example; water fluctuations, lack of food or space, exotic species, etc. On the other hand, we have reservoirs where largemouth bass natural reproduction and recruitment is successful (Toa Vaca, Guayo, Cerrillos, Lucchetti). Taking this into consideration it is recommended to focus the largemouth bass stocking only on reservoirs where natural reproduction is deficient, and where we can control and be effective in the management of this species instead of trying to stock in all reservoirs of the island. It may be necessary to stock largemouth bass of sizes larger than the standard size that the Maricao hatchery has historically produced in some cases where sampling has detected an abundance of other predatory species, and methods for this alternative management strategy should be investigated.

There are reservoirs where the cichlids and other fish species are favored (Loiza, Dos Bocas, Caonillas). Also, there are fishermen interested in others fish species different from the largemouth bass or peacock bass (ex., bigmouth sleeper in Carite). We are also witnessing the beginning of guided charter services for tourists interested in fishing for peacock bass in Loiza Reservoir. Therefore, there is an opportunity and a need to manage different reservoirs for different fish species. Our reservoir management strategies are evolving, in an effort to be as responsive as possible to Puerto Rico anglers' needs, within the biological limits of the reservoir systems.

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