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FINAL REPORT

Fish community assessment in selected reservoirs

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

A total of nine reservoirs and one lagoon were monitored from July 1, 2013 to December 31, 2014. Originally, this project was proposed (from July 1, 2013 to June 30, 2014) to sample six reservoirs: (Caonillas (280 ha), Carite (133 ha), Cidra (170.8 ha), Dos Bocas (254 ha), Loiza (388 ha) and Toa Vaca (321 ha). An amendment was approved to, among other things, extend the Grant Award Period for six additional months (ending on December 31, 2014) and to add an additional reservoir (Guayabal -131 ha) to the previously selected water bodies.

For the first semester (S2 2013 - July to December, 2013), six reservoirs and one lagoon were monitored: Caonillas, Carite, Cidra, Dos Bocas, Loiza, and Toa Vaca. Although it was not among the reservoirs scheduled to be sampled during this segment, Caño Tiburones lagoon (1,540 ha) was monitored because it is of great interest to recreational fisherman in Puerto Rico, and it allowed us to test the performance of the electrofishing boat in these waters which are at the upper limit of conductivity which the generator can handle.

For the second semester (S1 2014 – January to June, 2014), seven reservoirs were monitored: Caonillas, Carite, Cidra, Dos Bocas, Loiza, and Guayabal. It was not possible to sample in Toa Vaca reservoir due to the low water level caused by a drought. Instead, Garzas reservoir (44 ha) was monitored because in this reservoir there is a fishing club and largemouth bass tournaments are celebrated in it.

For the third semester (S2 2014 – July to December, 2014), six reservoirs were monitored: Caonillas, Cidra, Dos Bocas, Loiza, Guayabal and Toa Vaca. It was not possible to sample in Carite reservoir because the road access to the ramp was under repair, and thus the transportation of the electrofishing boat was not possible.

The majority of these reservoirs are of high priority for sport fish management, according to the Puerto Rico Reservoir Fisheries Management Manual, are not currently covered by Department of Natural and Environmental Resources (DNER) refuge management officials and are of great interest to the recreational fishermen. In these reservoirs, the water level fluctuates because they are primarily used to supply drinking water to the nearby communities. This situation can affect fish spawning and hence recruitment. The fish community assessments provide us with the data required to determine if these reservoirs are in need of active management of the fishery as a result of the water level fluctuations, fishing intensity or other causes.

During July 1, 2013 to December 31, 2014, project personnel collaborated in electrofishing with personnel from Project F-47 - *Development of Sport Fishing Activities at La Plata Reservoir*, and with personnel from Project F-53R - *Freshwater Sport Fish Management and Enhancement* in a study performed at Cerrillos reservoir. Also, project personnel performed broodstock capture as requested by Maricao Fish Hatchery personnel (Project F-35).

Methodology

Reservoirs were sampled by standardized daytime electrofishing, during each six month period (semesters). The sampled reservoirs were selected based on the greatest priority ranking for DNER but are not currently covered by DNER management officials (as described in the Puerto Rico Reservoir Fisheries Management Manual). Electrofishing procedures followed the Puerto Rico Reservoir Management Manual. A crew of three individuals sampled a total of six sites per reservoir. Each site was sampled for 10 minutes. All fish collected were identified to species, weighed (g) and measured (mm). Assemblage structure and relative abundance were established for all fish species. Size structure, relative abundance, and condition were analyzed for members of the fish assemblage as appropriate. Environmental data, including dissolved oxygen, temperature, depth and secchi disk transparency, were collected at each station. Certain fish were photographed for documentation purposes and reports.

Project personnel contacted tournament officials by telephone or email to obtain the following information: reservoir selected for tournaments, date, number of participants, fishing hours, and catch in terms of number and weight of specimens that qualify for the event. In addition, they were asked for the number of fish released alive, winning weight and number of anglers with at least one fish.

Data analysis and report preparation

To analyze data for annual and final reports.

Caonillas, Cidra, Dos Bocas and Loiza reservoir were monitored three times (July to December 2013 = **S2 2013**, January to June 2014 = **S1 2014** and July to December 2014 = **S2 2014**). Carite two times (**S2 2013** and **S1 2014**), Toa Vaca two times (**S2 2013** and **S2 2014**), Guayabal two times (**S1 2014** and **S2 2014**). Garzas once (**S1 2014**) and Caño Tiburones lagoon once (**S2 2013**).

CAONILLAS (N 18 15.875 W 66 39.320)

In this reservoir, 9 fish species were represented in 2013-2014 electrofishing. Threadfin shad (*Dorosoma petenense*) were observed during the sampling but were not counted as part of the species composition analysis. As in the past, the dominant species were the invasive armored catfish (*Pterygoplichthys pardalis*) (38.0%) and the red devil (33.0%), Table 1. The largemouth bass (*Micropterus salmoides*) is also present at a relative abundance of 6.7%.

The redear sunfish (*Lepomis microlophus*) was not collected during this electrofishing period. As in other reservoirs, this sunfish species has practically disappeared. There may be a correlation between high abundance of red devil cichlids and low abundance of sunfish. This deserves further observation.

Table 1. Target species present in electrofishing samples at Caonillas reservoir during July 2013 to December 2014. The number of fish of each species appears in parentheses.

Species	% Composition	% Composition	% Composition	% Average
	S2 2013	S1 2014	S2 2014	Composition
armored catfish	17 (15)	37 (96)	60 (74)	38.0
blue tilapia	6 (5)	7 (18)	0	4.3

channel catfish	0	1 (2)	1 (1)	0.7
firemouth cichlid	3 (3)	1 (3)	1 (2)	1.7
largemouth bass	2 (2)	7 (18)	11 (14)	6.7
mozambique tilapia	15 (13)	6 (16)	2 (2)	7.7
peacock bass	6 (5)	0 (1)	2 (2)	2.7
redbreast tilapia	8 (7)	7 (17)	1 (1)	5.3
red devil	43 (38)	34 (87)	22 (28)	33.0
Total	100 (88)	100 (258)	100 (124)	100

No fingerling sized (approximately 76 mm TL – 203 mm TL) largemouth bass were found in the S2 2013 Figure 1. However in S1 2014 and S2 2014 fingerling size were present (Figure 2 and Figure 3).

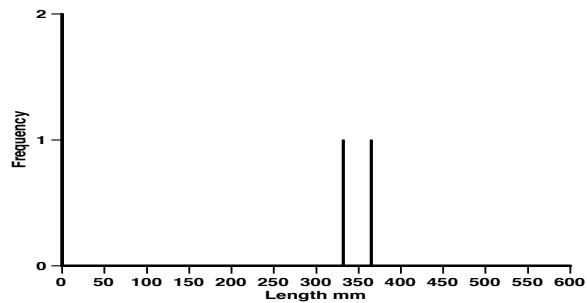


Figure 1. Length frequency distribution of largemouth bass at Caonillas reservoir during S2 2013 electrofishing.

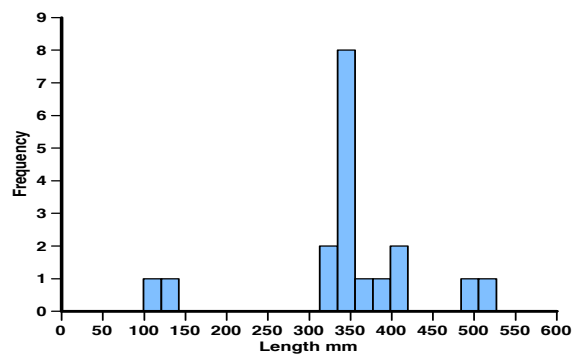


Figure 2. Length frequency distribution of largemouth bass at Caonillas reservoir during S1 2014 electrofishing.

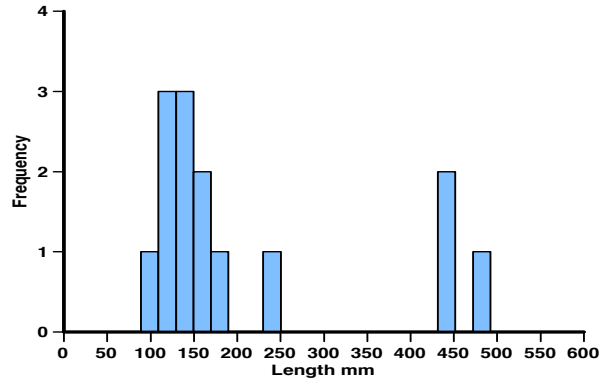


Figure 3. Length frequency distribution of largemouth bass at Caonillas reservoir during S2 2014 electrofishing.

Total CPUE, LMB CPUE and LMB relative weight is presented in Table 2. LMB CPUE for S2 2013 electrofishing was 2 fish/hour, which is very low. However, for S1 2014 was 18 fish/hour and for S2 2014 was 14, which is also very good. As expected, the condition factor for largemouth bass was excellent.

Table 2. Total CPUE, LMB CPUE and LMB Relative Weight for Caonillas reservoir for July 2013 to December 2014.

Sample	TOTAL CATCH CPUE (fish/hour)	LMB CPUE (fish/hour)	MEAN LMB Wr
S2 2013	88	2	109
S1 2014	258	18	107
S2 2014	124	14	111

CIDRA (N18 11.035 W66 08.742)

The 2013-2014 electrofishing capture at Cidra reservoir was represented by 11 species. Threadfin shads were observed during the sampling but were not used as part of the species composition analysis (Table 3). Largemouth bass, one of our target fish, showed a relative abundance of 7% (4 individuals) for S2 2013 electrofishing and only 1% (2 individuals) for S2 2014. For S1 2014 it was not present in the electrofishing sampling. The red devil (*Amphilophus spp.*) that was detected for the first time during electrofishing in 2010, was present

in the S1 2014 (8%- 6 individuals) and S2 2014 (8%- 12 individuals) electrofishing sampling. The Guapote tigre (*Parachromis managuensis*) was detected for the first time in this reservoir (S2 2014). This cichlid, native to Costa Rica, is considered highly piscivorous and aggressive. It was introduced by university aquaculture researchers before 2003 to control the tilapia populations in an experimental aquaculture farm in Lajas, Puerto Rico. It is now established in Loiza reservoir, and is likely to establish successfully in Cidra.

The water hyacinth (*Eichhornia crassipes*) and the water lettuce (*Pistia stratiotes*) were present in part of the Cidra reservoir shore.

Table 3. Target species present in electrofishing samples at Cidra reservoir during July 2013 to December 2014. The number of fish of each species appears in parentheses.

Species	% Composition	% Composition	% Composition	% Average
	S2 2013	S1 2014	S2 2014	Composition
armored catfish	23 (14)	10 (7)	20 (31)	17.6
blue tilapia	2 (1)	2 (1)	2 (3)	2.0
channel catfish	0	0	1 (2)	0.3
guapote tigre	0	0	1 (2)	0.3
largemouth bass	7 (4)	0	1 (2)	2.6
mozambique tilapia	0	4 (3)	4 (6)	2.6
peacock bass	22 (13)	35 (25)	25 (39)	27.3
redbreast sunfish	3 (2)	1 (1)	0	1.3
redbreast tilapia	23 (14)	33 (24)	31 (48)	29.0
red devil	0	8 (6)	8 (12)	6.0
redecor sunfish	20 (12)	7 (5)	7 (10)	11.3
Total	100 (60)	100 (72)*	100 (155)	100

* Only five electrofishing stations were performed due mechanical problems with the pick-up vehicle.

LMB CPUE was 4 fish/hour for S2 2013 electrofishing sampling while for S2 2014 LMB CPUE was 2 fish/hour. No LMB was detected in S1 2014. The LMB condition factor (W_r) was 104 for S2 2013 and 95 for S2 2014 showing a very good condition for largemouth bass in both electrofishing samplings (Table 4).

Table 4. Total CPUE, LMB CPUE and LMB relative weight for Cidra reservoir for July 2013 to December 2014.

Sample	TOTAL CATCH CPUE (fish/hour)	LMB CPUE (fish/hour)	MEAN LMB Wr
S2 2013	60	4	104
S1 2014	86*	---	---
S2 2014	155	2	95

*Five out of the standard six electrofishing samples were performed.

Figures 4 and 5 present the LMB Length Frequency for S2 2013 and S2 2014 respectively. No LMB at fingerling size (approximately 76 mm TL – 203 mm TL) were captured at Cidra reservoir for S2 2013 although in S2 2014 LMB were captured (205 mm and 209 mm).

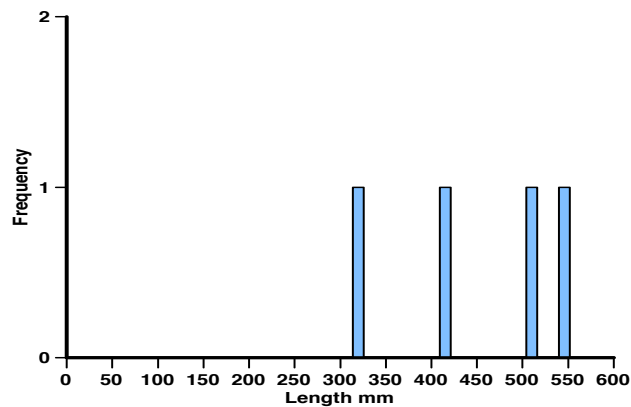


Figure 4. Length frequency distribution of largemouth bass at Cidra reservoir during S2 2013 electrofishing.

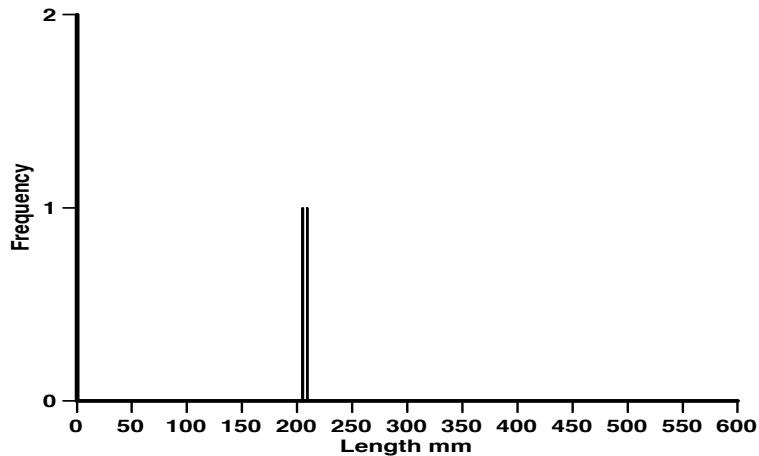


Figure 5. Length frequency distribution of largemouth bass at Cidra reservoir during S2 2014 electrofishing.

DOS BOCAS (N18 19.944 W66 40.017)

A total of 11 fish species were captured in Dos Bocas reservoir (Table 5). This reservoir has been characterized by its species diversity. Abundant threadfin shad were observed during the sampling and also the mosquito fish (*Gambusia sp.*) was present. However neither of these two species has been included in the species composition analysis, since boat electroshocking is not the appropriate sampling technique for this small species and they are not target species.

The dominant species were the Mozambique tilapia (23.3% average composition) and red devil (23.0% average composition). Similar to the case in Cidra reservoir, the Guapote tigre was detected for the first time in this electrofishing period (1% - 2 individuals for S1 2014 and 3% - 7 individuals for S2 2014).

Table 5. Target species present in electrofishing samples at Dos Bocas reservoir during July 2013 to December 2014. The number of fish of each species appears in parentheses.

Species	% Composition	% Composition	% Composition	% Average
	S2 2013	S1 2014	S2 2014	Composition
armored catfish	5 (13)	30 (59)	21 (56)	18.7
blue tilapia	16 (41)	10 (20)	29 (78)	18.3

channel catfish	3 (7)	7 (13)	2 (7)	4.0
firemouth cichlid	4 (11)	6 (12)	4 (12)	4.7
guapote tigre	0	1 (2)	3 (7)	1.3
largemouth bass	2 (4)	2 (4)	0 (1)	1.3
mozambique tilapia	42 (104)	14 (28)	14 (38)	23.3
peacock bass	2 (5)	1 (2)	0	1.0
redbreast sunfish	0	0	2 (5)	0.7
redbreast tilapia	2 (4)	5 (9)	4 (10)	3.7
red devil	24 (60)	24 (48)	21(58)	23.0
Total	100 (249)	100 (197)	100 (272)	100

Total Catch per Unit of Effort (CPUE fish/hour), LMB CPUE and LMB Relative Weight (W_r) at Dos Bocas reservoir during July 2013 to December 2014 is presented in Table 6.

Table 6. Total CPUE, LMB CPUE and LMB relative weight for Dos Bocas reservoir for July 2013 to December 2014.

Sample	TOTAL CATCH CPUE (fish/hour)	LMB CPUE (fish/hour)	MEAN LMB W_r
S2 2013	249	4	119
S1 2014	197	4	103
S2 2014	272	1	90

During S2 2013 and S1 2014, LMB CPUE was 4 fish/hour and largemouth bass condition factor was 119 and 103 respectively, which was very good. This is to be expected as this reservoir has abundant forage species (threadfin shad, *tilapia spp.*, molly and mosquito fish) and many other ornamental fish while the largemouth bass population density is low.

LMB relative abundance is presented in Figure 6 and Figure 7. No LMB at fingerling size (approximately 76 mm TL – 203 mm TL) were captured in either electrofishing period.

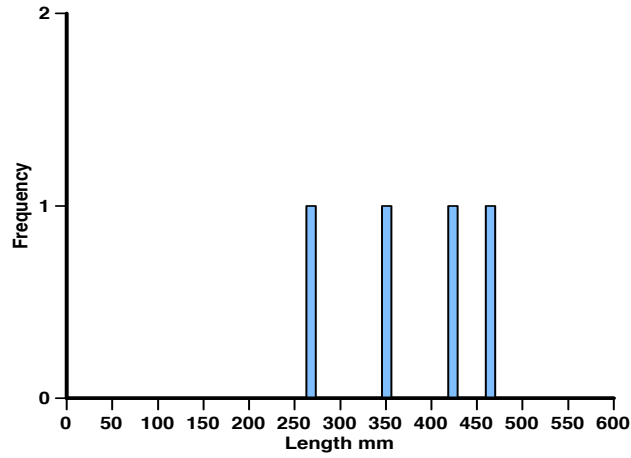


Figure 6. Length frequency distribution of largemouth bass at Dos Bocas reservoir during S2 2013 electrofishing.

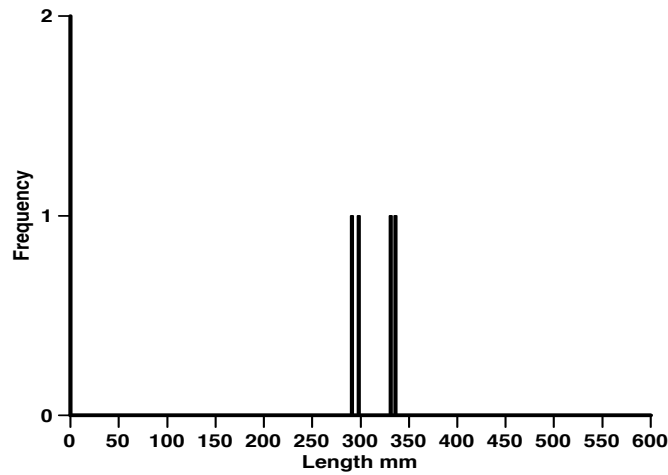


Figure 7. Length frequency distribution of largemouth bass at Dos Bocas reservoir during S1 2014 electrofishing.

LOIZA (N 18 18.278 W 66 01.409)

A total of eleven fish species were captured in Loiza reservoir (Table 7). In this reservoir, it is common to find several tropical aquarium species. Threadfin shad and mosquito fish were observed during the sampling but were not used as part of the species composition analysis. The dominant species was the red devil with a relative abundance of 28.7%. The peacock bass (*Cichla ocellaris*), one of the favorite sport fish on the island, showed a relative abundance of 17.0% (12 individuals) during S2 2013 electrofishing sampling, 19.0% (19 individuals) during S1 2014 and 19.0% (13 individuals) during S2 2014. This contrasts with the relative abundance in 2012 (31.0% - 50 individuals).

Table 7. Target species present in electrofishing samples at Loiza reservoir during July 2013 to December 2014. The number of fish of each species appears in parentheses.

Species	% Composition S2 2013	% Composition S1 2014	% Composition S2 2014	% Average Composition
armored catfish	27 (19)	30 (29)	18 (27)	25.0
blue tilapia	0	2 (2)	9 (13)	3.7
channel catfish	4 (3)	5 (5)	5 (7)	4.7
convict cichlid	2 (1)	0	0	0.7
firemouth cichlid	3 (2)	0	0	1.0
guapote tigre	12 (8)	12 (12)	10 (15)	11.3
mozambique tilapia	0	3 (3)	11 (17)	4.7
peacock bass	17 (12)	19 (19)	13 (19)	16.3
redbreast tilapia	3 (2)	5 (5)	3 (5)	3.7
red devil	31 (22)	24 (24)	31 (46)	28.7
redear sunfish	1 (1)	0	0	0.3
Total	100 (70)*	100 (99)	100 (149)	100

* Only five electrofishing samples were performed due to mechanical problems with the electrofishing boat generator.

Loiza Reservoir joins Carite and Dos Bocas Reservoir in having 3 top-level predators; largemouth bass, peacock bass and guapote tigre. The guapote was caught for the first time in Loiza reservoir during electrofishing sampling in 2008 and is now established. Although no largemouth bass were captured during the electrofishing period, it was reported by fisherman during their fishing tournaments. Oscars (*Astronotus ocellatus*) are commonly reported for this reservoir by anglers, however they have never been captured with the electrofishing gear. Some

electrofishing sampling areas were restricted due a heavy infestation of water hyacinth and water lettuce.

Total Catch per Unit of Effort (CPUE fish/hour), in Loiza reservoir for July 2013 to December 2014 is presented in Table 8.

Table 8. Total CPUE for Loiza reservoir for July 2013 to December 2014.

Sample	TOTAL CATCH CPUE (fish/hour)	LMB CPUE (fish/hour)	MEAN LMB Wr
S2 2013	84*	0*	---
S1 2014	99	0	---
S2 2014	149	0	---

* Five out of the standard six electrofishing samples were performed.

CARITE (N 18 04.56 W 66 06.164)

In Carite reservoir, a total of eight fish species were captured. As well as in Patillas, Loiza, Cidra and Dos Bocas reservoirs, Carite is distinguished by having 3 top-level predators (in this case, similarly to Patillas, largemouth bass, peacock bass and bigmouth sleepers). Like to last years, the native bigmouth sleeper (*Gobiomorus dormitor*) was the most abundant species (26.0%). The redbreast sunfish *Lepomis auritus* had relative abundance of 18%-10 individuals in S2 2013 and 31%-20 individuals for S1 2014. This represents the largest population of redbreast sunfish in all of the sampled reservoirs. The Australian redclaw *Cherax quadricarinatus* was present during the electrofishing sampling and a few adult specimens of armored catfish. No shad were observed.

Table 9. Target species present in electrofishing samples at Carite reservoir during July 2013 to December 2014. The number of fish of each species appears in parentheses.

Species	% Composition S2 2013	% Composition S1 2014	% Composition S2 2014	% Average Composition
armored catfish	5 (3)	6 (4)	---	5.5
bigmouth sleeper	24 (13)	28 (18)	---	26.0

channel catfish	13 (7)	8 (5)	---	10.5
largemouth bass	22 (12)	8 (5)	---	15.0
peacock bass	4 (2)	2 (1)	---	3.0
redbreast sunfish	18 (10)	31 (20)	---	24.5
redbreast tilapia	7 (4)	5 (3)	---	6.0
redecor sunfish	7 (4)	12 (8)	---	9.5
Total	100 (55)	100 (64)	---	100

LMB CPUE was 12 fish/hour for S2 2013 and 5 for S1 2014. The LMB condition factor (W_r) was low (92 for S2 2013). Nevertheless, for S1 2014 W_r had decreased to 77 which was extremely low (Table 10). Shad tend to be scarce in the low fertility waters of Carite, which probably affects LMB relative weight.

Table 10. Total CPUE, LMB CPUE and LMB Relative Weight for Carite reservoir for July 2013 to June 2014.

Sample	TOTAL CATCH CPUE (fish/hour)	LMB CPUE (fish/hour)	MEAN LMB W_r
S2 2013	55	12	92
S1 2014	64	5	77
S2 2014	---	---	---

Largemouth bass at fingerling size (approximately 76 mm TL – 203 mm TL) were captured during S2 2013 electrofishing sampling (Figure 8) but not during S1 2014 (Figure 9).

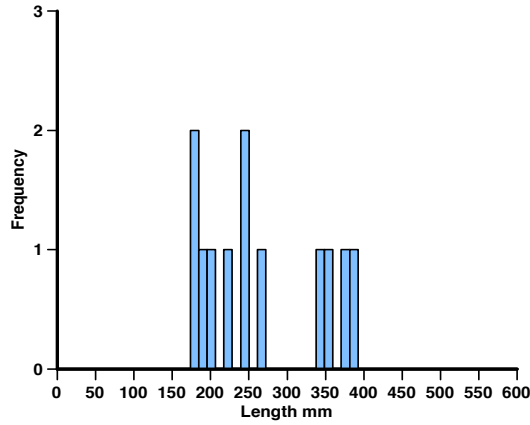


Figure 8. Length frequency distribution of largemouth bass at Carite reservoir during S2 2013 electrofishing.

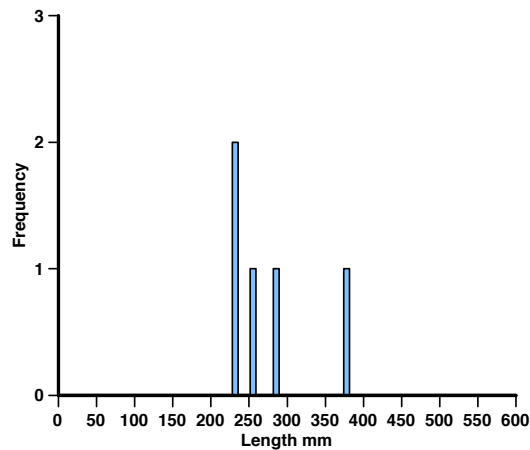


Figure 9. Length frequency distribution of largemouth bass at Carite reservoir during S1 2014 electrofishing.

TOA VACA (N 18 06.167 W 66 28.763)

Toa Vaca has low fish diversity. The electrofishing capture for July 2013 to December 2014 was represented by seven species (Table11). Also threadfin shad and the australian redclaw were observed during the sampling but have not been used in the species composition analysis. For

the first time the convict cichlid (*Archocentrus nigrafasciatus*) were captured in this reservoir (only one individual). Also, water quality is being impacted now in Toa Vaca by a recently installed aeration system operated by the Water Authority.

Table 11. Target species present in electrofishing samples at Toa Vaca reservoir during July 2013 to December 2014. The number of fish of each species appears in parentheses.

Species	% Composition S2 2013	% Composition S1 2014	% Composition S2 2014	% Average Composition
armored catfish	9 (14)	---	15 (18)	12.0
blue tilapia	2 (3)	---	2 (2)	2.0
convict cichlid	0	---	1 (1)	0.5
largemouth bass	47 (74)	---	57 (67)	52.0
mozambique tilapia	4 (6)	---	8 (9)	6.0
redbreast tilapia	13 (21)	---	4 (5)	8.5
redecor sunfish	25 (39)	---	13 (15)	19.0
Total	100 (157)	---	100 (117)	100

The S2 2013 electrofishing sampling was performed under drastic low water level conditions due to a drought that affected the island for several months. One of the electrofishing stations had to be changed and in another one no fish were caught.

The dominant species was largemouth bass, one of our target fish. It showed a relative abundance of 74 individuals (47%) during S2 2013 and 67 individuals (57%) during S2 2014. The redear sunfish showed a relative abundance of 39 individuals (25%) for S2 2013 and 15 individuals (13%) for S2 2014. The peacock bass has never been captured in this reservoir.

Total CPUE (fish/hour), LMB CPUE and LMB Relative Weight (W_r) at Toa Vaca reservoir for July 2013 to December 2014 is presented in Table 12. Both LMB CPUE and largemouth bass relative weight (for S2 2013) were excellent. For S2 2014 the largemouth bass condition was very low ($W_r=89$).

Table 12. Total CPUE, LMB CPUE and LMB Condition Factor for Toa Vaca reservoir for July 2013 to December 2014.

Sample	TOTAL CATCH CPUE (fish/hour)	LMB CPUE (fish/hour)	MEAN LMB W _r
S2 2013	157	74	101
S1 2014	---	---	---
S2 2014	117	67	89

LMB relative abundance is presented in Figure 10 and Figure 11. Largemouth bass at fingerling size (approximately 76 mm TL – 203 mm TL) were captured in both electrofishing periods evidencing the largemouth bass natural reproduction in this reservoir.

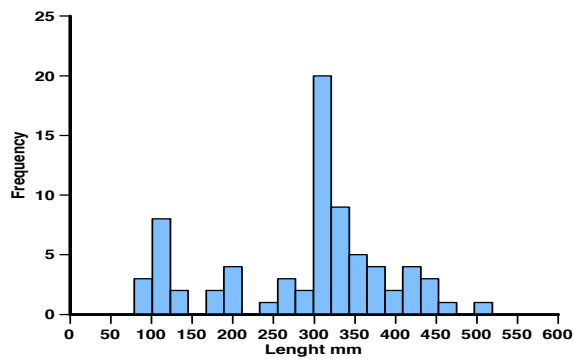


Figure 10. Length frequency distribution of largemouth bass at Toa Vaca reservoir during S2 2013 electrofishing.

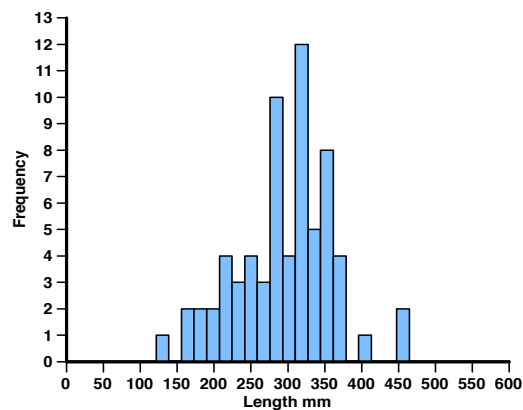


Figure 11. Length frequency distribution of largemouth bass at Toa Vaca reservoir during S2 2014 electrofishing.

GUAYABAL (N 18 05.599 W66 30.301)

The 2013 - 2014 electrofishing at Guayabal reservoir was represented by eleven species (Table 13). The dominant species was the tilapia (24.5% redbreast tilapia, 18% mozambique tilapia and 16% blue tilapia). The invasive red devil was present at a relative abundance of 13.5% and largemouth bass at 7%.

During both samplings we observed at the reservoir shore thousands of the native shrimp “salpiche” (*Xiphocaris elongata*). Also mosquito fish (*Gambusia sp.*) and the snail *Thiara (Tarebia) granifera* were observed. This little snail was observed in abundance.

Table 13. Target species present in electrofishing samples at Guayabal reservoir during July 2013 to December 2014. The number of fish of each species appears in parentheses.

Species	% Composition S2 2013	% Composition S1 2014	% Composition S2 2014	% Average Composition
armored catfish	---	3 (4)	4 (4)	3.5
blue tilapia	---	14 (18)	18 (16)	16.0
convict cichlid	---	0	2 (2)	1.0
largemouth bass	---	1 (2)	13 (12)	7.0
mozambique tilapia	---	20 (26)	16 (15)	18.0
peacock bass	---	1 (2)	9 (8)	5.0
redbreast sunfish	---	1 (2)	1 (1)	1.0
redbreast tilapia	---	40 (52)	9 (8)	24.5
red devil	---	8 (10)	19 (17)	13.5
redeer sunfish	---	10 (13)	9 (8)	9.5
river goby	---	2 (2)	0	1.0
Total	---	100 (131)	100 (91)	100

LMB CPUE was good during S2 2014 (Table 14). Largemouth bass condition factor was excellent for both electrofishing periods. This is normal as in this reservoir there are abundant forage species (threadfin shad, redear sunfish, and *tilapia spp.*)

Table 14. Total CPUE, LMB CPUE and LMB relative weight for Guayabal reservoir for July 2013 to December 2014.

Sample	TOTAL CATCH CPUE (fish/hour)	LMB CPUE (fish/hour)	MEAN LMB W_r
S2 2013	---	---	---
S1 2014	131	2	113
S2 2014	91	12	110

No LMB at fingerling size (approximately 76 mm TL – 203 mm TL) were captured in either electrofishing period.

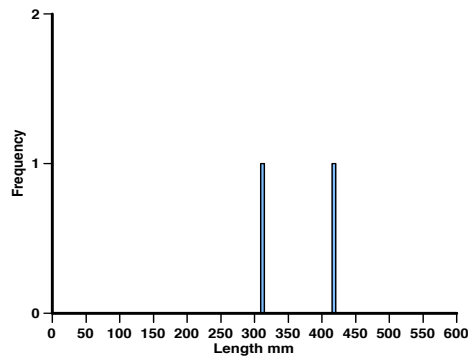


Figure 12. Length frequency distribution of largemouth bass at Guayabal reservoir during S1 2014 electrofishing.

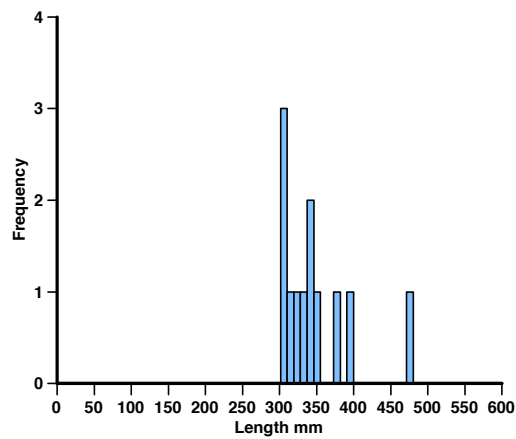


Figure 13. Length frequency distribution of largemouth bass at Guayabal reservoir during S2 2014 electrofishing.

GARZAS (N 18 08.174 W 66 44.687)

Among the reservoirs sampled, Garzas has the lowest fish diversity. The electrofishing capture for S1 2014 (January to June 2014) was represented by five species (Table 15). The dominant species was largemouth bass. It showed a relative abundance of 93 individuals (63%) during S1 2014 (the only period sampled). The redear sunfish showed a relative abundance of 33 individuals (22%). The peacock bass was not captured in this reservoir.

Table 15. Target species present in electrofishing samples at Garzas reservoir during July 2013 to December 2014. The number of fish of each species appears in parentheses.

Species	% Composition	% Composition	% Composition	% Average
	S2 2013	S1 2014	S2 2014	Composition
armored catfish	---	9 (14)	---	---
bluegill sunfish	---	3 (4)	---	---
largemouth bass	---	63 (93)	---	---
redbreast tilapia	---	3 (5)	---	---
redear sunfish	---	22 (33)	---	---
Total	---	100 (149)	---	---

Total CPUE (fish/hour), LMB CPUE and LMB Relative Weight (W_r) at Garzas reservoir for S1 2014 is presented in Table 16. LMB CPUE was excellent. However, largemouth bass relative weight was very low. This could be because of the absence of shad in this reservoir while the largemouth bass population density is very high.

Table 16. Total CPUE, LMB CPUE and LMB Condition Factor for Garzas reservoir for July 2013 to December 2014.

Sample	TOTAL CATCH	LMB CPUE	MEAN
	CPUE (fish/hour)	(fish/hour)	LMB W_r
S2 2013	---	---	---
S1 2014	149	93	84
S2 2014	---	---	---

LMB relative abundance is presented in Figure 14. A bimodal distribution is represented in the LMB length frequency (Figure 14). The first group is a group of LMB fingerling sizes only. The second group ranged from fingerling size to adult size. The largemouth bass natural reproduction in this reservoir is evident.

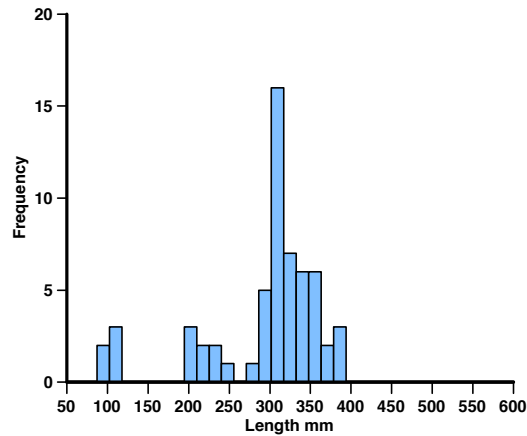


Figure 14. Length frequency distribution of largemouth bass at Garzas reservoir during S1 2014 electrofishing.

CAÑO TIBURONES (N 18 28.298 W 66 38.213)

This lagoon was sampled only during S2 2013 (July to December 2013). A total of eleven fish were captured in the electrofishing sampling (Table 17). The most abundant species was the snook (*Centropomus spp.*) a very popular fish among salt water recreational anglers. Also, the horse eye jack (*Caranx latus*) and the striped mojarra (*Eugerres plumieri*) were captured. Some specimens of eel and shrimp and blue crabs were observed during electrofishing sampling but it was not possible to capture them.

Table 17. Target species present in electrofishing samples at Caño Tiburones lagoon during July 2013 to December 2014. The number of fish of each species appears in parentheses.

Species	% Composition S2 2013	% Composition S1 2014	% Composition S2 2014	% Average Composition
horse-eye jack	9 (1)	---	---	---

striped mojarra	8 (1)	---	---	---
snook	83 (10)	---	---	---
Total	100 (12)	---	---	---

Water Quality

Table 18 shows the water quality data for all reservoirs during S2 2013, S1 2014 and S2 2014 electrofishing samplings. Water quality parameters were monitored at each reservoir when it was possible. In some samplings, it was not possible due to bad weather conditions such as heavy rain or heavy wind. In others samplings, the water quality equipment was not available.

The parameters measured were temperature, secchi disk transparency, dissolved oxygen and specific conductivity. Also, the reservoir depth was taken at the point where the other parameters were measured, usually in the dam area. In spite of the low dissolve oxygen in Cidra and Toa Vaca (S2 2013), there no were complications.

Table 18. Water quality data for the six reservoirs sampled during July 2013 to December 2014.

Reservoir	Temperature (°C)	Secchi (cm)	O. D. (mg/l)	Depth (feet)	Conductivity (μ)
Caonillas	S2 2013 / 21.8	S2 2013 / 110.0	S2 2013 / 6.45	S2 2013 / 51.8	S2 2013 / 145.7
	S1 2014 / 26.9	S1 2014 / 60.0	S1 2014 / 6.84	S1 2014 / 108.5	S1 2014 / 203.6
	S2 2014 / 26.9	S2 2014 / 40.0	S2 2014 / 4.18	S2 2014 / 124.3	S2 2014 / †
Cidra	S2 2013 / 27.0	S2 2013 / 101.0	S2 2013 / 2.96	S2 2013 / 45.5	S2 2013 / 173.1
	S1 2014 / †	S1 2014 / †	S1 2014 / †	S1 2014 / †	S1 2014 / †
	S2 2014 / 28.5	S2 2014 / 80.0	S2 2014 / 7.13	S2 2014 / 54.4	S2 2014 / †
Dos Bocas	S2 2013 / 26.9	S2 2013 / 72.0	S2 2013 / 3.20	S2 2013 / 64.0	S2 2013 / 212.0
	S1 2014 / 28.7	S1 2014 / †	S1 2014 / 10.80	S1 2014 / 61.8	S1 2014 / 196.6
	S2 2014 / 28.3	S2 2014 / 45.0	S2 2014 / 11.53	S2 2014 / 59.0	S2 2014 / †
Loiza	S2 2013 / 29.0	S2 2013 / 130.0	S2 2013 / 3.77	S2 2013 / 33.2	S2 2013 / 2.98
	S1 2014 / 29.5	S1 2014 / 189.0	S1 2014 / 9.19	S1 2014 / 24.5	S1 2014 / 365.5
	S2 2014 / 31.8	S2 2014 / 101.3	S2 2014 / 8.33	S2 2014 / 40.8	S2 2014 / †
Carite	S2 2013 / 24.8	S2 2013 / 193.0	S2 2013 / 3.45	S2 2013 / 66.1	S2 2013 / 91.8
	S1 2014 / 26.0	S1 2014 / 84.0	S1 2014 / 7.91	S1 2014 / 62.5	S1 2014 / 106.8
	S2 2014 / †	S2 2014 / †	S2 2014 / †	S2 2014 / †	S2 2014 / †
Toa Vaca	S2 2013 / 29.1	S2 2013 / 120.0	S2 2013 / 2.77	S2 2013 / 98.0	S2 2013 / 304.7
	S1 2014 / †	S1 2014 / †	S1 2014 / †	S1 2014 / †	S1 2014 / †
	S2 2014 / 28.7	S2 2014 / 120.0	S2 2014 / 4.36	S2 2014 / 15.5	S2 2014 / †
Guayabal	S2 2013 / †	S2 2013 / †	S2 2013 / †	S2 2013 / †	S2 2013 / †
	S1 2014 / 27.9	S1 2014 / 378.0	S1 2014 / 7.5	S1 2014 / 28.4	S1 2014 / 265.9
	S2 2014 / 27.6	S2 2014 / 90.0	S2 2014 / 6.25	S2 2014 / 39.5	S2 2014 / †

Garzas	S2 2013 / †	S2 2013 / †	S2 2013 / †	S2 2013 / †	S2 2013 / †
	S1 2014 / 21.8	S1 2014 / 110.0	S1 2014 / 6.45	S1 2014 / 5.8	S1 2014 / 145.7
	S2 2014 / †	S2 2014 / †	S2 2014 / †	S2 2014 / †	S2 2014 / †
Caño	S2 2013 / 26.6	S2 2013 / 163.0	S2 2013 / 2.37-7.29	S2 2013 / 1.8	S2 2013 / 4.4-5.5
Tiburones	S1 2014 / †	S1 2014 / †	S1 2014 / †	S1 2014 / †	S1 2014 / †
	S2 2014 / †	S2 2014 / †	S2 2014 / †	S2 2014 / †	S2 2014 / †

† Data not collected.

Bass tournaments

To describe the competitive fishery in selected reservoirs (Caonillas, Carite, Cidra, Dos Bocas, Loiza and Toa Vaca).

Tournament officials from the reservoirs monitored were contacted via telephone and/or e-mail by project personnel to obtain the information necessary to calculate the Effort, CPUE, # of tournaments, # of anglers, largemouth bass maximum weight, and successful anglers (%).

Some reservoirs did not reported tournament data as of the date of this report (Table 19). For Caonillas 3 tournaments were reported, for Cidra 7, for Loiza 13, for Toa Vaca 1 and for Guayo 2. An average of only 2 largemouth bass per event were captured in the Loiza tournaments (CPUE LMB = 0.01) which was the most active reservoir (13 events). On the other hand, in Toa Vaca the Average LMB per event was 204 in only 1 event (LMB CPUE = 0.41). This reservoir was recently opened to celebrate fishing tournaments and it is of the great interest due to its remarkable largemouth bass population. Guayo reservoir presents a LMB CPUE = 0.25 with 2 events. As expected, Toa Vaca and Garzas reservoirs had LMB CPUE higher than the other reservoirs due to the great largemouth bass population in them.

Table 19. Tournament data reported in reservoirs monitored during Jul 2013-Dec 2014.

Reservoir	No. events reported	Effort (a/h)	Average anglers per event	Successful Anglers (%)	CPUE LMB	CPUE PKB	Average LMB per event	LMB Max. weight (kg)
Loiza	13	3386.5	24	57	0.01	0.14	2	2.39
Caonillas	3	1070	36	†	0.05	0.08	18	†
Cidra	7	2492	30	60	0.00	0.13	0.7	1.64
Toa Vaca	1	494.5	43	79	0.41	n/a	204	1.76

Guayo	2	429	20	85%	0.25	n/a	54	1.79
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† Data was not provided.

Discussion

Caonillas reservoir

In Caonillas, (9 fish species in 2013-2014 electrofishing) the dominant species were the invasive armored catfish (33.0% average relative abundance) and the red devil (33.0%). Largemouth bass average relative abundance was low (6.7%) although this reservoir was stocked with largemouth bass fingerlings several times during 2013-2014.

Cidra reservoir

In Cidra, eleven fish species in total were represented in the electrofishing samples. The dominant species was redbreast tilapia with 29.0% average relative abundance, followed by the peacock bass 27.33% and armored catfish (17.7%). Largemouth bass was 2.7% and apparently the abundant populations of threadfin shad and redbreast tilapia contribute to a very good largemouth bass condition (Wr averaging 99.5%).

Dos Bocas reservoir

Dos Bocas also presented a total of 11 fish species. The dominant species were the mozambique tilapia (23.3% Average Composition) and red devil (23.0% Average Composition). This last one is an undesirable invasive species. The firemouth cichlid was present at an average relative abundance of 4.7%. The guapote tigre was detected for the first time in this electrofishing period. Largemouth bass showed an average relative abundance of 1.3% (extremely low) and an excellent condition (Wr averaging 104%) probably due to the presence of forage species (threadfin shad and mosquito fish).

Loiza reservoir

Loiza reservoir presented a species diversity of 11 fish species. Similarly to Caonillas and Dos Bocas the sunfish species (*Lepomis spp.*) that were part of the fish species composition in the past were practically absent during 2014 samplings but only one individual was captured during S2 2013 sampling. The peacock bass, one of the favorite sport fish on the island, showed an average relative abundance of 16.3%. No largemouth bass were captured during the electrofishing period. The guapote tigre that was caught for the first time during electrofishing

sampling (2008), is still present in this reservoir. Similar to Cidra and Dos Bocas reservoir, Loiza has 3 top-level predators in its species composition; largemouth bass (*Micropterus salmoides*), peacock bass (*Cichla ocellaris*) and guapote tigre (*Parachromis managuensis*).

Carite reservoir

In Carite reservoir, a total of seven fish species were found. Historically, this reservoir had distinguished itself from almost all other reservoirs in Puerto Rico (except Patillas) by having 3 top-level predators (largemouth bass, peacock bass and bigmouth sleepers). Now, Cidra, Dos Bocas and Loiza reservoirs also have in their fish species, 3 top-level predators. In this case; largemouth bass, peacock bass and guapote tigre.

The most abundant fish species is the native bigmouth sleeper (26.0% average relative abundance) followed by largemouth bass (15.0%). 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 Bachelier et al. 2004, in Carite reservoir, recreational fishermen frequently target, catch, and consume bigmouth sleepers. In the past, this reservoir had had the three sunfish species present in Puerto Rico reservoirs (redear sunfish *Lepomis microlophus*, bluegill sunfish *Lepomis macrochirus* and redbreast sunfish *Lepomis auritus*). During this electrofishing sampling, only the redbreast sunfish was present (24.5% Average Composition). These three species have disappeared from reservoirs like Loiza and Caonillas where they were present in the past, coinciding with increasing abundance of red devil cichlids. However, in Carite reservoir no red devils were present.

Toa Vaca reservoir

Toa Vaca reservoir presented a low species richness compared with the others reservoirs sampled (7 fish species). On the other hand, it had great largemouth bass abundance (LMB CPUE 74 fish/hour for S2 2013 and LMB CPUE 67 fish/hour for S2 2014). This reservoir has not been stocked with largemouth bass since 2003. However, it had a healthy largemouth bass population with representation of all sizes (% Average Composition of 52) and good condition (Wr averaging = 95). Also the redear sunfish is very abundant (19% Average Composition) although has decreased since 2012-2013 (24%).

This reservoir is being considered for construction of a public boat ramp sponsored by DNER in order to promote sport fishing. An agreement to develop this project is in place. This reservoir keeps a tremendous largemouth bass population that should be available to all the sport

fishermen. At present, the Puerto Rico Aqueduct and Sewer Authority (PRASA) administers this reservoir and has ceded to PRDNER the authority and responsibility to conduct fishing tournaments

Guayabal reservoir

The 2014 electrofishing at Guayabal reservoir was represented by eleven species. The native shrimp “salpiche” *Xiphocaris elongata* and the native river goby *Awaous banana* were present in the electrofishing sampling. In this reservoir exists abundant forage species, therefore largemouth bass condition factor was excellent (Average LMB $W_r = 111.5$)

Garzas reservoir

Garzas presented the lowest species richness among the reservoirs sampled (5 fish species). Similar to Toa Vaca reservoir, the most abundant fish was the largemouth bass (63% Composition 93 individuals). This reservoir has not been stocked with largemouth bass since 2010. However, the largemouth bass natural reproduction is evident. The LMB condition factor was extremely low ($W_r=84$) probably due to the low fish diversity and the lack of shad.

Caño Tiburones lagoon

In Caño Tiburones lagoon only three fish species were captured during S2 2013. The most abundant species was the snook, which is a very attractive fish among salt water and estuarine recreational anglers. This lagoon was sampled because it is of great interest to recreational fisherman in Puerto Rico, and it allowed us to test the performance of the electrofishing boat in these waters which are at the upper limit of conductivity that the generator can handle.

Bass Tournaments

Bass tournaments are very important to obtain users' information related to their CPUE. They usually provide valuable feedback for our stocking regimes. Nevertheless, sometimes there is a mismatch between the CPUE from the electrofishing sampling and the fishermen's reported experience. This may reflect the need for better outreach with our stakeholders, since the lack of success in the tournaments is sometimes interpreted by anglers as a need to stock additional bass.

Recommendations

- In Cidra where there is a fishing Club and adequate facilities for the users, supplemental largemouth bass stocking should continue with high priority to maintain a quality sport fishery.
- In Dos Bocas is recommended to continue supplementing the largemouth bass population because it has adequate facilities for sport fishermen but natural recruitment problems.
- Carite presents a complex scenario where additional research may be required in order to formulate a specific management strategy. The main problem appears to be very poor primary productivity which is reflected in a paucity of forage species. All three top level predators, therefore, are limited in their abundance.
- In Toa Vaca, and Garzas where a healthy largemouth bass population exist, no largemouth bass stocking should be performed. Continued monitoring is recommended.
- In Garzas, forage species should be stocked and shad relocation should be performed in order to establish this species there. Garzas should be considered for construction of a public ramp. This reservoir has a tremendous largemouth bass population but access is restricted to the members of the fishing club.
- The presence of invasive fish species in the island's reservoirs has worsened. Some of these species are present in Loiza, Dos Bocas, Caonillas, Cidra, La Plata, Lucchetti, Patillas, Guayabal and Guajataca reservoirs and we expect their range to extend eventually to other reservoirs. It is recommended to investigate the impact of invasive species on fresh water habitat and sportfish populations. Aquatic Resources Educational Program (Project F-9) should continue to educate the public intensively about the problem of aquatic invasives and discourage the transfer of fish between reservoirs.
- The armored catfish was present in the nine reservoirs sampled in 2013-2014. Also we were informed that it was detected recently in Cerrillos reservoir. A small scale private fish culture station has been established upstream from this reservoir, and this may be the source. We know about the negative impact this species causes to the reservoir shoreline hence it is recommended to promote 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 performed by aquarium hobbyists discarding their pets without understanding the consequences of their actions (Williams et al., 1994). An intense educational campaign should be performed to the general public in order to educate about this important matter.

- The majority of the water bodies in the island are subject to illegal fishing. We recommend intensive vigilance by the DNER rangers. No positive management results are possible if the efforts to improve and sustain Puerto Rico's fresh water fisheries are not accompanied by law enforcement.
- The Maricao Fish Hatchery should continue to investigate techniques to produce larger fingerling largemouth bass for stocking, to increase survival in reservoirs with abundant predatory invasives.

Significant Deviations

The bad weather conditions, the low water level, mechanical problems with the pick-up vehicle and road reconstruction impeded us to perform the work plan as originally proposed. Changes were done to some reservoir stations and reservoirs were substituted by others.

Tournament data sometimes is incomplete due to the lack of cooperation from fishing clubs. Improving this is an on-going effort of this grant.

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APPENDIX

armored catfish	<i>Pterygoplichthys pardalis</i>
bigmouth sleeper	<i>Gobiomorus dormitor</i>
bluegill sunfish	<i>Lepomis macrochirus</i>
blue tilapia	<i>Tilapia aurea</i>
channel catfish	<i>Ictalurus punctatus</i>
convict cichlid	<i>Archocentrus nigrafasciatus</i>
firemouth cichlid	<i>Thorichthys meeki</i>
guapote tigre	<i>Parachromis managuensis</i>
horse-eye jack	<i>Caranx latus</i>
largemouth bass	<i>Micropterus salmoides</i>
mosquito fish	<i>Gambusia sp.</i>
mozambique tilapia	<i>Tilapia mossambica</i>
oscar	<i>Astronotus ocellatus</i>
peacock bass	<i>Cichla ocellaris</i>
redbreast sunfish	<i>Lepomis auritus</i>
redbreast tilapia	<i>Tilapia rendalli</i>
red devil	<i>Amphilophus spp.</i>
redeer sunfish	<i>Lepomis microlophus</i>
river goby	<i>Awaous banana</i>
snook	<i>Centropomus spp.</i>
striped mojarra	<i>Eugerres plumieri</i>
threadfin shad	<i>Dorosoma petenense</i>