Draft for Institutional Representative Review – Please Respond by 3 March 2023

Population Analysis & Breeding and Transfer Plan

West African Slender-snouted Crocodile (*Mecistops cataphractus*) AZA Species Survival Plan® Red Program

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26 January 2023

PMC Population Management Center

LINCOLN PARK ZOO. ASSOCIATION OF ZOOS & AQUARIUMS

San Diego Zoo Wildlife Alliance

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Acknowledgments

The West African Slender-snouted Crocodile SSP planning meeting was held at the San Diego Zoo and via online conferencing on 9 January 2023, attended by the following:

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Cover photo courtesy of: San Diego Zoo Wildlife Alliance

This plan was prepared and distributed with the assistance of the Planning Coordinator and Program Assistant at the AZA Population Management Center (pmc@lpzoo.org).

Description of Population Status

Species Survival Plan® for the West African Slender-snouted Crocodile (*Mecistops cataphractus)*

Introduction: The West African slender-snouted crocodile is a medium-sized crocodilian native to freshwater habitats in central and western Africa. Very little is known about this shy species and it is among the least known of all crocodilians. A recent assessment by the IUCN in 2014 listed slender-snouted crocodiles as "critically endangered", after an assessment in 1996 identified the species as "data deficient". Threats to the species include commercial skin hunting and the bushmeat trade, as well as habitat loss and fishing pressures. This current SSP population consists of 36 animals (22 males, 12 females, 2 unknown sex) distributed among 11 AZA facilities. The Crocodilian Taxon Advisory Group has set the target population size for this population to be 50 animals (2019 TAG Annual Report). Under AZA's current sustainability designations, this Program qualifies as a Red SSP (<50 formally managed animals; <90% gene diversity for 100 years). This is the third Breeding and Transfer Plan for this Program.

Analytical Assumptions and Exclusions: The pedigree of this population is 88.9% known before assumptions and exclusions. No assumptions were necessary to perform genetic analyses (Appendix A). Five individuals have been excluded from the potentially breeding population due to advanced age and unknown pedigree (Appendix C). Following exclusions, the potentially breeding population included 31 animals (19 males, 10 females, 2 unknown sex) with a pedigree that was 100% known and 100% certain (Appendix A).

Demography: Studbook records indicate that West African slender-snouted crocodiles were first held in AZA facilities as early as the 1940s, but the entire population prior to 1961 was comprised of only one individual. The population remained small in size (<10 animals) from 1961 through the mid-1980s, but has subsequently exhibited an overall trend of positive growth due to a combination of periodic imports and successful captive breeding (average λ 1984 – 2022 = 1.053; Figure 1). The first captive hatches occurred at Zoo Miami in 1982, and successful reproduction resulted in rapid growth for a decade between 1984 and 1994 at an average rate of 18% (average λ 1984 – 1994 = 1.18; Figure 1). This was followed by a period of slow decline between 1995 and 2009 at an average rate of -3.9% as there was no successful breeding for 15 years (average λ 1995 – 2009 = 0.96). This was due to a combination of factors including a shift in breeding facilities and presence of many younger animals that were not yet of reproductively age. The population was able to grow again after the importation of 14 animals and two successful clutches by a single pair in 2010, allowing the population to reach a peak of 44 animals in 2019. However, there has been no reproduction in the last three years as a result of space limitations among holding facilities (2020-2022). Due in part to the species' long lifespan and the acquisition of wild-caught imports in the 1980s and 1990s, there are still five wild-caught animals remaining in the population (Figure 1). Due an extreme paucity of demographic data for this population, growth rate projections from current life tables are largely uninformative (see Appendix D for sample sizes).

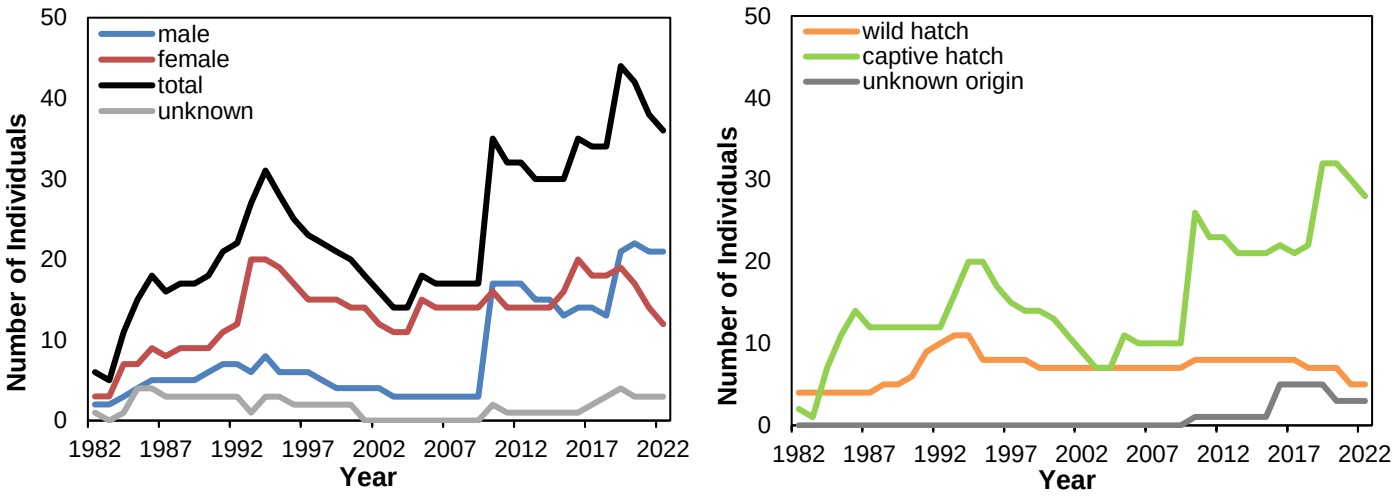

Figure 1. *Census of West African Slender-snouted Crocodile SSP from 1982 to 2022 by sex (left) and hatch type (right).*

Significant numbers of West African slender-snouted crocodiles have been held in captivity for a short period of time relative to their potential lifespan, and demographic data for this population may not yet accurately reflect biological parameters. To date, the oldest male recorded in the studbook is still living at ~62 years of age (SB# 5) and the oldest female is still living at ~89 years of age (SB# 3), however, it is important to note both individuals are wild-caught with estimated ages. Current life tables used for demographic analyses indicate first-year mortality is 19% for males and 33% for females, although these values are calculated from very small sample sizes (Appendix D). Both sexes likely reach sexual maturity at ~10–15 years of age, with females producing a single clutch of eggs per breeding season.

The age structure illustrates the number of males and females in each age class (Figure 2). The age structure of the West African slender-snouted crocodile population is very sparse with gaps in many age classes, which is a result of the population's small size and the species' long lifespan (Figure 2). A columnar age structure is common for a long-lived species such as this, so the lack of a traditional pyramidal-shaped structure is not a cause of immediate concern. If captive reproduction improves and the population can continue to grow with the addition of new holding space, a more robust age structure should begin to emerge. The sex ratio of the potential breeding population is skewed, with 1.83 males present for every female. A single clutch of nine eggs produced all males, which explains the male bias for age class three. Although slender-snouted crocodiles are polygamous, a highly skewed sex ratio could still limit breeding in captivity. Future imports should be focus on optimizing the sex ratio for the captive population and egg incubation temperatures may need to be manipulated, if and when possible, to produce individuals of a specific sex.

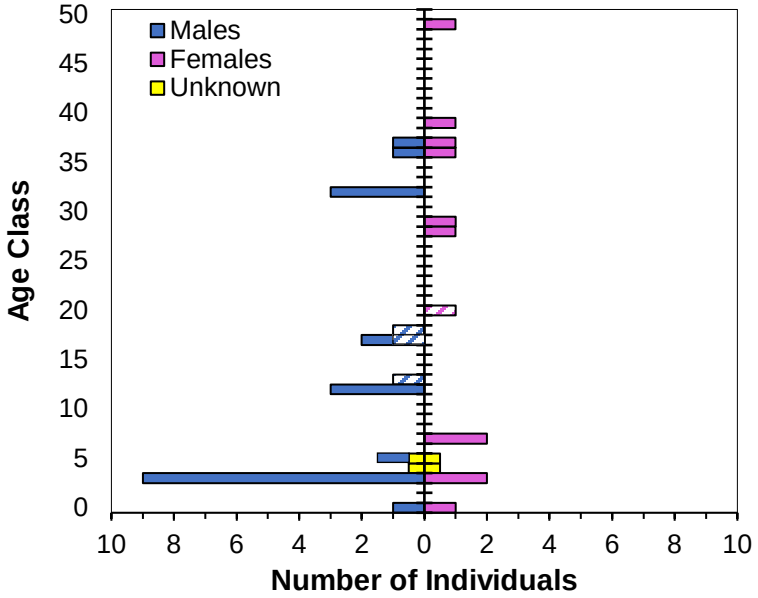

Figure 2. *Age distribution of the West African Slender-snouted Crocodile SSP for the total population, N= 36 (22.12.2).* Unknown sexes are equally distributed in yellow between males and females, and animals excluded from the potentially breeding population are represented by hash marks. One female 89 years of age is excluded from the figure.

Table 1: *Demographic status of SSP population, according to studbook.*

Demography Summary		
Current size of SSP population (N) – Total (Males.Females.Unknown Sex)	36 (22.12.2)	
Number of individuals excluded from breeding	5 (3.2.0)	
Breeding Population size following exclusions	31 (19.10.2)	
Target population size (Kt) *Crocodilian 2018 TAG Annual Report	50	
Mean generation time (T, years)	30.7	
Population growth rates (λ; lambda)*: Life Table / 5–year / Projected	0.983 / 1.011 / 0.944<>0.962<>0.979	
Percentage (%) of living population born/hatched ex situ	86%	
Survival/Mortality	**Males**	**Females**
Observed first year mortality rate (Q_x)	0.19	0.33
Median life expectancy (MLE), excluding first year mortalities (years) (from PopLink Survival Statistics Report (https://www.aza.org/species-survival-statistics)) *data were not of sufficient robustness to analyze	--	--
Observed maximum longevity (L_x) (Studbook ID # of individual) *both animals are wild-caught with estimated ages	62 (SB# 5)	89 (SB# 3)
Reproduction		
Observed reproductive age range *range represented by wild-caught animals with estimated ages	21 – 40	11 - 75
Incubation time	95 days	
Median clutch size hatched	2 (1-9)	

* Life table (AZA, 1999 – present); 5-year from studbook census; Projected from PMx stochastic 20 year projections

Genetics: The studbook pedigree indicates that analytical population of West African slender-snouted crocodile is descended from eight founders with one potential founder remaining (Figure 3). The mean kinship in the population is 0.1197. Half-siblings have a kinships of 0.125, which means that the average relationship across the population is just below that of second-order relatives. The gene diversity of the analytical population is 88.03%, which is equivalent to that found in approximately four founders (FGE = 4.18). Typical AZA program goals include thresholds for tolerance of gene diversity loss over time; 90% gene diversity retention for 100 years is a common management goal. Decreases in gene diversity below 90% of that in the founding population have been associated with reproduction increasingly compromised by, among other factors, lower hatch weights, smaller clutch sizes, and greater hatchling mortality in some species. Gene diversity in the analytical West African Slender-snouted Crocodile population is below the diversity threshold thought to confer genetic vigor. Long-term gene diversity projections were deemed uninformative due to a lack of accurate generation length and projected growth rate. As more demographic data are available to estimate these parameters, gene diversity projections will be included in future Breeding and Transfer Plans.

The best genetic management strategy to maximize a population's long-term gene diversity retention is typically managed breeding targeted at equalizing founder representations by breeding animals with low and well-matched mean kinships. Founder representations in the West African slender-snouted crocodile population are currently skewed; more equal representations would retain more gene diversity (Figure 3). The eight founders represent four of the breeding pairs that have successfully produced offspring: M5 x F3, M11 x F12, M7 x F39, and M26 x F25. The representations of M26 x F25 are notably more over-represented due to the production of more offspring. The population's potential gene diversity is much greater at 93.48% due to the under-represented founder lineages. Thus, particular priority is being placed on breeding animals with low mean kinships (representative of under-represented founders) and the one remaining potential founder. Furthermore, there is one potential founder remaining in the population (SB# 18). If more equal founder representations can be achieved and the potential founder can be recruited by producing surviving offspring, some of the potential gene diversity in the population can be realized and current gene diversity would rise. However, because genetic management must be balanced against demographic goals, some animals with low mean kinships may not receive breeding recommendations so as to not exceed the carrying capacity of the population.

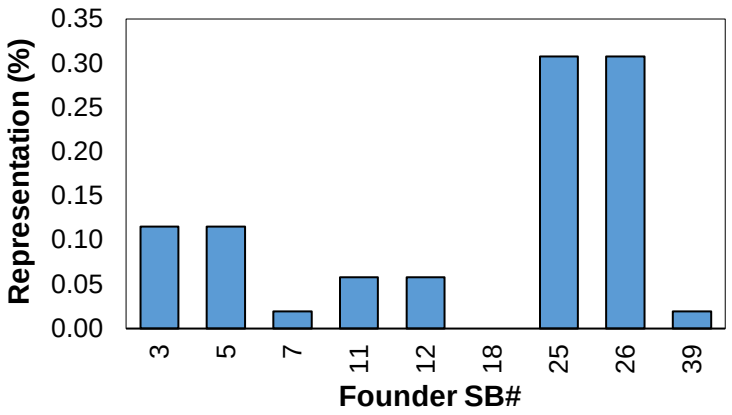

Figure 3. *Founder representation distribution of the analytical West African Slender-snouted Crocodile population.*

Table 2: *Population size, genetic status, and projections for the West African Slender-snouted Crocodile SSP population.*

Genetics Summary*				
	*2016***	*2020***	**2022**	**Potential**
Founders	*9*	*9*	8	1
Founder genome equivalents (FGE)	*6.31*	*4.38*	4.18	7.67
Gene diversity (GD %)	*92.07*	*88.58*	88.03	93.49
Population mean kinship (MK)	*0.0793*	*0.1142*	0.1197	--
Mean inbreeding (F)	*0.0000*	*0.0000*	0.0000	--
Effective population size (N_e/N)	*0.09* ‡	*0.13* ‡	0.1548‡	--
Percentage of pedigree known before / after assumptions and exclusions	*82 / 94*	*95 / 100*	88.9 / 100	--
Percentage pedigree certain after assumptions and exclusions	*84*	*94*	100	--
Projections†				
Years to 90% gene diversity	--	--	--	--
Years to 10% loss of gene diversity	--	--	--	--
Gene diversity at 100 Years (%)	--	--	--	--
Gene diversity in 10 Generations (%)	--	--		
Parameters for analysis: growth rate (λ), target size (Kt), generation length (T), starting population size (n)			--	--

*Genetic statistics may not be comparable across years due to changes in software and parameters used for projections from year to year.
**Pedigree assumptions were created for this population and may over- or under-estimate genetic statistics shown in this table.
‡ includes founders
† projections uninformative due to a lack of accurate generation length and projected growth rate

Recommendation Outcomes: The website PMCTrack calculates the outcomes fo SSP recommendations by comparing Breeding and Transfer Plan recommendations to births/hatches and transfers recorded in the studbook (Figure 4). There are many reasons that recommendations might not be fulfilled, including interim recommendations issued by the SSP Coordinator; these reasons can be captured using PMCTrack Outcomes Surveys. Note that starting in 2022, SSP Coordinators directly add interim recommendations to PMCTrack to improve the accuracy of recommendation outcomes. The fulfillment rates of any plan that had outcomes calculated in 2022 or after may reflect inclusion of these interim rates; in the graph, this may include the last plan before 2022, such as a 2021 plan, plus any plans with a date of 2022 or after.

Of the recommendations proprosed in the 2020 Breeding and Transfer Plan, 0% of the BREED WITH recommendations and 0% of the SEND TO recommendations were fulfilled as requested by 01/09/22. SSP participants are always encouraged to attempt to fulfill recommendations and communicate sucesses and challenges to the SSP Coordinator.

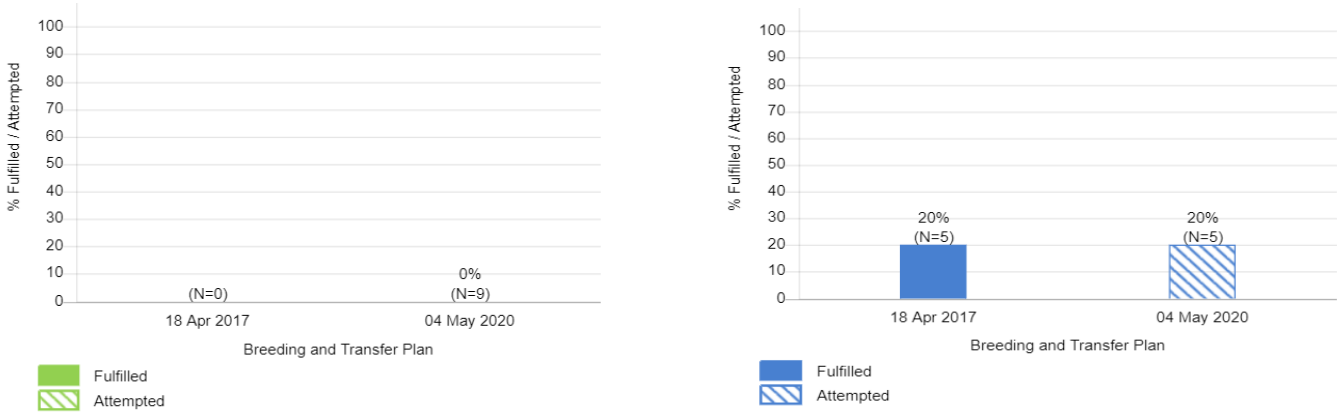

Figure 4. Recommendation outcomes by transfers (left) and breeding (right) for the past West African Slender-snouted Crocodile SSP Breeding and Transfer Plans. *N* represents the number of recommendations scored for each recommendation type, per plan, and the number represents the percentage recommendations fulfilled. Please visit PMCTrack.org or contact pmctrack@lpzoo.org for more information or with any questions.

Management Strategies: The current SSP population consists of 36 animals (22 males, 12 females, 2 unknown sex) distributed among 11 AZA facilities. Demographic analyses based on current life tables (Appendix D) indicate that approximately 2 hatches are needed over the next three years to maintain the population at its current size. If the population could grow at a growth rate of 5% per year ($\lambda = 1.05$), then ~9 hatches are needed over the next three years (3 hatches per year) for the population to reach a population size of 41 animals, or to reach the TAG-recommended target size of 50 animals in approximately seven years. The population averaged 3 hatches per year in the last five years (2018-2022), indicating that recent reproduction is sufficient to both maintain the population at its current size and to slowly grow the population towards the target size in a relatively short timeframe.

Gene diversity in the analytical population is 88.03%, which is below the 90% threshold commonly thought to represent genetic vigor. Gene diversity projections were not performed due to the uncertainty surrounding projection parameters. As more demographic data are available to inform genetic projections, additional recommendations for future genetic management will be included in future Breeding and Transfer Plans. The population has the potential to improve current gene diversity to 93.49% through careful management that prioritizes individuals from under-represented founder lineages (low mean kinship), and by recruiting the one remaining potential founder. Increasing the starting population size and target population size as well as the proportion of the population that is successfully producing offspring (Ne/N) can also improve long-term gene diversity retention. Establishing more consistent reproduction, both across facilities and individuals should also be a priority, as reproduction is currently occurring at only two facilities.

At this time, the number of breeding recommendations is intended to slowly grow the population towards the TAG target size of 50 animals. Particularly priority is being placed on breeding animals with low mean kinships (representative of under-represented founders) and the one potential founder to support long-term gene diversity retention across the population. As with most AZA-managed programs, breeding recommendations also aim to limit inbreeding and minimize differences between sire and dam kinships.

This is a 3-year plan (2023-2025). Interim recommendations will continue to be made as needed until another full set of recommendations are produced. Please promptly report any hatches or deaths to the Program Coordinator, so that interim recommendations can be based on accurate population data. Recommendations contained in this plan supersede all previous recommendations.

Table 3: *Historic reproduction and future population goals.*

Current Reproductive Goals Summary		
	Number of Hatches Needed per Year over the next 3 Years	**Target Population Size**
To maintain current population size (λ = 1.00)	1	36
To grow to the RCP target population size in 7 years (Kt = 50; λ = 1.05)	3	50
Reproductive Goals Summary from the Last BTP (2020)		
Number of females recommended to breed	5	
Number of hatches since then (5/4/20 – 1/9/23)	0	
Average Number of Births/Hatches in the SSP Population		
Average number of hatches per year, from the past five years (range)	3 (0 – 14)	

At this time, the SSP:

1. **Recommends 5 females to breed at 4 facilities.** Two of the five females have previously bred. All females recommended to breed are under-represented in the population.
    - Please contact the SSP Coordinator after each pair produces one surviving clutch before attempting to breed again.

2. **Recommends 8 transfers to establish new breeding pairs and meet institutional needs.** Three of the 8 transfers are intended to establish new breeding pairs. One facility will be lost as a result of these transfers.

3. **Requests institutions record egg incubation temperature.** The SSP would like to gather a robust dataset to assess temperature-dependent sex determination in this species. Please record egg incubation temperatures and provide the information to the SSP Coordinator.

4. **Requests institutions allow for parent-rearing to encourage learned parenting behavior in offspring.** Parent-reared offspring that experience one to two breeding seasons with their parents learn parenting behavior that may improve offspring survival in the population.

5. **The SSP is coordinating with EAZA's West African Slender-snouted Crocodile EEP.** The SSP has plans to provide the EEP with unrelated animals that would benefit their population. There is also the potential to bring unrelated animals into the SSP from EAZA to improve gene diversity of the SSP population. The SSP Coordinator is currently in the process of facilitating this exchange of animalsThe.

Breeding and Transfer Recommendations by Facility

ABQBIOPK (previously RIO GRAND)
Albuquerque Biological Park
Albuquerque, NM

Facility notes: The SSP will lose this facility as a result of this transfer.

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
12	R15059	F	49	SEND TO	SANDIEGOZ	BREED WITH	36	

ATLANTA
Zoo Atlanta
Atlanta, GA

Facility notes: Please contact the SSP Coordinator when you begin to see signs of incompatible behavior between your two males. When that time comes, an interim transfer recommendation will be made.

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
81	18R001	M	12	HOLD	ATLANTA	DO NOT BREED		
82	18R002	M	12	HOLD	ATLANTA	DO NOT BREED		

BALTIMORE
Maryland Zoo in Baltimore
Baltimore, MD

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
72	9324	M	17	SEND TO	ST AUGUST	BREED WITH	18, 70	
91	A15148	F	7	RECEIVE FROM	ST AUGUST	DO NOT BREED		

BUSCH TAM
Busch Gardens Tampa Bay
Tampa, FL

Facility notes: F61 can breed with either M40 or M41; however, M40 is more genetically valuable.

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
40	A14006	M	32	HOLD	BUSCH TAM	BREED WITH	61	
41	65632	M	32	HOLD	BUSCH TAM	BREED WITH	61	
61	65786	F	29	HOLD	BUSCH TAM	BREED WITH	40 or 41	
98	66187	U	5	SEND TO	ST AUGUST	DO NOT BREED		
99	101005	U	4	SEND TO	ST AUGUST	DO NOT BREED		
118	96614	M	5	SEND TO	SANDIEGOZ	DO NOT BREED		

MEMPHIS

Memphis Zoo
Memphis, TN

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
74	18H018	M	12	HOLD	MEMPHIS	DO NOT BREED		

METROZOO

Zoo Miami
Miami, FL

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
3	H00002	F	89	HOLD	METROZOO	DO NOT BREED		excluded

OCEAN VAL

Oceanografic Valencia
Valenica, Spain

Facility notes: You can breed your animals at your discretion, while considering your holding capacity and institutional needs. Please contact the SSP Coordinator if you need assistance placing offspring.

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
112	208113990239139	F	20	HOLD	OCEAN VAL	SEE NOTES		excluded
114	968000003947279	M	17	HOLD	OCEAN VAL	SEE NOTES		excluded

PORTLAND

Oregon Zoo
Portland, OR

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
32	91042	F	36	HOLD	PORTLAND	BREED WITH	42	
42	R00518	M	32	RECEIVE FROM	WACO	BREED WITH	32	

SANDIEGOZ

San Diego Zoo
San Diego, CA

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
12	R15059	F	49	RECEIVE FROM	ABQBIOPK	BREED WITH	36	
36	916043	M	36	HOLD	SANDIEGOZ	BREED WITH	12	
118	96614	M	5	RECEIVE FROM	BUSCH TAM	DO NOT BREED		

ST AUGUST

St. Augustine Alligator Farm
St. Augustine, FL

Facility notes: Prolific pair M26 x F25 is not recommended to breed due to their over-representation; any offspring produced will be considered non-essential to the SSP. Current male offspring produced from this pair may be placed outside the SSP at institutional discretion (M101, M103, M104, M105, M106, M107, M108, M109, M110). Please contact the SSP Coordinator about the possibility of sending some of these males to Europe to support EAZA's EEP.

An interim breeding recommendation will be provided for SB# 98 and 99 when their sexes are determined.

Please contact the SSP Coordinator to facilitate the transfer of genetically compatible animals from outside the SSP for more breeding opportunities at your facility.

F18 is a potential founder and a high priority for breeding.

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
18	91270	F	39	HOLD	ST AUGUST	BREED WITH	72	potential founder
25	91272	F	37	HOLD	ST AUGUST	DO NOT BREED		
26	91271	M	37	HOLD	ST AUGUST	DO NOT BREED		
70	96015	F	28	HOLD	ST AUGUST	BREED WITH	72	
72	9324	M	17	RECEIVE FROM	BALTIMORE	BREED WITH	18, 70	
84	A13007	M	13	HOLD	ST AUGUST	DO NOT BREED		excluded
91	A15148	F	7	SEND TO	BALTIMORE	DO NOT BREED		
93	A15190	F	7	SEND TO	WACO	DO NOT BREED		
94	A10035	M	18	HOLD	ST AUGUST	DO NOT BREED		excluded
98	66187	U	5	RECEIVE FROM	BUSCH TAM	DO NOT BREED		SEE NOTES
99	101005	U	4	RECEIVE FROM	BUSCH TAM	DO NOT BREED		SEE NOTES
100	A19013	F	3	HOLD	ST AUGUST	DO NOT BREED		
101	A19014	M	3	HOLD	ST AUGUST	DO NOT BREED		SEE NOTES
102	A19015	F	3	HOLD	ST AUGUST	DO NOT BREED		
103	A19016	M	3	HOLD	ST AUGUST	DO NOT BREED		SEE NOTES
104	A19017	M	3	HOLD	ST AUGUST	DO NOT BREED		SEE NOTES
105	A19018	M	3	HOLD	ST AUGUST	DO NOT BREED		SEE NOTES
106	A19019	M	3	HOLD	ST AUGUST	DO NOT BREED		SEE NOTES
107	A19021	M	3	HOLD	ST AUGUST	DO NOT BREED		SEE NOTES
108	A19022	M	3	HOLD	ST AUGUST	DO NOT BREED		SEE NOTES
109	A19023	M	3	HOLD	ST AUGUST	DO NOT BREED		SEE NOTES
110	A19024	M	3	HOLD	ST AUGUST	DO NOT BREED		SEE NOTES

WACO

Cameron Park Zoo
Waco, TX

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
42	R00518	M	32	SEND TO	PORTLAND	BREED WITH	32	
93	A15190	F	7	RECEIVE FROM	ST AUGUST	DO NOT BREED		

Appendices

A. Analytical Assumptions

No assumptions were necessary for this plan.

B. Summary of Data Exports

Studbook Name	West African Slender-snouted Crocodile
Studbook Currentness Date	11/30/2022
Studbook Software and version #	ZIMS for Studbooks v 3.0
Overlay Name (if applicable)	N/A
PMx version #	1.6.5.20220911
.fed file	N/A
Descriptive Survival Statistics Report	Report is archived with PMC/AZA and Median Life Expectancy can be viewed here: https://www.aza.org/species-survival-statistics

PMx Project: CrocodileWASlenderSnouted_SSP_20220104
Created: 2022-01-04

Studbook information:
Data compiled by: Kim Gray
Scope of data: AZA Regional

Primary data file:
zims.zims
Filter conditions:
Dates: 1999-01-01 to 2022-01-04
Association: AZA

Moves data files:
genetic.csv
demographic.csv
Filter conditions:
Dates: 1999-01-01 to 2022-01-04
Association: AZA

Census data file:
Exchcens.txt
Filter conditions:
Dates: annual census taken on 12/31
Association: AZA

PMx Analysis Notes: SB# 44 was removed from the demographic and genetic analyses in PMx for being held at a non-AZA facility. SB# 118 was directly added to the PMx project. Hatches throughout the year were set to seasonal.

There are 0 hatches to parents with unknown ages that have been added in proportion to known aged parents. This is 0% of TOTAL hatches (N=29).

Sustainability Partners: none

C. Animals Excluded from Genetic Analyses

ID	Location	Sex	Age	Reason for Exclusion
3	METROZOO	F	89	advanced age
84	ST AUGUST	M	13	unknown pedigree
94	ST AUGUST	M	18	unknown pedigree
112	OCEAN VAL	F	20	unknown pedigree
114	OCEAN VAL	M	17	unknown pedigree

D. Life Tables

Px = survival; Qx = mortality; Lx = cumulative survivorship; Mx = fecundity; Ex = life expectancy; Vx = expected future reproduction, At Risk (Qx and Mx) = number of animals corresponding values are estimated from.

Ex not calculated because oldest female (SB# 3) in demographic selection is still living. Qx changed to 1.0 for female age class 56 for all analyses, with no notable impact.

MALES											
Age	**Px**	**Mid Px**	**Qx**	**Risk Qx**	**Lx**	**Mid Lx**	**Mx**	**Risk Mx**	**Ex**	**Vx**	**Cx**
0	0.811	0.896	0.189	16.621	1.000	0.905	0.000	16.621	16.252	1.000	0.055
1	1.000	1.000	0.000	18.121	0.811	0.811	0.000	18.121	18.811	1.224	0.045
2	1.000	1.000	0.000	18.838	0.811	0.811	0.000	18.838	17.811	1.215	0.045
3	1.000	1.000	0.000	14.408	0.811	0.811	0.000	14.408	16.811	1.206	0.045
4	1.000	1.000	0.000	9.534	0.811	0.811	0.000	9.534	15.811	1.197	0.046
5	1.000	0.917	0.000	8.501	0.811	0.811	0.000	8.501	14.811	1.188	0.046
6	0.833	0.879	0.167	8.127	0.811	0.743	0.000	8.127	13.811	1.179	0.046
7	0.933	0.784	0.067	7.233	0.676	0.653	0.000	7.233	15.373	1.404	0.039
8	0.625	0.692	0.375	6.082	0.631	0.512	0.000	6.082	15.400	1.493	0.037
9	0.800	0.889	0.200	4.219	0.394	0.355	0.000	4.219	23.040	2.371	0.023
10	1.000	1.000	0.000	5.170	0.315	0.315	0.000	5.170	27.550	2.942	0.019
11	1.000	1.000	0.000	6.000	0.315	0.315	0.000	6.000	26.550	2.920	0.019
12	1.000	1.000	0.000	4.068	0.315	0.315	0.000	4.068	25.550	2.898	0.019
13	1.000	1.000	0.000	3.315	0.315	0.315	0.000	3.315	24.550	2.877	0.019
14	1.000	1.000	0.000	4.000	0.315	0.315	0.000	4.000	23.550	2.855	0.019
15	1.000	1.000	0.000	4.721	0.315	0.315	0.000	4.721	22.550	2.834	0.019
16	1.000	1.000	0.000	5.000	0.315	0.315	0.000	5.000	21.550	2.813	0.019
17	1.000	1.000	0.000	3.556	0.315	0.315	0.000	3.556	20.550	2.792	0.020
18	1.000	1.000	0.000	1.170	0.315	0.315	0.000	1.170	19.550	2.771	0.020
19	1.000	1.000	0.000	2.364	0.315	0.315	0.000	2.364	18.550	2.750	0.020
20	1.000	1.000	0.000	6.229	0.315	0.315	0.000	6.229	17.550	2.729	0.020
21	1.000	1.000	0.000	6.500	0.315	0.315	0.000	6.500	16.550	2.709	0.020
22	1.000	0.923	0.000	6.500	0.315	0.315	0.000	6.500	15.550	2.689	0.020
23	0.846	0.917	0.154	5.648	0.315	0.291	0.000	5.648	14.550	2.669	0.021
24	1.000	1.000	0.000	5.500	0.267	0.267	0.000	5.500	16.013	3.130	0.018
25	1.000	1.000	0.000	5.500	0.267	0.267	0.818	5.500	15.013	3.107	0.018
26	1.000	1.000	0.000	5.500	0.267	0.267	0.000	5.500	14.013	2.272	0.018
27	1.000	1.000	0.000	5.500	0.267	0.267	0.091	5.500	13.013	2.255	0.018
28	1.000	1.000	0.000	5.500	0.267	0.267	0.091	5.500	12.013	2.147	0.018
29	1.000	0.876	0.000	6.415	0.267	0.267	0.182	6.415	11.013	2.041	0.018
30	0.751	0.858	0.249	6.736	0.267	0.234	0.297	6.736	10.013	1.845	0.018
31	1.000	1.000	0.000	6.500	0.200	0.200	0.000	6.500	12.000	2.046	0.014
32	1.000	1.000	0.000	4.068	0.200	0.200	0.000	4.068	11.000	2.030	0.014
33	1.000	1.000	0.000	3.000	0.200	0.200	0.000	3.000	10.000	2.015	0.014
34	1.000	1.000	0.000	3.000	0.200	0.200	2.000	3.000	9.000	2.000	0.014
35	1.000	1.000	0.000	3.000	0.200	0.200	0.000	3.000	8.000	0.000	0.014
36	1.000	1.000	0.000	2.296	0.200	0.200	0.000	2.296	7.000	0.000	0.014
37	1.000	1.000	0.000	1.622	0.200	0.200	0.000	1.622	6.000	0.000	0.014
38	1.000	1.000	0.000	1.000	0.200	0.200	0.000	1.000	5.000	0.000	0.015
39	1.000	1.000	0.000	1.000	0.200	0.200	0.000	1.000	4.000	0.000	0.015
40	1.000	1.000	0.000	1.000	0.200	0.200	0.000	1.000	3.000	0.000	0.015
41	1.000	0.500	0.000	1.000	0.200	0.200	0.000	1.000	2.000	0.000	0.015

FEMALES											
Age	**Px**	**Mid Px**	**Qx**	**Risk Qx**	**Lx**	**Mid Lx**	**Mx**	**Risk Mx**	**Ex**	**Vx**	**Cx**
0	0.667	0.800	0.333	8.144	1.000	0.833	0.000	8.144	---	1.000	0.013
1	1.000	1.000	0.000	8.121	0.667	0.667	0.000	8.121	---	1.462	0.009
2	1.000	1.000	0.000	8.000	0.667	0.667	0.000	8.000	---	1.424	0.009
3	1.000	1.000	0.000	6.816	0.667	0.667	0.000	6.816	---	1.388	0.009
4	1.000	0.969	0.000	9.129	0.667	0.667	0.000	9.129	---	1.352	0.009
5	0.938	0.919	0.062	13.419	0.667	0.646	0.000	13.419	---	1.318	0.010
6	0.900	0.888	0.100	14.382	0.625	0.594	0.000	14.382	---	1.369	0.009
7	0.875	0.887	0.125	11.677	0.563	0.527	0.000	11.677	---	1.483	0.008
8	0.900	0.895	0.100	9.981	0.492	0.468	0.000	9.981	---	1.650	0.008
9	0.889	0.874	0.111	8.299	0.443	0.419	0.000	8.299	---	1.787	0.007
10	0.857	0.846	0.143	6.921	0.394	0.366	0.000	6.921	---	1.959	0.006
11	0.833	0.909	0.167	6.362	0.338	0.310	0.000	6.362	---	2.226	0.006
12	1.000	1.000	0.000	9.715	0.281	0.281	0.000	9.715	---	2.603	0.005
13	1.000	1.000	0.000	12.041	0.281	0.281	0.000	12.041	---	2.537	0.005
14	1.000	0.967	0.000	14.000	0.281	0.281	0.000	14.000	---	2.472	0.005
15	0.933	0.966	0.067	14.227	0.281	0.272	0.000	14.227	---	2.408	0.005
16	1.000	0.958	0.000	14.000	0.263	0.263	0.000	14.000	---	2.514	0.005
17	0.917	0.957	0.083	12.795	0.263	0.252	0.000	12.795	---	2.450	0.005
18	1.000	1.000	0.000	10.197	0.241	0.241	0.000	10.197	---	2.604	0.005
19	1.000	1.000	0.000	10.162	0.241	0.241	0.000	10.162	---	2.538	0.005
20	1.000	1.000	0.000	10.533	0.241	0.241	0.000	10.533	---	2.473	0.005
21	1.000	1.000	0.000	10.500	0.241	0.241	0.000	10.500	---	2.409	0.005
22	1.000	0.952	0.000	10.500	0.241	0.241	0.000	10.500	---	2.348	0.005
23	0.905	0.900	0.095	10.445	0.241	0.229	0.000	10.445	---	2.288	0.005
24	0.895	0.944	0.105	9.089	0.218	0.206	0.053	9.089	---	2.464	0.005
25	1.000	1.000	0.000	8.840	0.195	0.195	0.588	8.840	---	2.626	0.005
26	1.000	1.000	0.000	9.500	0.195	0.195	0.105	9.500	---	1.985	0.005
27	1.000	1.000	0.000	9.500	0.195	0.195	0.000	9.500	---	1.832	0.005
28	1.000	1.000	0.000	8.215	0.195	0.195	0.000	8.215	---	1.785	0.005
29	1.000	1.000	0.000	5.925	0.195	0.195	0.000	5.925	---	1.739	0.005
30	1.000	1.000	0.000	5.500	0.195	0.195	0.364	5.500	---	1.695	0.005
31	1.000	1.000	0.000	5.500	0.195	0.195	0.000	5.500	---	1.297	0.005
32	1.000	1.000	0.000	5.140	0.195	0.195	0.000	5.140	---	1.264	0.006
33	1.000	1.000	0.000	5.000	0.195	0.195	0.000	5.000	---	1.232	0.006
34	1.000	1.000	0.000	5.000	0.195	0.195	1.200	5.000	---	1.200	0.006
35	1.000	1.000	0.000	5.000	0.195	0.195	0.000	5.000	---	0.000	0.006
36	1.000	1.000	0.000	4.312	0.195	0.195	0.000	4.312	---	0.000	0.006
37	1.000	1.000	0.000	3.622	0.195	0.195	0.000	3.622	---	0.000	0.006
38	1.000	1.000	0.000	3.000	0.195	0.195	0.000	3.000	---	0.000	0.007
39	1.000	1.000	0.000	2.041	0.195	0.195	0.000	2.041	---	0.000	0.007
40	1.000	1.000	0.000	2.000	0.195	0.195	0.000	2.000	---	0.000	0.007
41	1.000	1.000	0.000	2.000	0.195	0.195	0.000	2.000	---	0.000	0.007
42	1.000	1.000	0.000	1.595	0.195	0.195	0.000	1.595	---	0.000	0.007
43	1.000	1.000	0.000	1.000	0.195	0.195	0.000	1.000	---	0.000	0.007
44	1.000	1.000	0.000	1.000	0.195	0.195	0.000	1.000	---	0.000	0.008
45	1.000	1.000	0.000	1.000	0.195	0.195	0.000	1.000	---	0.000	0.008
46	1.000	1.000	0.000	1.000	0.195	0.195	0.000	1.000	---	0.000	0.008
47	1.000	1.000	0.000	1.000	0.195	0.195	0.000	1.000	---	0.000	0.008
48	1.000	1.000	0.000	1.000	0.195	0.195	0.000	1.000	---	0.000	0.008
49	1.000	1.000	0.000	0.688	0.195	0.195	0.000	0.688	---	0.000	0.009
50	1.000	1.000	0.000	0.000	0.195	0.195	0.000	0.000	---	0.000	0.009
51	1.000	1.000	0.000	0.000	0.195	0.195	0.000	0.000	---	0.000	0.009
52	1.000	1.000	0.000	0.000	0.195	0.195	0.000	0.000	---	0.000	0.009
53	1.000	1.000	0.000	0.000	0.195	0.195	0.000	0.000	---	0.000	0.010
54	1.000	1.000	0.000	0.000	0.195	0.195	0.000	0.000	---	0.000	0.010
55	1.000	1.000	0.000	0.000	0.195	0.195	0.000	0.000	---	0.000	0.010
56	0.667	0.800	0.333	8.144	1.000	0.833	0.000	8.144	---	1.000	0.013

E. Ordered Mean Kinship List

These lists are current to January 2023 and values are subject to change with any birth/hatch, death, import, export, inclusion, exclusion, or changes in pedigree or pedigree assumptions. Unknown sexed animals appear on both the male and female side of the mean kinship list and are designated by a 'U' after the studbook ID.

Population MK = 0.1197

Males

ID	MK	Known	Age	Location
72	0.0185	100	17	BALTIMORE
42	0.0417	100	32	WACO
36	0.0694	100	36	SANDIEGOZ
40	0.0694	100	32	BUSCH TAM
118	0.0787	100	5	BUSCH TAM
98U	0.0787	100	5	BUSCH TAM
99U	0.0787	100	4	BUSCH TAM
41	0.0833	100	32	BUSCH TAM
26	0.1481	100	37	ST AUGUST
74	0.1574	100	12	MEMPHIS
81	0.1574	100	12	ATLANTA
82	0.1574	100	12	ATLANTA
101	0.1574	100	3	ST AUGUST
103	0.1574	100	3	ST AUGUST
104	0.1574	100	3	ST AUGUST
105	0.1574	100	3	ST AUGUST
106	0.1574	100	3	ST AUGUST
107	0.1574	100	3	ST AUGUST
108	0.1574	100	3	ST AUGUST
109	0.1574	100	3	ST AUGUST
110	0.1574	100	3	ST AUGUST

Females

ID	MK	Known	Age	Location
18	0	100	39	ST AUGUST
12	0.0324	100	49	ABQBIOPK
61	0.0556	100	29	BUSCH TAM
32	0.0694	100	36	PORTLAND
70	0.0694	100	28	ST AUGUST
98U	0.0787	100	5	BUSCH TAM
99U	0.0787	100	4	BUSCH TAM
25	0.1481	100	37	ST AUGUST
91	0.1574	100	7	ST AUGUST
93	0.1574	100	7	ST AUGUST
100	0.1574	100	3	ST AUGUST
102	0.1574	100	3	ST AUGUST

F. Definitions

Management Terms (as of December 2021)

Green Species Survival Plan® (Green SSP) Program – A Green SSP Program has a population size of 50 or more animals and is projected to retain 90% gene diversity for a minimum of 100 years or 10 generations. Green SSP Programs are subject to AZA's Full Participation and Sustainability Partner Policies.

Yellow Species Survival Plan® (Yellow SSP) Program – A Yellow SSP Program has a population size of 50 or more animals but cannot retain 90% gene diversity for 100 years or 10 generations. Yellow SSP participation by AZA facilities is voluntary. Yellow SSP Programs are subject to AZA's Sustainability Partner Policy.

Red Species Survival Plan® (Red SSP) Program – A Red SSP Program has a population size of twenty or more animals managed among three or more participating AZA facilities. If a population does not meet these minimum criteria, but has an IUCN designation of Critically Endangered, Endangered, or Extinct in the Wild, and the TAG has developed three goals to sustain this population, then the population will be considered a Red SSP Program. Red SSPs cannot retain 90% gene diversity for 100 years or 10 generations and participation by AZA facilities is voluntary. Red SSP Programs are subject to AZA's Sustainability Partner Policy.

Candidate Program – A Candidate Program either has a population size of fewer than twenty individuals and/or found at fewer than three AZA facilities or it does not yet have a completed studbook so the population size is unclear. A Candidate Program is overseen by the TAG, with no additional AZA accountability requirements.

Sustainability Partners – AZA Animal Population Management (APM) Committee approved wildlife facilities that regularly exchange animals with AZA-accredited facilities and certified related facilities, typically as part of the Species Survival Plan® (SSP) Program Breeding and Transfer Plan or other SSP Program management process.

Full Participation – AZA policy stating that all AZA accredited facilities and certified related facilities having a Green SSP animal in their collection are required to participate in the collaborative SSP planning process (e.g., provide relevant animal data to the AZA Studbook Keeper, assign an Institutional Representative who will communicate facility wants and needs to the SSP Coordinator and comment on the draft plan during the 30-day review period, and abide by the recommendations agreed upon in the final plan).

All AZA member facilities and Animal Programs, regardless of management designation, must adhere to the AZA Policy on Responsible Population Management and the AZA Code of Professional Ethics. For more information on AZA policies, see https://www.aza.org/board-approved-policies-and-position-statements.

Currentness Date – The date when the entire studbook is updated. This equates to the first date you received an update after requesting updates from all the facilities included in your studbook.

Demographic Terms

Age Distribution – A visual representation of the numbers or percentages of individuals in various age and sex classes.

Ex, Life Expectancy – The average years of further life for an animal in age class x.

Lambda (λ) or Population Growth Rate – The proportional change in population size from one year to the next. A lambda of 1.11 means an 11% per year increase; a lambda of 0.97 means a 3% decline in size per year. The three lambdas highlighted in this BTP are: 1) Life Table, from the PMx life tables, the change in the population based on the demographic regional and date window exported from the studbook, the life table lambda is the rate at which the population would be expected to grow (in the future) given the birth and death rates reported in the life tables and assuming a stable age distribution (does NOT factor in imports or exports); 2) 5-year, from the studbook census, the 5-year lambda is calculated from observed changes in population size over the last 5 years and includes births, deaths, imports and exports; and 3) Projected, from the PMx stochastic 20-year projections (includes confidence intervals), models how the population is predicted to grow or decline over the next 20 years given the birth and death rates from the life tables and the age structure of the current population.

lx, Age-Specific Survivorship – The probability that a new individual (e.g., age 0) is alive at the *beginning* of age *x*. Alternatively, the proportion of individuals which survive from birth to the beginning of a specific age class.

Mean Generation Time (T) – The average time elapsing from reproduction in one generation to the time the next generation reproduces. Also, the average age at which a female (or male) produces offspring. It is not the age of first reproduction. Males and females often have different generation times.

Median Life Expectancy (MLE) – The 'typical' age at which an average animal is expected to live; 50% will die before the median life expectancy and 50% die after. The MLE reported in Breeding and Transfer Plans (BTPs) and Survival Stats Reports, does excludes individuals that did not survive to their first birthday. The MLE obtained from population management software (PM2000, PMx, ZooRisk) or from life tables in BTPs (e.g., where Lx = 0.5) will be lower because they include those individuals that did not survive to their first birthday in order to project the correct number of births needed. A Survival Statistics Library is maintained for most AZA Animal Programs on the AZA website: https://www.aza.org/species-survival-statistics.

Maximum Longevity – The maximum age at which we have observed a species to live. If the oldest observed animal is currently living, we do not yet know the maximum longevity.

Mx, Fecundity – The average number of same-sexed offspring born to animals in that age class. Because studbooks typically have relatively small sample sizes, studbook software calculates Mx as 1/2 the average number of offspring born to animals in that age class. This provides a somewhat less "noisy" estimate of Mx, though it does not allow for unusual sex ratios. The fecundity rates provide information on the age of first, last, and maximum reproduction.

Px, Age-Specific Survival – The probability that an individual of age *x* survives an age class; is conditional on an individual being alive at the beginning of the age class. Alternatively, the proportion of individuals that survive from the beginning of one age class to the next.

Qx, Mortality – The probability that an individual of age *x* dies during an age class (Qx = 1-Px). Alternatively, the proportion of individuals that die during an age class. It is calculated from the number of animals that die during an age class divided by the number of animals that were alive at the beginning of the age class (i.e., "at risk").

Risk (Qx or Mx) – The number of individuals that have lived during an age class. The number “at risk” is used to calculate Mx and Qx by dividing the number of births and deaths that occurred during an age class by the number of animals at risk of dying and reproducing during that age class.

Target Population Size (TPS) – The desired number of SSP animals to be held across AZA and approved partner facilities over a specific, stated timeframe. This number is determined with consideration for program roles and goals (genetic, demographic, and others), logistical constraints, spatial competition with other TAG-managed species, and other population-specific concerns. Target Population Size is determined by the Taxon Advisory Group (TAG) and published in their Regional Collection Plan (RCP).

Vx, **Reproductive Value –** The expected number of offspring produced this year and in future years by an animal of age *x*.

Genetic Terms

Allele – Alternate forms of DNA at a particular position in a genome (genetic locus). Alleles represent the most basic form of genetic diversity.

Gene Diversity (GD) – The probability that two alleles randomly sampled from the same genetic locus across a population are not identical by descent. Gene diversity is calculated relative to a population’s founders, which are assumed to be unrelated and not inbred, and is the proportional diversity retained by the current, descendant population.

Effective Population Size (N_e) – The size of a randomly mating population of constant size with equal sex ratio and a Poisson distribution of family sizes that would (a) result in the same mean rate of inbreeding as that observed in the population, or (b) would result in the same rate of random change in allele frequencies (genetic drift) as observed in the population. These two definitions are identical only if the population is demographically stable (because the rate of inbreeding depends on the distribution of alleles in the parental generation, whereas the rate of allele frequency drift is measured in the current generation). More specifically, PMx software uses the definition as the size of the current population that have produced offspring, assuming that there are current breeders, that these current breeders have a Poisson distribution of family sizes, that none of the current breeders are now post-reproductive, and none of the not-yet-breeding adults will breed.

Founder – An individual obtained from a source population (often the wild) that has no known relationship to any individuals in the derived population (except for its own descendants).

Founder Genome Equivalents (FGE) – The number of wild-caught individuals (founders) that represent the same amount of gene diversity as does the population under study. The gene diversity of a population is 1 - 1 / (2 * FGE).

Founder Representation – The proportion of the alleles in the living, descendant population that are derived from that founder.

Inbreeding Coefficient (F) – The probability that the two alleles present at an individual’s genetic locus are identical by descent (i.e., both alleles originated from an ancestor common to both the individual’s parents).

Mean Kinship (MK) – The mean (or average) kinship coefficient between an animal and all animals (including itself) in the living, captive-born population. An individual’s mean kinship is a measure of how well its alleles are represented within a population. Animals with low mean kinships have few relatives, are from under-represented founder lineages, and have transmitted few of their alleles to the next generation; these individuals should be prioritized for breeding to slow a population’s gene diversity loss.

Percent Known – The percentage of an animal's genome that is traceable to known founders. Thus, if an animal has an UNK sire, its % Known = 50. If it has an UNK grandparent, its % Known = 75.

Percent Certain – The percentage of the living individuals’ pedigree that can be completely identified as *certain:* (exact identity of both parents is known) and traceable back to known founders. Individuals that are 100% *certain* do not have any MULTs or UNKs in their pedigree. *Certainty* represents a higher degree of knowledge than *Known* and therefore is always less than or equal to *Known.*

G. AZA Animal Population Management (APM) Committee Disclaimers

as of June 2019

This Animal Program is currently a Red SSP and recommendations proposed are non-binding – participation is voluntary. Transfers to non-AZA facilities must comply with each facility's acquisition/transfer policy, in accordance with the AZA Policy on Responsible Population Management. APM Committee-approved Sustainability Partners are expected to agree and abide by AZA's Code of Professional Ethics, SSP Full Participation Policy, Policy on Responsible Population Management, and Accreditation Standards related to animal care and welfare.

H. Directory of Institutional Representatives

Contact Name (IR or Advisor)	Mnemonic – Facility Name	Email Address
Keith Crow	ABQBIOPK Albuquerque Biological Park	kcrow@cabq.gov
Robert Hill	ATLANTA Zoo Atlanta	rhill@zooatlanta.org
Kevin Barrett	BALTIMORE Maryland Zoo in Baltimore	kevin.barrett@marylandzoo.org
Jennifer Mairot-Mendoza	BUSCH TAM Busch Gardens Tampa Bay	Jenny.Mendoza@BuschGardens.com
Christopher Baker	MEMPHIS Memphis Zoological Garden & Aquarium	cbaker@memphiszoo.org
Nicole Atteberry	METROZOO Zoo Miami	Nicole.Atteberry@miamidade.gov
Beatriz Dominguez	OCEAN VAL Oceanografic Valencia	bdominguez@oceanografic.org
Travis Koons	PORTLAND Oregon Zoo	travis.koons@oregonzoo.org
Kim Gray - SSP Coordinator	SANDIEGOZ San Diego Zoo	kgray@sdzwa.org
Jim Darlington	ST AUGUST St. Augustine Alligator Farm	jimd@alligatorfarm.com
Brian Henley	WACO Cameron Park Zoo	gordonh@wacotx.gov

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