Population Analysis & Breeding and Transfer Plan

Ploughshare Tortoise (*Astrochelys yniphora*) AZA Species Survival Plan® Red Program

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15 August 2017

PMC Population Management Center

LINCOLN PARK ZOO.

ASSOCIATION OF ZOOS & AQUARIUMS

Executive Summary

Species Survival Plan® for the Ploughshare Tortoise (*Astrochelys yniphora*)

At the time of analysis, the ploughshare tortoise population consists of 30 tortoises (1 confirmed male, 2 confirmed females, 1 ovariectomized female, and 26 unknown sex) distributed among 4 AZA facilities and 1 non-AZA facility. The Chelonian Taxon Advisory Group in their 2016 Regional Collection Plan designated a target population size of 50 animals. All tortoises in the current population are confiscated animals due to illegal trade. This species is listed as "Critically Endangered" in the wild and a breeding program exists in the range country. According to AZA sustainability guidelines, this population qualifies as a Red SSP.

An analytical studbook with minor pedigree assumptions intended to estimate relatedness and inbreeding was used to evaluate genetics. Only one hatch has been observed in the North American population thus far and that offspring is no longer living. Therefore, no genetic diversity can be calculated at this time. Currently, there are 29 potential founders and any breeding will be valuable.

Demography

Current size of population (N) – Total (Males.Females.Unknown Sex)	30 (1.3.26)
Number of individuals excluded from genetic analyses	1 (0.1)
Population size following exclusions	29 (1.2.26)
Target population size (Kt) from Chelonian TAG 2016 RCP	50
Mean generation time (T, years)	35.5
Population Growth Rates (λ; lambda)*: Historical / 5 –year / Projected	0.00 / 1.20 / N/A

*Historical from life tables (N.AMERICA – 1971 – present); 5-year from AZA studbook census; Projected from PMx stochastic 20 yr projections (AZA).

Genetics

	Current	Potential
Founders	0	29
Founder genome equivalents (FGE)	0.5	0
Gene diversity (GD %)	0	--
Population mean kinship (MK)	1.0000	--
Mean inbreeding (F)	0.0000	--
Effective Population size/potentially breeding population ratio (Ne / N)	--	--
Percentage of pedigree known before assumptions & exclusions	100	--
Percentage of pedigree known after assumptions & exclusions	100	--
Percentage of pedigree certain after assumptions & exclusions	100	--

*based on an analytical studbook, "Ploughshare_Tortoise_23Jan17 + PMC2017"

Due to the lack of breeding in the North American population, it is not possible at this time to project or estimate how many hatches are needed annually to maintain the population. Any successful breeding for this species, however, will be beneficial for establishing a genetically and demographically stable population. The SSP will attempt breeding, however, there are currently only 3 tortoises that can potentially breed. The remaining tortoises will not reach sexual maturity until at least ages 19 or 20 and the oldest unknown sex animals are currently only 12 years of age.

The 5-year average population growth rate is 20%, however, this is due to wild confiscations and import events. Ploughshare Tortoises are listed as Critically Endangered and are considered one of the most endangered reptile species in the world. An international effort to breed and release animals has been in place since 1986 and is based in Madagascar. The North American population is to serve as an extra assurance population to prevent extinction and to serve as a conservation ambassador to other zoos to bring attention to conservation efforts for this species.

Summary Actions: Two (2) females are recommended for breeding with the available male. Two (2) pre-arranged transfers are recommended at this time to fill institutional needs.

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Acknowledgments

The Ploughshare Tortoise planning meeting was held 5/23/2017 at via GO TO internet conference call and was attended by the following:

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This plan was prepared and distributed with the assistance of the
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Description of Population Status

Species Survival Plan® for the Ploughshare Tortoise *(Astrochelys yniphora)*

At the time of analysis, the ploughshare tortoise population consists of 30 tortoises (1 confirmed male, 3 confirmed females, and 26 unknown sex) distributed among 4 AZA facilities and 1 non-AZA facility. The Chelonian Taxon Advisory Group in their 2016 Regional Collection Plan designated a target population size of 50 animals. All tortoises in the current population are confiscated animals due to illegal trade. This species is listed as Critically Endangered in the wild and breeding programs are underway in the range country. According to AZA sustainability guidelines, this population qualifies as a Red SSP.

Comprehensive genetic and demographic analyses of the ploughshare tortoise population were performed on 23 May 2017. The results herein represent the first formal breeding and transfer plan for this population. Analyses were based on both the North American Regional (Current to 19 July 2016) and International Studbook (Current to 1 February 2015) data sets. Software used included SPARKS v.1.6, PopLink v.2.4 and PMx v. 1.4.20161017.

Status and Conservation:
The ploughshare tortoise, also known as the Angonoka, is currently listed as “Critically Endangered, CR” on the IUCN Red list (2008) and is listed under CITES Appendix I. Additionally, they are listed on the Endangered Species Act (ESA). Currently, this species is considered one of the most endangered reptiles with rapidly declining populations in the wild and only a few hundred mature animals estimated to remain (Gibbons, 2016).

Analytical Population:
The pedigree of this population is currently 100% known. Analytical assumptions for specimens with MULT parentage were made and are included in Appendix A. One (1) female of breeding age was excluded for sterility and listed in Appendix C (Studbook #1). After these assumptions and exclusions, the potentially breeding population consists of 29 animals (1.2.26) with 100% known pedigree.

Demography:
Using studbook data from the North American Regional Studbook, the first Ploughshare Tortoise was brought into the US in 1971. All specimens in the population are wild caught animals confiscated from the high poaching pressure experienced by this species in the wild. One hatch was observed in North America in 1983, however, no other hatches have occurred since then (Fig. 1). The five year growth rate is currently 20% (lambda = 1.2) from 2012 - 2016 driven entirely by confiscations. Only one death has been recorded in the last 10 years and most animals are currently 12 years of age or younger. A breeding program was started in 1986 by Durrell Wildlife Conservation Trust (UK) in Madagascar near the native range of the species. Later in 2006, this program was expanded to a reintroduction program with several dozen tortoises now being hatched in the wild from captive-hatched parents. Release sites are now, unfortunately, susceptible to poaching pressures making the establishment of multiple assurance populations

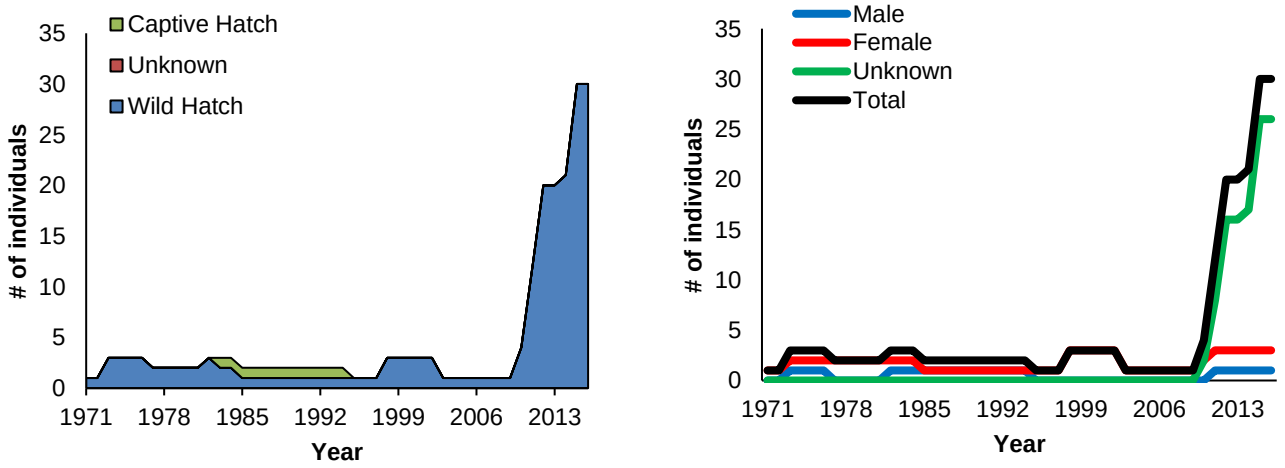

Figure 1: Census of the North American population of Ploughshare Tortoises by (left) origin and by (right) sex (Data current to 19 July 2016).

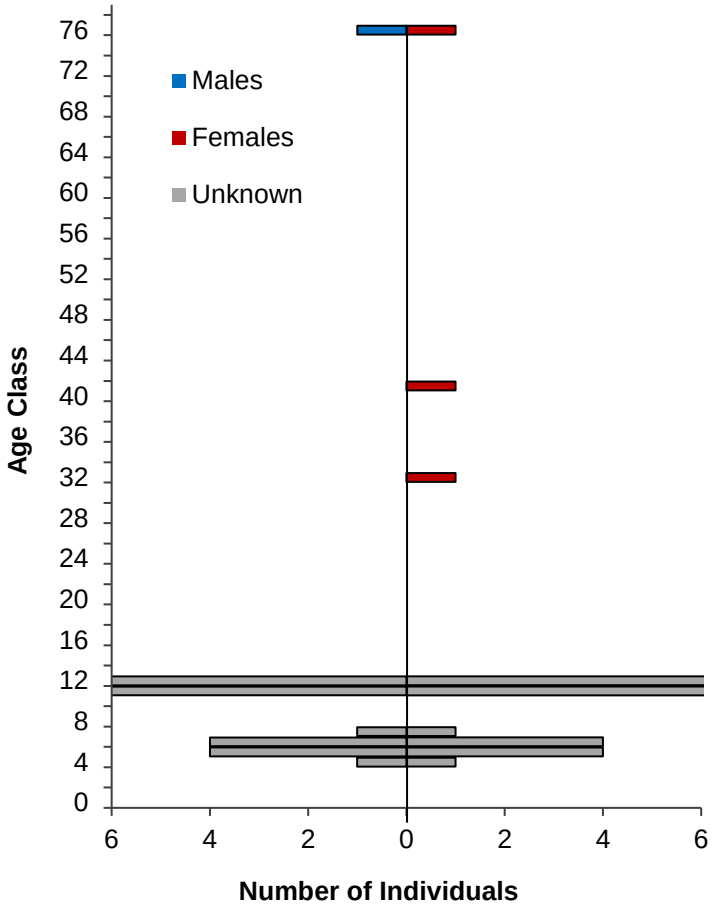

Figure 2: Age structure of the total population of the Ploughshare Tortoise SSP, N = 30.

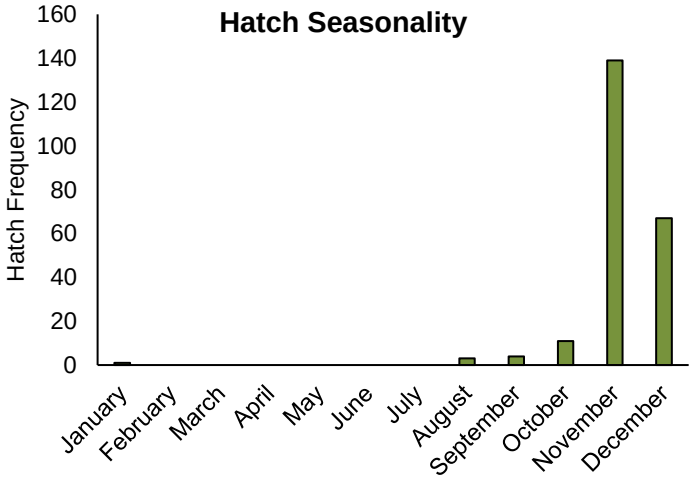

Figure 3: Hatch seasonality from the Ploughshare Tortoise International Studbook (Data current to July 2015).

vital to avoid extinction of this species (Gibbons, 2016). The SSPs goal is to breed and develop a stable population in North America to serve as an assurance population and conservation ambassadors.

The age structure of the total ploughshare tortoise population is currently unstable and greatly stretched (Fig. 2). Currently there are only four individuals with known sex and the majority of animals are 12 years of age or younger. Once breeding can commence more readily in the population, the SSP should focus on breeding at consistent and low levels to maintain a structure with a wide base of younger animals to replace older animals as they age. Focused breeding of 3 of the known sex adults is the immediate priority.

Demographic data are lacking in this population due to the short history of the species in North American zoos relative to their longevity. Data are not robust enough to produce demographically reliable estimates. Therefore, the following estimates were pulled from the International Ploughshare Tortoise Studbook (Current to July 2015; Goetz, 2016). Based on the international studbook, first year mortality is estimated to be 15% for males and 12% for females. The oldest age classes yet occupied for either sex has been 76 years of age with +/- 9 year age estimates. Maximum longevity is not yet known, however, managers speculate that ploughshare tortoises can live up to 150 years (Goetz, 2016). Data is not robust enough to produce median life expectancy estimates at this time (Appendix F).

The oldest tortoises recorded to breed were 72 years for males and 57 years for females according to the international studbook (Goetz, 2016). Sexual maturity can occur as early as 19 or 20 years of age and breeding is possible at this age, however, breeding is more common after age 25. Clutch sizes range from 4 – 5 eggs per female with anything higher considered a large clutch. Incubation can be highly variable due to the reliance of this species in the wild on seasonal rains. Intense seasonality in the hatches is evident in the international studbook data with most hatches occurring in November or December (Fig. 3). Breeding in the wild is thought to include herds of tortoises where males combat for access to females.

Currently, 86% of the population is of unknown sex. The oldest unknown sex animals are 11 or 12 years of age and not yet old enough for visual sex determination. Sexual maturity generally occurs around 20 years of age and visual sexing is possible at or after this age. Surgical or other invasive methods of sex determination are not recommended at this time.

Genetics:
An analytical studbook with minor pedigree assumptions for a MULT parentage was used to estimate relatedness and inbreeding. The current potentially breeding population consists of 29 potential founders that have yet to reproduce. With no reproduction and all animals as potential founders, gene diversity and other estimates cannot be calculated at this time. Only three animals are currently old enough and mature enough to breed. Any pairings producing offspring will be beneficial to the population.

A high level of gene diversity may be retained for a longer period of time through careful breeding targeted at equalizing founder representations. Successfully breeding as many or all of the potential founders in the population would produce equal representation among founder lineages. Generation time in this species is long (T = 35.5 years: Goetz 2016) and will improve gene diversity retention with consistent breeding. Lastly, maintaining a high effective size ratios (proportion of population breeding) will also help retain more gene diversity through time.

Genetic Summary*

	Current	Potential
Founders	0	29
Founder genome equivalents (FGE)	0.5	0
Gene diversity (GD %)	0	--
Population mean kinship (MK)	1.0000	--
Mean inbreeding (F)	0.0000	--
Effective Population size/potentially breeding population ratio (Ne/N)	--	--
Percentage of pedigree known before assumptions & exclusions	100	--
Percentage of pedigree known after assumptions & exclusions	100	--
Percentage of pedigree certain after assumptions & exclusions	100	--

*based on an analytical studbook, "Ploughshare_Tortoise_23Jan17 + PMC2017"

Management Strategy:
Due to the lack of breeding in the North American population, it is not possible at this time to project or estimate how many hatches are needed annually to maintain the population. Any successful breeding for this species, however, will be beneficial for establishing a genetically and demographically stable population. The SSP will attempt breeding, however, there are currently only 3 tortoises that can potentially breed. The remaining tortoises will not reach sexual maturity until ages 19 or 20 and the oldest unknown sex animals are currently only 12 years of age.

The 5-year average population growth rate is 20%, however, this is due to wild confiscations and import events. Ploughshare Tortoises are listed as Critically Endangered and are considered one of the most endangered reptile species in the world. An international effort to breed and release animals has been in place since 1986 and is based in Europe. The North American population is to serve as an extra assurance population to prevent extinction and to serve as a conservation ambassador to other zoos to bring attention to conservation efforts for this species.

Because the majority of animals are of unknown sex and sexually immature, there is not a need for planning every 3 years as with other SSP populations. **Therefore, this will be a 5-year plan (2017 – 2022) and interim recommendations will be made as needed.**

Summary Actions:

1. The SSP recommends 2 females for breeding with the one male old enough to breed.

2. The SSP recommends 2 transfers at this time that were pre-arranged within the program.

3. Facilities interested in acquiring this species or contributing to conservation efforts should contact the SSP Coordinator for details.

Summary of Breeding and Transfer Recommendations

By Studbook ID

Studbook ID	Location	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1	HONOLULU	850068	F	76	HOLD	HONOLULU	DO NOT BREED		Excluded - Sterile
2	OJAI	YNIP01	M	76	HOLD	OJAI	BREED WITH	12, 10	
10	OJAI	YNIP00	F	32	HOLD	OJAI	BREED WITH	2	
11	OJAI	YNIP00	U	12	HOLD	OJAI	DO NOT BREED		
12	OJAI	YNIP00	F	41	HOLD	OJAI	BREED WITH	2	
13	OJAI	YNIP00	U	12	HOLD	OJAI	DO NOT BREED		
14	OJAI	YNIP00	U	12	HOLD	OJAI	DO NOT BREED		
15	OJAI	YNIP00	U	12	HOLD	OJAI	DO NOT BREED		
16	OJAI	YNIP00	U	12	HOLD	OJAI	DO NOT BREED		
17	OJAI	YNIP00	U	12	HOLD	OJAI	DO NOT BREED		
18	OJAI	YNIP01	U	12	HOLD	OJAI	DO NOT BREED		
19	OJAI	YNIP01	U	12	HOLD	OJAI	DO NOT BREED		
20	ATLANTA	12R008	U	11	SEND TO	OKLAHOMA	DO NOT BREED		Pre-arranged transfers
21	OKLAHOMA	768002	U	11	HOLD	OKLAHOMA	DO NOT BREED		
22	ATLANTA	12R002	U	11	SEND TO	OKLAHOMA	DO NOT BREED		Pre-arranged transfers
23	OKLAHOMA	768001	U	11	HOLD	OKLAHOMA	DO NOT BREED		
24	KNOXVILLE	4471	U	11	HOLD	KNOXVILLE	DO NOT BREED		
25	KNOXVILLE	4472	U	11	HOLD	KNOXVILLE	DO NOT BREED		
26	KNOXVILLE	4473	U	11	HOLD	KNOXVILLE	DO NOT BREED		
27	KNOXVILLE	4474	U	11	HOLD	KNOXVILLE	DO NOT BREED		
29	OJAI	YNIP01	U	5	HOLD	OJAI	DO NOT BREED		
30	OJAI	YNIP01	U	5	HOLD	OJAI	DO NOT BREED		
31	OJAI	YNIP01	U	7	HOLD	OJAI	DO NOT BREED		
32	OJAI	YNIP01	U	5	HOLD	OJAI	DO NOT BREED		
33	OJAI	YNIP01	U	4	HOLD	OJAI	DO NOT BREED		
34	OJAI	YNIP01	U	6	HOLD	OJAI	DO NOT BREED		
35	OJAI	YNIP02	U	5	HOLD	OJAI	DO NOT BREED		
36	OJAI	YNIP02	U	6	HOLD	OJAI	DO NOT BREED		
37	OJAI	YNIP02	U	6	HOLD	OJAI	DO NOT BREED		
38	OJAI	YNIP02	U	6	HOLD	OJAI	DO NOT BREED		

Breeding and Transfer Recommendations by Institution

ATLANTA
Zoo Atlanta
Atlanta, GA

Studbook ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
20	12R008	U	11	SEND TO	OKLAHOMA	DO NOT BREED		Pre-arranged transfers
22	12R002	U	11	SEND TO	OKLAHOMA	DO NOT BREED		Pre-arranged transfers

HONOLULU (non-AZA)
Honolulu Zoo
Honolulu, HI

Studbook ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1	850068	F	76	HOLD	HONOLULU	DO NOT BREED		Excluded - Sterile

KNOXVILLE
Knoxville Zoological Gardens
Knoxville, TN

Studbook ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
24	4471	U	11	HOLD	KNOXVILLE	DO NOT BREED		
25	4472	U	11	HOLD	KNOXVILLE	DO NOT BREED		
26	4473	U	11	HOLD	KNOXVILLE	DO NOT BREED		
27	4474	U	11	HOLD	KNOXVILLE	DO NOT BREED		

OJAI
The Turtle Conservancy
Ojai, CA

Studbook ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2	YNIP01	M	76	HOLD	OJAI	BREED WITH	12, 10	
12	YNIP00	F	41	HOLD	OJAI	BREED WITH	2	
10	YNIP00	F	32	HOLD	OJAI	BREED WITH	2	
11	YNIP00	U	12	HOLD	OJAI	DO NOT BREED		
13	YNIP00	U	12	HOLD	OJAI	DO NOT BREED		
14	YNIP00	U	12	HOLD	OJAI	DO NOT BREED		
15	YNIP00	U	12	HOLD	OJAI	DO NOT BREED		
16	YNIP00	U	12	HOLD	OJAI	DO NOT BREED		
17	YNIP00	U	12	HOLD	OJAI	DO NOT BREED		
18	YNIP01	U	12	HOLD	OJAI	DO NOT BREED		
19	YNIP01	U	12	HOLD	OJAI	DO NOT BREED		
31	YNIP01	U	7	HOLD	OJAI	DO NOT BREED		
34	YNIP01	U	6	HOLD	OJAI	DO NOT BREED		
36	YNIP02	U	6	HOLD	OJAI	DO NOT BREED		
37	YNIP02	U	6	HOLD	OJAI	DO NOT BREED		
38	YNIP02	U	6	HOLD	OJAI	DO NOT BREED		
29	YNIP01	U	5	HOLD	OJAI	DO NOT BREED		
30	YNIP01	U	5	HOLD	OJAI	DO NOT BREED		
32	YNIP01	U	5	HOLD	OJAI	DO NOT BREED		
35	YNIP02	U	5	HOLD	OJAI	DO NOT BREED		
33	YNIP01	U	4	HOLD	OJAI	DO NOT BREED		

OKLAHOMA
Oklahoma City Zoological Park
Oklahoma City, OK

Studbook ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
21	768002	U	11	HOLD	OKLAHOMA	DO NOT BREED		
23	768001	U	11	HOLD	OKLAHOMA	DO NOT BREED		
20	12R008	U	11	RECEIVE FROM	ATLANTA	DO NOT BREED		Pre-arranged transfers
22	12R002	U	11	RECEIVE FROM	ATLANTA	DO NOT BREED		Pre-arranged transfers

Appendix A: Analytical Assumptions

ANALYTICAL DATA FOR TRUE INDIVIDUALS

- True data has all living turtles currently with WILD parents and a unique number identifier for each wild parent (e.g. WILD1/WILD2). This alters genetic analysis and therefore, all individuals were given "WILD" only lineages in an overlay labeled "PMC2017." Future versions of the studbook should change true data of these individuals to WILD only parents unless incoming animals are otherwise assumed to be siblings.

- 1 MULT was included in the ped file; MULT1 *DAMS: 3; 4 are the potential dams for SB# 6.

Studbook ID	Field	TRUE	Overlay	Notes
1, 2, 10-38	Dam	WILD#	WILD	See Notes above
	Sire	WILD#	WILD	
6	Dam	MULT1	PMx Ped	See Notes above

Appendix B: Summary of Data Exports

****Note:** No demographic data are available for the North American population alone, therefore, the international studbook database was used to produce life tables and other valuable demographic estimates. Data exports for the North American SSP Population and for the ISB demographic data are shown below.

North American Studbook Data Exports:

PMx Project: Ploughshare_1
Created: 2017-05-22 by PMx version 1.4.20161017
File: C:\PMxProjects\Ploughshare_1.pmxproj
Description: WILD only assumptions for everyone using PMC2017 Overlay

Primary data file
Data File Name: XXPloughshare_Tortoise_23Jan17.ped
Common Name: Ploughshare Tortoise
Scientific Name: Astrochelys yniphora
Data Source: PopLink
Studbook Name: Ploughshare_Tortoise_23Jan17
Exported On: 2017-05-22
Software version: PopLink 2.4
Current through: 2016-07-19
Compiled by: Paul Gibbons
Scope: North American Regional
Dates: 2017-05-22
Locations:
Association: AZA_Honolulu.FED
Other Filters: Status = Living
User: jandrews

Locations data file
Data File Name: location.txt

Demographic input files
MPrn file: mXXPloughshare_Tortoise_23Jan17.prn
FPrn file: fXXPloughshare_Tortoise_23Jan17.prn
Census1 file: Exchcens.txt

Male/Female LifeTable filter:
*Common Name: Ploughshare Tortoise
*Scientific Name: Astrochelys yniphora
*Data Source: PopLink
*Studbook Name: Ploughshare_Tortoise_23Jan17
*Exported On: 2017-05-22
*Software version: PopLink 2.4
*Current through: 2016-07-19
*Compiled by: Paul Gibbons
***Scope: North American Regional**
***Dates: 1971-01-01 to 2017-05-22**
*Locations: N.AMERICA
*Association:
*Other Filters: Status = Living
*User: jandrews

International Studbook Data Exports

PMx Project: Ploughshare_2
Created: 2017-05-22 by PMx version 1.4.20161017
File: C:\PMxProjects\Ploughshare_2.pmxproj

Primary data file
Data File Name: Ploughshare_ISB.ped
Common Name: Ploughshare tortoise, angonoka
Scientific Name: Astrochelys yniphora
Data Source: PopLink
Studbook Name: Ploughshare_ISB
Exported On: 2017-05-22
Software version: PopLink 2.4
Current through: 2015-02-01
Compiled by: Matt Goetz
Scope: InternationalYHOSTC.Durrell Wildlife Conservation Trust YLASTACCSC 986YLASTEDITC 837
Dates: 2017-05-22
Locations:
Association:
Other Filters: Status = Living
User: jandrews

Locations data file
Data File Name: location.txt

Demographic input files
MPrn file: mPloughshare_ISB.prn
FPrn file: fPloughshare_ISB.prn
Census1 file: Exchcens.txt

Male/Female LifeTable filter:
*Common Name: Ploughshare tortoise, angonoka
*Scientific Name: Astrochelys yniphora
*Data Source: PopLink
*Studbook Name: Ploughshare_ISB
*Exported On: 2017-05-22
*Software version: PopLink 2.4
*Current through: 2015-02-01
*Compiled by: Matt Goetz
*Scope: InternationalYHOSTC.Durrell Wildlife Conservation Trust YLASTACCSC 986YLASTEDITC 837
***Dates: 1971-01-01 to 2017-05-22**
*Locations:
*Association:
***Other Filters: Status = Living**
*User: jandrews

Citations:

1. Goetz, M. (2016). International Studbook for the Ploughshare tortoise *Astrochelys yniphora* 1st edition (to end January 2015). Durrell Wildlife Conservation Trust, Jersey.

2. Gibbons, P. (2016). North American Regional Studbook for the Ploughshare tortoise *Astrochelys yniphora* 2nd edition. The Turtle Conservancy, Ojai, California, USA.

Appendix C: Animals Excluded from the Genetic Analysis

SB ID	Age	Sex	Location	Notes
1	76	F	HONOLULU	Ovariectomized - sterile

Appendix D: Life Tables

Px = survival; Qx = mortality; lx = cumulative survivorship; Mx = fecundity; Vx = reproductive value; Ex = life expectancy;
At Risk (Qx & Mx) = number of animals the corresponding values are estimated from

Special Note: Demographic data here are from the international studbook for this species (Current to July 2015: Goetz, 2016) and includes a large conservation breeding program. Therefore, estimates within these tables may not be entirely comparable to other ex situ populations but should serve as a reference or benchmark for this species.

MALES

Age	Px	Qx	Risk Qx	Lx	Mx	Risk Mx	Vx
0	0.85	0.15	286.10	1.00	0.00	265.9	1.08
1	0.95	0.05	243.00	0.85	0.00	235.3	1.30
2	0.98	0.02	232.00	0.81	0.00	230.3	1.46
3	0.99	0.01	220.40	0.79	0.00	221.4	1.61
4	0.98	0.02	218.00	0.78	0.00	216.4	1.76
5	0.99	0.01	206.90	0.77	0.00	208	1.94
6	0.97	0.03	184.70	0.76	0.00	182.8	2.13
7	1.00	0.00	167.30	0.74	0.00	168.2	2.34
8	0.99	0.01	141.80	0.74	0.00	143.4	2.55
9	1.00	0.00	108.60	0.73	0.00	110.5	2.77
10	0.99	0.01	93.20	0.73	0.00	93.3	3.01
11	0.99	0.01	80.90	0.72	0.00	82.1	3.29
12	0.97	0.03	59.90	0.72	0.00	59.4	3.63
13	1.00	0.00	49.40	0.69	0.00	49.6	3.98
14	1.00	0.00	43.50	0.69	0.00	43.8	4.30
15	1.00	0.00	33.60	0.69	0.00	33.9	4.65
16	1.00	0.00	22.10	0.69	0.00	23	5.03
17	0.94	0.06	16.80	0.69	0.00	16.4	5.61
18	1.00	0.00	14.40	0.65	0.00	14.6	6.26
19	1.00	0.00	12.70	0.65	0.00	12.7	6.77
20	1.00	0.00	9.10	0.65	0.22	9.6	7.32
21	1.00	0.00	8.10	0.65	0.08	8.2	7.68
22	1.00	0.00	8.30	0.65	0.16	8.5	8.21
23	1.00	0.00	7.80	0.65	0.00	7.8	8.71
24	1.00	0.00	8.80	0.65	0.00	8.8	9.42
25	1.00	0.00	9.80	0.65	0.00	9.8	10.18
26	1.00	0.00	10.80	0.65	0.00	10.8	11.01
27	1.00	0.00	10.90	0.65	1.29	11	11.91
28	0.90	0.10	10.00	0.65	1.50	9.4	12.08
29	1.00	0.00	9.00	0.59	0.89	9	12.08
30	1.00	0.00	8.70	0.59	0.31	8.7	12.10
31	1.00	0.00	9.80	0.59	0.00	9.8	12.75
32	1.00	0.00	10.90	0.59	1.78	10.9	13.79
33	1.00	0.00	11.00	0.59	0.00	11	12.98
34	1.00	0.00	11.00	0.59	0.43	11	14.04

FEMALES

Age	Px	Qx	Risk Qx	Lx	Mx	Risk Mx	Vx
0	0.88	0.12	373.10	1.00	0.00	352.9	1.06
1	0.96	0.04	330.00	0.88	0.00	322.3	1.26
2	0.98	0.02	317.30	0.84	0.00	314.9	1.41
3	1.00	0.00	302.80	0.83	0.00	303.9	1.55
4	0.99	0.01	298.50	0.83	0.00	296.9	1.69
5	0.99	0.01	286.80	0.82	0.00	287.9	1.85
6	0.98	0.02	266.10	0.81	0.00	263.4	2.05
7	0.99	0.01	246.80	0.80	0.01	246.8	2.26
8	0.99	0.01	234.60	0.79	0.00	233.3	2.46
9	1.00	0.00	221.90	0.78	0.00	222.7	2.69
10	0.99	0.01	214.70	0.78	0.00	213.1	2.94
11	0.99	0.01	195.20	0.77	0.00	196.6	3.22
12	0.99	0.01	165.90	0.76	0.00	166.7	3.54
13	0.99	0.01	146.10	0.76	0.00	146	3.88
14	0.99	0.01	129.70	0.75	0.00	130	4.26
15	1.00	0.00	117.50	0.74	0.00	117.6	4.65
16	1.00	0.00	99.30	0.74	0.00	99.9	5.05
17	1.00	0.00	85.60	0.74	0.00	86.1	5.48
18	1.00	0.00	68.90	0.74	0.00	70.5	5.96
19	1.00	0.00	50.00	0.74	0.00	50.8	6.47
20	0.95	0.05	39.70	0.74	0.00	39.9	7.21
21	1.00	0.00	30.30	0.70	0.09	31	8.04
22	1.00	0.00	22.30	0.70	0.10	22.3	8.63
23	1.00	0.00	21.00	0.70	0.10	21.2	9.27
24	1.00	0.00	18.20	0.70	0.36	18.4	9.96
25	1.00	0.00	14.40	0.70	0.98	14.6	10.43
26	1.00	0.00	12.90	0.70	0.97	13	10.26
27	1.00	0.00	11.00	0.70	0.93	11.2	10.10
28	1.00	0.00	10.20	0.70	0.74	10.3	9.96
29	1.00	0.00	10.00	0.70	0.00	10	10.01
30	1.00	0.00	10.80	0.70	0.70	10.8	10.88
31	1.00	0.00	9.90	0.70	0.11	10	11.05
32	1.00	0.00	10.70	0.70	0.56	10.8	11.89
33	1.00	0.00	11.70	0.70	1.39	11.7	12.30
34	1.00	0.00	12.00	0.70	0.81	12	11.86

MALES							
Age	Px	Qx	Risk Qx	Lx	Mx	Risk Mx	Vx
35	1.00	0.00	11.00	0.59	0.30	11	14.71
36	1.00	0.00	11.00	0.59	2.19	11	15.58
37	1.00	0.00	11.00	0.59	1.28	11	14.48
38	1.00	0.00	11.00	0.59	1.82	11	14.28
39	1.00	0.00	11.00	0.59	0.00	11	13.47
40	1.00	0.00	11.00	0.59	0.55	11	14.57
41	1.00	0.00	11.00	0.59	1.40	11	15.15
42	1.00	0.00	11.00	0.59	0.49	11	14.87
43	1.00	0.00	10.60	0.59	2.34	10.6	15.55
44	1.00	0.00	10.00	0.59	2.34	10	14.29
45	1.00	0.00	10.00	0.59	3.08	10	12.92
46	1.00	0.00	9.50	0.59	0.21	9.8	10.64
47	1.00	0.00	5.00	0.59	0.94	5	11.28
48	1.00	0.00	5.00	0.59	1.07	5	11.18
49	1.00	0.00	5.40	0.59	0.62	5.4	10.93
50	1.00	0.00	6.80	0.59	1.88	6.8	11.15
51	1.00	0.00	7.00	0.59	0.38	7	10.02
52	1.00	0.00	6.00	0.59	2.55	6	10.42
53	1.00	0.00	5.90	0.59	1.93	6	8.51
54	1.00	0.00	5.00	0.59	3.08	5	7.12
55	1.00	0.00	4.90	0.59	0.27	5	4.37
56	1.00	0.00	3.90	0.59	1.55	4	4.43
57	1.00	0.00	2.90	0.59	1.85	3	3.11
58	1.00	0.00	2.00	0.59	0.33	2	1.36
59	1.00	0.00	3.10	0.59	0.00	3.1	1.12
60	1.00	0.00	4.60	0.59	0.00	4.6	1.21
61	1.00	0.00	4.90	0.59	0.00	5	1.31
62	1.00	0.00	4.90	0.59	0.00	4.9	1.41
63	1.00	0.00	4.80	0.59	0.00	4.9	1.53
64	1.00	0.00	3.00	0.59	0.22	3	1.65
65	1.00	0.00	3.00	0.59	0.00	3	1.55
66	1.00	0.00	2.90	0.59	0.00	3	1.68
67	1.00	0.00	2.00	0.59	0.00	2	1.81
68	1.00	0.00	2.00	0.59	0.00	2	1.96
69	1.00	0.00	2.00	0.59	0.00	2	2.12
70	1.00	0.00	2.00	0.59	0.00	2	2.29
71	1.00	0.00	2.00	0.59	0.00	2	2.48
72	1.00	0.00	2.00	0.59	2.68	2	2.68
73	1.00	0.00	2.00	0.59	0.00	2	0.00
74	1.00	0.00	1.90	0.59	0.00	2	0.00
75	1.00	0.00	1.00	0.59	0.00	1	0.00
76	1.00	0.00	0.50	0.59	0.00	0.5	0.00
77	1.00	0.00	0.00	0.59	0.00	0	0.00

FEMALES							
Age	Px	Qx	Risk Qx	Lx	Mx	Risk Mx	Vx
35	1.00	0.00	12.00	0.70	2.30	12	12.00
36	1.00	0.00	12.00	0.70	0.95	12	10.54
37	1.00	0.00	12.00	0.70	2.12	12	10.41
38	1.00	0.00	12.00	0.70	0.68	12	9.01
39	1.00	0.00	12.00	0.70	0.18	12	9.05
40	1.00	0.00	12.00	0.70	0.09	12	9.63
41	1.00	0.00	11.50	0.70	1.27	11.5	10.37
42	1.00	0.00	11.00	0.70	0.98	11	9.88
43	1.00	0.00	11.00	0.70	1.03	11	9.67
44	1.00	0.00	11.00	0.70	2.12	11	9.38
45	1.00	0.00	11.00	0.70	1.87	11	7.89
46	1.00	0.00	10.60	0.70	0.00	10.9	6.54
47	1.00	0.00	7.00	0.70	1.08	7	7.10
48	0.86	0.14	7.00	0.70	1.71	6	7.03
49	1.00	0.00	6.80	0.61	0.56	6.8	6.26
50	1.00	0.00	8.00	0.61	1.83	8	6.19
51	1.00	0.00	8.00	0.61	0.95	8	4.73
52	1.00	0.00	7.10	0.61	1.45	7.1	4.11
53	1.00	0.00	6.70	0.61	0.00	6.9	2.89
54	1.00	0.00	4.00	0.61	0.00	4	3.14
55	0.75	0.25	4.00	0.61	0.00	3.9	3.89
56	1.00	0.00	3.00	0.45	3.61	3	4.94
57	1.00	0.00	3.00	0.45	1.44	3	1.44
58	1.00	0.00	3.00	0.45	0.00	3	0.00
59	1.00	0.00	2.80	0.45	0.00	2.9	0.00
60	1.00	0.00	1.60	0.45	0.00	1.6	0.00
61	1.00	0.00	2.00	0.45	0.00	2	0.00
62	1.00	0.00	2.00	0.45	0.00	2	0.00
63	1.00	0.00	1.00	0.45	0.00	1	0.00
64	1.00	0.00	1.00	0.45	0.00	1	0.00
65	1.00	0.00	1.00	0.45	0.00	1	0.00
66	1.00	0.00	1.00	0.45	0.00	1	0.00
67	1.00	0.00	1.00	0.45	0.00	1	0.00
68	1.00	0.00	1.00	0.45	0.00	1	0.00
69	1.00	0.00	1.00	0.45	0.00	1	0.00
70	1.00	0.00	1.00	0.45	0.00	1	0.00
71	1.00	0.00	1.00	0.45	0.00	1	0.00
72	1.00	0.00	1.00	0.45	0.00	1	0.00
73	1.00	0.00	1.00	0.45	0.00	1	0.00
74	1.00	0.00	1.00	0.45	0.00	1	0.00
75	1.00	0.00	1.00	0.45	0.00	1	0.00
76	1.00	0.00	0.50	0.45	0.00	0.5	0.00
77	1.00	0.00	0.00	0.45	0.00	0	0.00

MALES

Age	Px	Qx	Risk Qx	Lx	Mx	Risk Mx	Vx
78	1.00	0.00	0.00	0.59	0.00	0	0.00
**r = 0.078, λ= 1.081, Ro=17.938, T = 36.9, N@20=1776							

FEMALES

Age	Px	Qx	Risk Qx	Lx	Mx	Risk Mx	Vx
78	1.00	0.00	0.00	0.45	0.00	0	0.00
**r = 0.083, λ= 1.086, Ro=16.838, T = 34, N@20=1776							

Appendix E: Ordered Mean Kinship

***Note:** Only one hatch has occurred in the North American SSP Population of Ploughshare Tortoises at this time and there are no mean kinship values to report.*

Appendix F: Descriptive Survival Statistics Report

Ploughshare Tortoise *Astrochelys yniphora* Studbook
North American Regional Studbook
Studbook data current as of 7/19/2016

Compiled by: Paul Gibbons, paul@turtleconservancy.org

PopLink Studbook filename: Ploughshare_Tortoise_23Jan17 + PMC2017
PopLink User Who Exported Report: jandrews
Date of Export: 5/24/2017
Data Filtered by: **StartDate = 1/1/1971** AND EndDate = 5/24/2017
PopLink Version: 2.4

REPORT OVERVIEW:

Data for Ploughshare Tortoise were not of sufficient robustness to analyze and report survival statistics. See the body of the report for further details.

BACKGROUND ON ANALYSES:

These analyses were conducted using animals that lived during the period 1 January 1971 to 24 May 2017 at all institutions in the studbook. The analyses mainly focus on survival statistics from 1 year (e.g. excluding any individuals that did not survive past their first birthday). These statistics most accurately reflect typical survival for animals which can be seen on exhibit in zoos and aquariums.

This report summarizes survival records of individuals housed at zoological facilities for a specific geographic range and time period; these records trace an individual's history from birth or entry into the population to death, exit out of the population, or the end of the time period. As such, this history only reflects standard practices - including management, husbandry, and acquisition/disposition practices - for the specified time period and geographic range. Thus, the report contents should be viewed with some caution as they may not fully reflect current and newly emerging zoo and aquarium management techniques or practices. For example, if the population has not been maintained in zoos and aquariums long enough to have many adults living into old age, median life expectancy will likely be an underestimate until more data accrue in older age classes. Thus, users of these reports should recognize that the results produced will likely vary over time or depending on the subset of data selected.

SUMMARY OF ANALYSES:
SURVIVAL STATISTICS

Unfortunately, **data were not robust enough to analyze and report survival statistics**[1] (see Data Quality section). The dataset used for analysis includes partial or full lifespans of 38 individuals, 6 (15.8%) of which had died by 24 May 2017. These data are not sufficient for further analysis.

For general reference, data are provided on the oldest individuals in the dataset defined with the analysis window. Please note that these are the individual's ages as of the end date of the demographic window (24 May 2017); for the most up-to-date ages of the oldest animals in this population, you should contact the studbook keeper for this species directly.

10 Oldest Censored Individuals[2]

Studbook ID	Sex	Birth Type	Age at Censoring	Birth Date Est.	Exit Method
1	Female	Wild Hatch	76.5	+/- 9 Years	alive at end of window
2	Male	Wild Hatch	76.5	+/- 9 Years	alive at end of window
2	Male	Wild Hatch	58.5	+/- 9 Years	LTF
4	Female	Wild Hatch	52.1	+/- 9 Years	LTF
5	Male	Wild Hatch	42.7	+/- 9 Years	LTF
12	Female	Wild Hatch	41.5	+/- 5 Years	alive at end of window
2	Male	Wild Hatch	36.3	+/- 9 Years	LTF

Studbook ID	Sex	Birth Type	Age at Censoring	Birth Date Est.	Exit Method
12	Female	Wild Hatch	33.1	+/- 5 Years	LTF
10	Female	Wild Hatch	32.5	+/- 5 Years	alive at end of window
3	Female	Wild Hatch	32.3	+/- 9 Years	LTF

10 Oldest Dead Individuals

Studbook ID	Sex	Birth Type	Age at Death	Birth Date Est.
3	Female	Wild Hatch	55.9	+/- 9 Years
7	Male	Wild Hatch	28.4	+/- 9 Years
9	Female	Wild Hatch	13.4	+/- 2 Years
8	Female	Wild Hatch	11.8	+/- 2 Years
6	Male	Captive Hatch	11.7	None
28	Unknown	Wild Hatch	7.8	+/- 2 Years

The PopLink Age Outliers report can give further information on these and other 'old' individuals within the studbook dataset.

DATA QUALITY

The PopLink Survival Tool uses five data quality measures to determine whether data are robust enough to make reliable estimates of key survival parameters. **This population failed at least one of the following tests:**

1. Can the median life expectancy be calculated? **PASS**
2. Is the sample size (number of individuals at risk) greater than 20 individuals at the median? **FAIL**
3. Is the 95% Confidence Interval (CI) bounded? **FAIL**
4. Is the sample size in the first age class of analysis (e.g. the first day of analysis) greater than 30 individuals? **FAIL**
5. Is the length of the 95% CI < 33% of the maximum longevity? **FAIL**

PopLink data validation has never been run; if errors are present in this studbook, they may affect the data in this analysis.

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[1] The statistics analyzed for this report (median life expectancy, 95% confidence limits, and age to which 25% of individuals survive) exclude any individuals who did not survive to their first birthday; these individuals are excluded because this Report is focused on providing median survival estimates for the typical individual that survives the vulnerable infant stage. In other words, this report answers the question, 'how long is this species expected to live once it has reached its first birthday?' For this studbook, 0 individuals died before their first birthday and were excluded from these analyses.

For all animals that survive to their first birthday, 50% will die before the median life expectancy in this report and 50% die after. Note that the median life expectancy obtained from population management software (PM2000, PMx, ZooRisk) or from life tables in Breeding and Transfer Plans (e.g. where Lx = 0.5) will be lower because it includes these individuals that did not survive to their first birthday in order to project the correct number of births needed. See the PopLink manual for more details.

[2] Censored individuals are individuals whose deaths have not been observed as of the end of the analysis window, including individuals who 1) are still alive as of the end date, 2) exited the geographic window before the end date (through transfer or release), or 3) were lost-to-follow up before the end date.

Appendix G: Definitions

Management Terms

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 Non–Member Participation 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 institutions is voluntary.

Red Species Survival Plan® (Red SSP) Program – A Red SSP has a population size of greater than 20 but fewer than 50 animals, at least three AZA member institutions, and a published studbook. Animal Programs that manage species designated as Extinct in the Wild, Critically Endangered, or Endangered (IUCN) do not need to meet minimum population size and number of participating institution criteria to be designated as an SSP Program. Red Program participation by AZA institutions is voluntary.

Full Participation – AZA policy stating that all AZA accredited institutions 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 institutional 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 institutions 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.

Demographic Terms

Age Distribution – A two-way classification showing the numbers or percentages of individuals in various age and sex classes.

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

Lambda (□) or Population Growth Rate – The proportional change in population size from one year to the next. Lambda can be based on life-table calculations (the expected lambda) or from observed changes in population size from year to year. A lambda of 1.11 means an 11% per year increase; lambda of 0.97 means a 3% decline in size per year.

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.

Mx, Fecundity – The average number of same-sexed young born to animals in that age class. Because studbooks typically have relatively small sample sizes, studbook software calculate Mx as 1/2 the average number of young 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 one-time period; is conditional on an individual being alive at the beginning of the time period. Alternatively, the proportion of individuals which survive from the beginning of one age class to the next.

Qx, Mortality – Probability that an individual of age x dies during time period. 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.

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

Genetic Terms

Allele Retention – The probability that a gene present in a founder individual exists in the living, descendant population.

Current Gene Diversity (GD) -- The proportional gene diversity (as a proportion of the source population) is the probability that two alleles from the same locus sampled at random from the population will not be identical by descent. Gene diversity is calculated from allele frequencies, and is the heterozygosity expected in progeny produced by random mating, and if the population were in Hardy-Weinberg equilibrium.

Effective Population Size (Inbreeding Ne) -- 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 gene 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 gene frequency drift is measured in the current generation).

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 wild-caught individuals (founders) that would produce 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 -- Proportion of the genes in the living, descendant population that are derived from that founder.

Inbreeding Coefficient (F) -- Probability that the two alleles at a genetic locus are identical by descent from an ancestor common to both parents. The mean inbreeding coefficient of a population will be the proportional decrease in observed heterozygosity relative to the expected heterozygosity of the founder population.

Mean Kinship (MK) – The mean kinship coefficient between an animal and all animals (including itself) in the living, captive-born population. The mean kinship of a population is equal to the proportional loss of gene diversity of the descendant (captive-born) population relative to the founders and is also the mean inbreeding coefficient of progeny produced by random mating. Mean kinship is also the reciprocal of two times the founder genome equivalents: MK = 1 / (2 * FGE). MK = 1 - GD.

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

Prob Lost – Probability that a random allele from the individual will be lost from the population in the next generation, because neither this individual nor any of its relatives pass on the allele to an offspring. Assumes that each individual will produce a number of future offspring equal to its reproductive value, Vx.

Appendix H: Directory of Institutional Representatives

Contact Name (IR)	Institution	Email Address
Robert Hill	ATLANTA - Zoo Atlanta, Atlanta, GA	rhill@zooatlanta.org
Laura Debnar	HONOLULU - Honolulu Zoo, Honolulu, HI	ldebnar@honolulu.gov
Michael Ogle	KNOXVILLE - Zoo Knoxville, Knoxville, TN	mogle@zooknoxville.org
Paul Gibbons	OJAI – Turtle Conservancy, Ojai, CA	paul@turtleconservancy.org
Barry Downer	OKLAHOMA - Oklahoma City Zoological Park, Oklahoma City, OK	bdowner@okczoo.org
Diane Barber	FORTWORTH - Fort Worth Zoological Park, Ft Worth, TX	dbarber@fortworthzoo.org
Paula Kolvig	MOODY - Aquarium & Rainforest at Moody Gardens, Galveston, TX	pkolvig@moodygardens.org
Craig Pelke	SAN ANTON - San Antonio Zoological Gardens & Aqua, San Antonio, TX	craig.pelke@sazoo.org
Sean Putney	KANSASCTY - Kansas City Zoo, Kansas City, MO	SeanPutney@fotzkc.org
Drew Foster	PHOENIX - Phoenix Zoo, Phoenix, AZ	dfoster@phoenixzoo.org
Andy Snider	CHICAGOBR - Chicago Zoological Park, Brookfield, IL	andy.snider@czs.org