Draft for Review by Institutional Representatives – Please Respond by 9 December 2016

Population Analysis & Breeding and Transfer Plan

Steller's Sea-eagle (*Haliaeetus pelagicus*)
AZA Species Survival Plan®
Red Program

AZA Studbook Keeper
Beau Parks, San Diego Zoo
bparks@sandiegozoo.org

Adjunct Population Advisor
Jamie Ivy, San Diego Zoo Global
jivy@sandiegozoo.org

9 November 2016

PMC Population Management Center
Lincoln Park Zoo
Association of Zoos & Aquariums
San Diego Zoo Global

This Animal Program is currently a Red SSP Program and recommendations proposed are non-binding – Participation is voluntary. Dispositions to non-AZA institutions should comply with each institution's acquisition/disposition policy.

Executive Summary

Steller's Sea-eagle (*Haliaeetus pelagicus)*

The current population of Steller's Sea-eagles is 27 birds (15 males, 12 females) distributed among 12 AZA institutions and two private North American facilities. The Raptor Taxon Advisory Group has set the target size for this population to be 20 birds (2015 Regional Collection Plan), which the population has exceeded. At present, the Steller's Sea-eagle program qualifies as a Red SSP Program (<50 animals).

Genetic and demographic analyses of the North American Regional Studbook for Steller's Sea-eagles (current to 01 October 2016) were performed using PopLink 2.4 and PMx 1.2.20160928 resulting in the current Breeding & Transfer Plan for this species. Recommendations contained in this plan supersede previous recommendations. The current gene diversity in the population is 93.49% of that present in the founding population. 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 & Transfer Plans.

Demography

Current population size (males.females.unknowns)	27 (15.12.0)
# Animals excluded from management	0 (0.0.0)
Population size following exclusions	27 (15.12.0)
Target population size	20
Mean generation time (T; in years)	na*
Projected Population Growth Rate (λ) – from life tables (Appendix C)	na*
Historic Population Growth Rate (average North American λ 1997-2015)	1.14
Recent Population Growth Rate (average North American λ 2011-2015)	1.08

*deemed uninformative due to a paucity of demographic data

Genetics

	2016	Current Potential
Founders	17	2 additional
Founder genome equivalents (FGE)	7.68	14.26
Current gene diversity (GD %)	93.49	96.49
Population mean kinship (MK)	0.0651	-----
Mean inbreeding (F)	0.0000	-----
% pedigree known before / after assumptions and exclusions	85 / 100	-----
% pedigree certain before / after assumptions and exclusions	85 / 100	-----
Effective population size/census size ratio (Ne / N)	0.30*	-----
Years To 90% Gene Diversity	na**	-----
Years To 10% Loss of GD	na**	-----
Gene Diversity at 100 Years From Present (%)	na**	-----

*includes founders

**projections uninformative due to a lack of accurate generation length and projected growth rate

This is a 3-year plan. At this time, all reproductively capable females are recommended to breed to continue improving reproductive husbandry and slowly growing the population. Over the last 10 years (2006-2015) there were 14 hatches and only 8 deaths, suggesting that the population can continue to slowly grow if desired. Although the population is currently over its TAG-recommended target size of 20 birds, a larger target size will be necessary for this population to be genetically and demographically viable over the long-term. From a genetic perspective, particular emphasis should be placed on breeding the two remaining potential founders (SB#s 5 and 34) and individuals descended from founders with low representations (SB#s 48, 33, 43) to help maintain, as well as potentially increase, gene diversity.

Summary Actions: The Program recommends 12 females for unrestricted breeding and 5 transfers to establish one new breeding pair and meet institutional needs. All other animals are recommended to remain in previously established pairs.

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Report and Analyses prepared by:
Jamie Ivy, Ph.D., Population Biologist – San Diego Zoo Global, jivy@sandiegozoo.org

Planning occurred at the San Diego Zoo on 18 October 2016.
Attending: Beau Parks, Jamie Ivy,

Cover Photo Credit: Rodger Charlwood (worldwildlifeimages.com)

This plan was reviewed and distributed with the assistance of the Population Management Center.
pmc@lpzoo.org

Description of Population Status

Introduction: Steller's Sea-eagles are native to coastal northeastern Asia. They're considered the heaviest eagles in the world and have a striking plumage that includes white shoulder, tail, and leg patches set against a dark body. The species' small, regional population is declining due to habitat loss, lead poisoning, and prey declines due to over-fishing, making this a species of conservation concern. Steller's Sea-eagles are "cold-hardy" and provide an excellent exhibit option for northern facilities. The current, formally managed captive population of Steller's Sea-eagles is 27 birds (15 males, 12 females) distributed among 12 AZA institutions and two private North American facilities. The Raptor Taxon Advisory Group has set the target size for this population to be 20 birds (2015 Regional Collection Plan), which the population has exceeded. At present, the Steller's Sea-eagle program qualifies as a Red SSP Program (<50 animals).

Genetic and demographic analyses of the North American Regional Studbook for Steller's Sea-eagles (current to 01 October 2016) were performed using PopLink 2.4 and PMx 1.2.20160928, resulting in the current Breeding & Transfer Plan for this species. Recommendations contained in this plan supersede previous recommendations.

Conservation Status: IUCN Red List – Vulnerable; USFWS – not listed; CITES – Appendix II

Analytical Population: The population size at the time of analyses was 27 birds (15 males, 12 females); the population's pedigree was 85% known/certain prior to the application of assumptions. A small number of pedigree assumptions were applied (Appendix A), resulting in a pedigree that was 100% known/certain. No birds were excluded from the potential breeding population or genetic analyses.

Demography: Studbook records indicate that the current captive population of Steller's Sea-eagles in North America was established in 1996 when the San Diego Zoo imported two wild-caught males from Russia (Figure 1). Prior to that time, only a single bird was ever recorded to occur in a North American collection. The population has grown by ~14% since 1996 (average λ 1997-2015 = 1.14) due to a combination of continued imports and successful captive breeding. Over the last five years, the population has grown by ~8% (average λ 2011-2015 = 1.14). The first captive hatch in North American occurred in 2003 at the Cincinnati Zoo (Figure 2). Since that time the captive-hatched portion of the population has grown by ~27% (average λ 2004-2015 = 1.27), although some of that growth has been due to the continued importation of captive-hatched birds from outside North America. The population currently still includes seven wild-caught birds. Due to the population's short history in North America and a paucity of data from which to base demographic analyses, growth rate projections from current life tables are largely uninformative (see Appendix C for sample sizes). Over the last 10 years (2006-2015) there were 14 hatches and only 8 deaths, suggesting that the population can continue to slowly grow if desired.

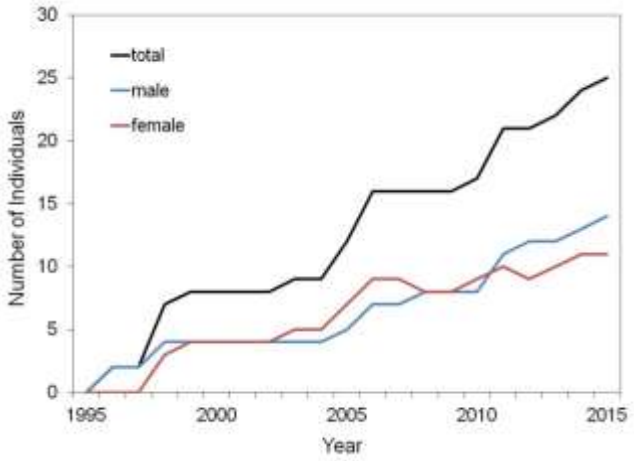

Figure 1. Census of Stellar's Sea-Eagles in North American facilities from 1995 to 2015, by sex.

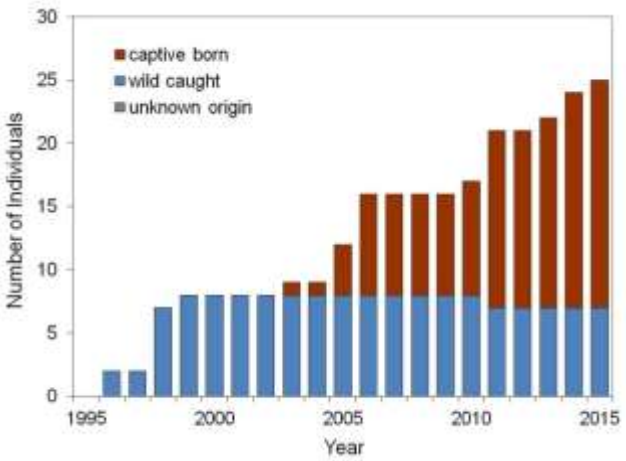

Figure 2. Census of Stellar's Sea-Eagles in North American facilities from 1995 to 2015, by birth type.

There is a paucity of empirical data on which to base predictions of life span for Steller's Sea-eagles, but academic sources suggest the species lives at least into its 20s (The duration of life in animals – IV. Birds, 1938, 195-235). To date, the oldest male Steller's Sea-eagle to have lived in North America died at ~29 years of age (SB# 29; approximate age of wild-caught bird) and the oldest female is still alive at ~19 years of age (SB#s 6 and 3; approximate age of wild-caught birds). Current life tables used for demographic analyses (Appendix C) indicate first-year mortality is 56% for males and 55% for females, although these values are calculated from very small sample sizes. Both sexes reach sexual maturity at ~4-5 years of age and females produce a single clutch of one to three eggs per breeding season.

The age structure of the Steller's Sea-eagle population depicts a small population with little recent or consistent reproduction (Figure 3). There are few birds in any particular age class, there are many gaps with no birds throughout the structure, and there is a paucity of birds in the youngest age classes. A columnar age structure is common for long-lived species, and such a structure also can oftentimes be robust while still containing gaps and few individuals per age class. This is typically only true with larger population sizes and consistent reproduction though, such that a sufficient number of animals exist to absorb demographic fluctuations in hatch and death rates. The sex ratio of the population is currently skewed towards males, with 1.25 males present for every female in the population. Because this species is monogamous, a biased sex ratio can significantly impact reproductive rates. If future imports are considered to improve the long-term viability of the population, the impact of imports on the population's sex ratio should be considered.

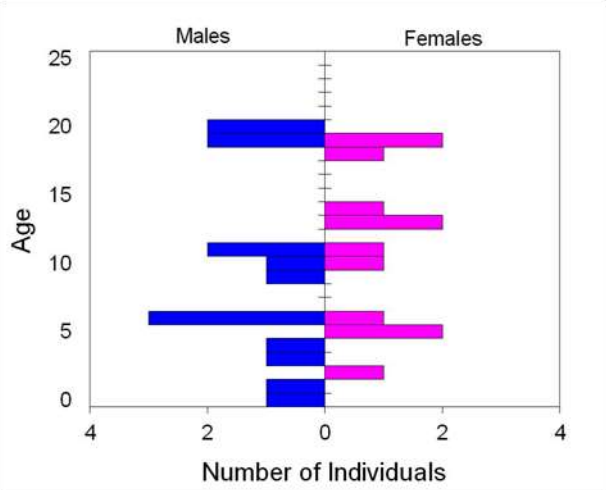

Figure 3. Age distribution of the formally managed population of Stellar's Sea-eagles. The population currently includes 15 males and 12 females.

Demographic analyses based on current life tables are largely uninformative in predicting the number of hatches needed to meet demographic goals, because they contain almost no mortality after one year of age (Appendix C). Over the last 10 years (2006-2015) there were 14 hatches and only 8 deaths, suggesting that the population can continue to slowly grow if desired. However, at 27 birds, the population is already over its TAG-recommended target of 20 individuals. Although reproduction has exceeded deaths, it is also important to note that all hatches have occurred to one of only three pairs at the Cincinnati Zoo and one pair at the Denver Zoo.

Genetics: The studbook pedigree indicates that the analytical Steller's Sea-eagle population is descended from 17 founders with two potential founders still remaining (Figure 4). The gene diversity of the population is 93.49%, which is equivalent to that found in approximately 7 or 8 unrelated animals (FGE = 7.68).

Genetics Summary

	2016	Current Potential
Number of Founders	17	2 additional
Founder Genome Equivalents (FGE)	7.68	14.26
Gene Diversity Retained (%)	93.49	96.49
Population Mean Kinship	0.0651	-----
Mean Inbreeding (F)	0.0000	-----
% Known Pedigree (Before/After Assumptions Exclusions)	85 / 100	-----
% Certain Pedigree (Before/After Assumptions and Exclusions)	85 / 100	-----
N_e/N	0.30*	-----
Years To 90% Gene Diversity	na**	-----
Years To 10% Loss of GD	na**	-----
Gene Diversity at 100 Years From Present (%)	na**	-----

*includes founders

**projections uninformative due to a lack of accurate generation length and projected growth rate

This Animal Program is currently a Red SSP Program and recommendations proposed are non-binding – Participation is voluntary. Dispositions to non-AZA institutions should comply with each institution's acquisition/disposition policy.

Typical AZA program goals include thresholds for tolerance of gene diversity loss over time; 90% gene diversity retention for 100 years is not an uncommon management goal. Decreases in gene diversity below 90% of that in the founding population have been associated with increasingly compromised reproduction by, among other factors, lower hatch weights, smaller clutch sizes, and greater neonatal mortality. The current gene diversity of the Steller's Sea-eagle population is ~93% and expected to further decline over time. 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 & Transfer Plans.

At this time, the best management strategy for improving gene diversity retention in the Steller's Sea-eagle population is managed breeding targeted at equalizing founder representations, which can be accomplished by preferentially breeding animals with low and well-matched mean kinships. Founder representations in the population are highly skewed (Figure 4); more equal representations would retain more gene diversity. Although nearly all individuals must receive breeding recommendations to ensure demographic viability, particular priority should be placed on breeding the two remaining potential founders (SB#s 5 and 34) and individuals descended from founders with low representations. SB# 48 is the only representative of founders 2 and 8, SB# 33 is the only representative of founders 41 and 42, and SB# 43 is the only representative of founders 44, 45, and 47 – these three birds (SB#s 48, 33, 43) are high genetic priorities for breeding. Because only two institutions within the managed population have been successful at breeding Steller's Sea-eagles, rotating genetically valuable birds into these institutions is likely to afford them higher probabilities of successfully producing offspring.

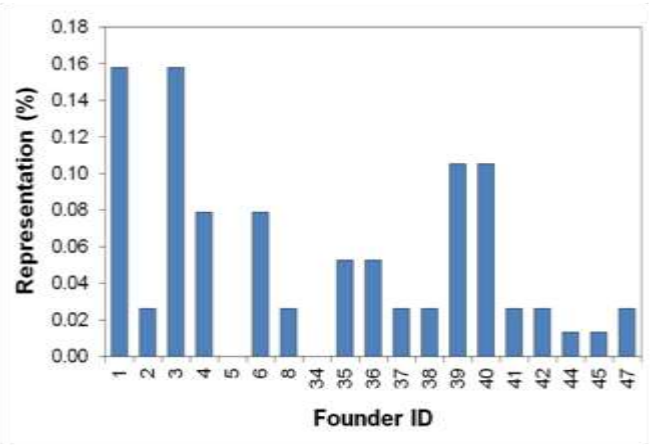

Figure 4. Graph illustrating the distribution of founder representations in the analytical Stellar's Sea-eagle population.

Management Strategy: The current, formally managed population of Steller's Sea-eagles is 27 birds (15 males, 12 females) distributed among 12 AZA institutions and two private North American facilities. At this time, all reproductively capable females are recommended to breed to continue improving reproductive husbandry and slowly growing the population. Over the last 10 years (2006-2015) there were 14 hatches and only 8 deaths, suggesting that the population can continue to slowly grow if desired. However, it is important to note that all hatches have occurred to one of only three pairs at the Cincinnati Zoo and one pair at the Denver Zoo. The recruitment of additional facilities that are likely to have reproductive success, as well as improving husbandry at existing facilities, would afford a greater degree of demographic stability to this population. Although the population is currently over its TAG-recommended target size of 20 birds, a larger target size will be necessary for this population to be genetically and demographically viable over the long-term. From a genetic perspective, particular emphasis should be placed on breeding the two remaining potential founders (SB#s 5 and 34) and individuals descended from founders with low representations (SB#s 48, 33, 43) to help maintain, as well as potentially increase, gene diversity.

This is a 3-year plan (2016-2018). Although another full set of recommendations will not be produced until 2019, interim recommendations will continue to be made as needed. 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.

At this time, the program:

1. **Recommends 12 females for unrestricted breeding.**

2. **Recommends 5 transfers to meet institutional requests and establish one new breeding pair.**

Summary of Breeding and Transfer Recommendations

ID	Location	Sex	Age	Disposition	Location	Breeding	With	Notes
1	LOUISVILL	M	20	HOLD	LOUISVILL	BREED WITH	3	
2	CINCINNAT	M	20	HOLD	CINCINNAT	BREED WITH	8	
3	LOUISVILL	F	19	HOLD	LOUISVILL	BREED WITH	1	
4	SANDIEGOZ	M	19	HOLD	SANDIEGOZ	BREED WITH	6	
5	SEATTLE	M	19	HOLD	SEATTLE	BREED WITH	14	
6	SANDIEGOZ	F	19	HOLD	SANDIEGOZ	BREED WITH	4	
8	CINCINNAT	F	18	HOLD	CINCINNAT	BREED WITH	2	
9	PITTS CA	F	14	HOLD	PITTS CA	BREED WITH	11	
10	CLEVELAND	F	13	HOLD	CLEVELAND	BREED WITH	43	
11	PITTS CA	M	11	HOLD	PITTS CA	BREED WITH	9	
12	DENVER	F	11	HOLD	DENVER	BREED WITH	15	
13	ROCKTON	M	10	HOLD	ROCKTON	BREED WITH	18	
14	SEATTLE	F	10	HOLD	SEATTLE	BREED WITH	5	
15	DENVER	M	9	HOLD	DENVER	BREED WITH	12	
16	LOSANGELE	M	6	HOLD	LOSANGELE	BREED WITH	19	
17	LOSANGELE	M	6	HOLD	LOSANGELE	DO NOT BREED		
18	ROCKTON	F	6	HOLD	ROCKTON	BREED WITH	13	
19	CHINDGREN	F	5	SEND TO	LOSANGELE	BREED WITH	16	
21	FORTWORTH	M	4	SEND TO	COLUMBUS	BREED WITH	24	
24	FORTWORTH	F	2	SEND TO	COLUMBUS	BREED WITH	21	
28	COLUMBUS	M	1	SEND TO	TBD	DO NOT BREED		
31	WINNIPEG	F	13	HOLD	WINNIPEG	BREED WITH	32	
32	WINNIPEG	M	11	HOLD	WINNIPEG	BREED WITH	31	
33	TORONTO	F	5	HOLD	TORONTO	BREED WITH	34	
34	TORONTO	M	3	HOLD	TORONTO	BREED WITH	33	
43	CLEVELAND	M	6	HOLD	CLEVELAND	BREED WITH	10	
48	CINCINNAT	M	0	SEND TO	CHINDGREN	DO NOT BREED		

Recommendations by Institution

CHINDGREN

Skyking Birds
Salt Lake City, UT

Institutional Notes: The SSP would like to move F19 into a breeding institution. Please discuss any concerns you have with this recommendation with the SSP Coordinator.

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
19	unknown	F	5	SEND TO	LOSANGELE	BREED WITH	16	
48	216012	M	0	RECEIVE FROM	CINCINNAT	DO NOT BREED		

CINCINNAT

Cincinnati Zoo & Botanical Garden
Cincinnati, OH

Institutional Notes: This is an established breeding pair that last produced a chick in 2016. The SSP continues to recommend breeding this pair at this time.

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2	212153	M	20	HOLD	CINCINNAT	BREED WITH	8	
8	212152	F	18	HOLD	CINCINNAT	BREED WITH	2	
48	216012	M	0	SEND TO	CHINDGREN	DO NOT BREED		

CLEVELAND

Cleveland Metroparks Zoo
Cleveland, OH

Institutional Notes: This pair has been together at CLEVELAND since 2011 and has not yet produced offspring, but M43 has just reached reproductive age. Please update the SSP Coordinator on any observed breeding behavior.

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
10	M90432	F	13	HOLD	CLEVELAND	BREED WITH	43	
43	110321	M	6	HOLD	CLEVELAND	BREED WITH	10	

COLUMBUS

Columbus Zoo and Aquarium
Columbus, OH

Institutional Notes: The SSP recommends you receive an immature pair from FORTWORTH, which is intended to be a future breeding pair when both birds reach sexual maturity. Please work with the SSP Coordinator to place M28.

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
28	115083	M	1	SEND TO	TBD	DO NOT BREED		
21	207759	M	4	RECEIVE FROM	FORTWORTH	BREED WITH	24	
24	208990	F	2	RECEIVE FROM	FORTWORTH	BREED WITH	21	

DENVER

Denver Zoo
Denver, CO

Institutional Notes: This is an established breeding pair that last produced chicks in 2016. The SSP continues to recommend breeding this pair at this time.

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
12	A06040	F	11	HOLD	DENVER	BREED WITH	15	
15	A08388	M	9	HOLD	DENVER	BREED WITH	12	

FORTWORTH

Fort Worth Zoo
Fort Worth, TX

Institutional Notes: Per institutional request, the SSP is recommending a transfer for this pair.

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
21	207759	M	4	SEND TO	COLUMBUS	BREED WITH	24	
24	208990	F	2	SEND TO	COLUMBUS	BREED WITH	21	

LOSANGELE

Los Angeles Zoo
Los Angeles, CA

Institutional Notes: The SSP would like to pair one of your males for breeding. If you're unable to hold an additional bird, please discuss placement options for one of your males with the SSP Coordinator.

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
16	992361	M	6	HOLD	LOSANGELE	BREED WITH	19	
17	992362	M	6	HOLD	LOSANGELE	DO NOT BREED		
19	unknown	F	5	RECEIVE FROM	CHINDGREN	BREED WITH	16	

LOUISVILL

Louisville Zoo
Louisville, KY

Institutional Notes: This breeding pair successfully produced chicks at CINCINNAT, with the last chick being produced in 2006. The pair was transferred to SANDIEGOZ in 2006 and then LOUISVILL in 2012; no chicks were produced at SANDIEGOZ and none have yet been produced at LOUISVILL. Please update the SSP Coordinator on any observed breeding behavior.

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1	202522	M	20	HOLD	LOUISVILL	BREED WITH	3	
3	202523	F	19	HOLD	LOUISVILL	BREED WITH	1	

PITTS CA

National Aviary
Pittsburgh, PA

Institutional Notes: This pair has been together at PITTS CA since 2006 and has not yet produced any offspring. Please update the SSP Coordinator on any observed breeding behavior.

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
9	7503	F	14	HOLD	PITTS CA	BREED WITH	11	
11	7473	M	11	HOLD	PITTS CA	BREED WITH	9	

ROCKTON

African Lion Safari
Cambridge, ON (Canada)

Institutional Notes: This pair has been together at ROCKTON since 2015 and has not yet produced any offspring, but F18 has just reached reproductive age. Please update the SSP Coordinator on any observed breeding behavior.

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
13	NONE	M	10	HOLD	ROCKTON	BREED WITH	18	
18	52829	F	6	HOLD	ROCKTON	BREED WITH	13	

SANDIEGOZ

San Diego Zoo
San Diego, CA

Institutional Notes: This breeding pair successfully produced chicks at CINCINNAT, with the last chick being produced in 2012. The pair has been at SANDIEGOZ since 2012 and not yet produced any offspring. There is some speculation that SANDIEGOZ may be too southern a facility for this species to breed without husbandry manipulation.

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
4	398003	M	19	HOLD	SANDIEGOZ	BREED WITH	6	
6	398001	F	19	HOLD	SANDIEGOZ	BREED WITH	4	

SEATTLE

Woodland Park Zoo
Seattle, WA

Institutional Notes: This pair has been together at SEATTLE since 2011; they produced an egg in 2016 but don't yet have any surviving offspring. Please continue to update the SSP Coordinator on any observed breeding behavior.

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
5	203640	M	19	HOLD	SEATTLE	BREED WITH	14	
14	203939	F	10	HOLD	SEATTLE	BREED WITH	5	

TORONTO

Toronto Zoo
Toronto, ON (Canada)

Institutional Notes: This is an immature pair that can breed when both birds are sexually mature.

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
33	47097	F	5	HOLD	TORONTO	BREED WITH	34	
34	47216	M	3	HOLD	TORONTO	BREED WITH	33	

WINNIPEG

Assiniboine Park Zoo
Winnipeg, MB (Canada)

Institutional Notes: This pair has been together at WINNIPEG since 2006 and has not yet produced any offspring. Please update the SSP Coordinator on any observed breeding behavior.

ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
31	F00138	F	13	HOLD	WINNIPEG	BREED WITH	32	
32	G00051	M	11	HOLD	WINNIPEG	BREED WITH	31	

Appendix A
Analytical Assumptions

SB#	Current Sire ID	New Sire ID	Current Dam ID	New Dam ID	Notes
34	UNK	WILD	UNK	WILD	Hatched at SAPPORO in 3/1996; believed unrelated to other birds with UNK/UNK parentage.
39	UNK	WILD	UNK	WILD	Hatched by Jullmann in 4/2001; believed unrelated to other birds with UNK/UNK parentage.
41	UNK	WILD	UNK	WILD	Hatched at LIBEREC in 4/2004; believed unrelated to other birds with UNK/UNK parentage.
42	UNK	WILD	UNK	WILD	Hatched by Petr Stika in 5/2013; believed unrelated to other birds with UNK/UNK parentage.

Appendix B
Summary of Data Exports

Report compiled under PopLink V. 2.4 and PMx 1.2.20160928
Project: EagleStellarsSea_October2016
Created: 2016-10-17

Studbook information:
Data compiled by: Beau Parks
Data current thru: 01 October 2016
Scope of data: North America

Primary data file:
XXEagleStellarsSea_August2016.ped
Filter conditions:
Dates: 1996-01-01 to 2016-10-17
Locations: N.AMERICA
Other Filters: Status = Living

Moves data files:
XXEagleStellarsSea_August2016genetics.csv
XXEagleStellarsSea_August2016demog.csv
Filter conditions:
Dates: 1996-01-01 to 2016-10-17
Locations: N.AMERICA
Other Filters: Status = Living

There are 20 hatches in the demographic window. Of these:
20 births are attributed to known parents with a known age (0%).
0 births are attributed to known parents with an unknown age.
0 births are attributed to unknown parents.

Non-AZA Institutions: CHINDGREN, ROCKTON

Appendix C
Life Tables

MALES											
Age	**Px**	**Mid Px**	**Qx**	**Risk Qx**	**Lx**	**Mid Lx**	**Mx**	**Risk Mx**	**Ex**	**Vx**	**Cx**
0	0.56	0.71	0.44	7.0	1.00	0.78	0.00	7.0	---	1.29	0.06
1	1.00	1.00	0.00	13.2	0.56	0.56	0.00	13.2	---	1.81	0.04
2	1.00	1.00	0.00	13.0	0.56	0.56	0.00	13.0	---	1.81	0.04
3	1.00	1.00	0.00	13.0	0.56	0.56	0.00	13.0	---	1.82	0.04
4	1.00	1.00	0.00	12.4	0.56	0.56	0.00	12.4	---	1.82	0.04
5	1.00	1.00	0.00	11.5	0.56	0.56	0.05	11.5	---	1.83	0.04
6	1.00	1.00	0.00	10.1	0.56	0.56	0.19	10.1	---	1.79	0.04
7	1.00	1.00	0.00	8.0	0.56	0.56	0.13	8.0	---	1.61	0.04
8	1.00	1.00	0.00	8.0	0.56	0.56	0.25	8.0	---	1.49	0.04
9	1.00	1.00	0.00	7.9	0.56	0.56	0.14	7.9	---	1.24	0.04
10	1.00	1.00	0.00	6.9	0.56	0.56	0.00	6.9	---	1.10	0.04
11	1.00	1.00	0.00	5.5	0.56	0.56	0.00	5.5	---	1.11	0.04
12	1.00	1.00	0.00	5.0	0.56	0.56	0.13	5.0	---	1.11	0.04
13	1.00	1.00	0.00	4.0	0.56	0.56	0.25	4.0	---	0.99	0.04
14	1.00	1.00	0.00	4.0	0.56	0.56	0.25	4.0	---	0.74	0.04
15	1.00	1.00	0.00	4.0	0.56	0.56	0.00	4.0	---	0.49	0.04
16	1.00	1.00	0.00	4.0	0.56	0.56	0.00	4.0	---	0.50	0.04
17	1.00	1.00	0.00	4.0	0.56	0.56	0.00	4.0	---	0.50	0.04
18	1.00	1.00	0.00	4.0	0.56	0.56	0.13	4.0	---	0.50	0.04
19	1.00	1.00	0.00	3.7	0.56	0.56	0.38	3.7	---	0.38	0.04
20	---	---	---	---	---	---	---	---	---	---	---

Px = survival; Qx = mortality; lx = cumulative survivorship; Mx = fecundity
Ex = life expectancy; Vx = reproductive value; Cx = stable age distribution
At Risk (Qx and Mx) = number of animals corresponding values are estimated from
r = 0.0030; lambda = 1.0030; T = 12.3

Ex not calculated because oldest male in data selection (SB# 2) is still living.

FEMALES											
Age	**Px**	**Mid Px**	**Qx**	**Risk Qx**	**Lx**	**Mid Lx**	**Mx**	**Risk Mx**	**Ex**	**Vx**	**Cx**
0	0.55	0.71	0.45	7.9	1.00	0.77	0.00	7.9	---	1.29	0.06
1	1.00	1.00	0.00	9.0	0.55	0.55	0.00	9.0	---	1.82	0.04
2	1.00	1.00	0.00	9.0	0.55	0.55	0.00	9.0	---	1.80	0.04
3	1.00	1.00	0.00	9.0	0.55	0.55	0.00	9.0	---	1.78	0.04
4	1.00	1.00	0.00	9.6	0.55	0.55	0.00	9.6	---	1.77	0.04
5	1.00	1.00	0.00	10.5	0.55	0.55	0.05	10.5	---	1.75	0.04
6	1.00	1.00	0.00	9.6	0.55	0.55	0.00	9.6	---	1.69	0.04
7	1.00	1.00	0.00	9.0	0.55	0.55	0.17	9.0	---	1.67	0.04
8	1.00	1.00	0.00	9.0	0.55	0.55	0.22	9.0	---	1.49	0.05
9	1.00	1.00	0.00	9.0	0.55	0.55	0.11	9.0	---	1.26	0.05
10	1.00	1.00	0.00	8.9	0.55	0.55	0.13	8.9	---	1.14	0.05
11	1.00	1.00	0.00	7.5	0.55	0.55	0.00	7.5	---	1.00	0.05
12	1.00	1.00	0.00	7.0	0.55	0.55	0.07	7.0	---	1.00	0.05
13	1.00	0.90	0.00	6.4	0.55	0.55	0.20	6.4	---	0.92	0.05
14	0.80	0.89	0.20	4.4	0.55	0.49	0.33	4.4	---	0.79	0.04
15	1.00	1.00	0.00	3.0	0.44	0.44	0.00	3.0	---	0.51	0.04
16	1.00	1.00	0.00	3.0	0.44	0.44	0.17	3.0	---	0.50	0.04
17	1.00	1.00	0.00	3.0	0.44	0.44	0.33	3.0	---	0.33	0.04
18	1.00	1.00	0.00	2.8	0.44	0.44	0.00	2.8	---	0.00	0.04
19	1.00	1.00	0.00	1.7	0.44	0.44	0.00	1.7	---	0.00	0.04
20	---	---	---	---	---	---	---	---	---	---	---

Px = survival; Qx = mortality; lx = cumulative survivorship; Mx = fecundity
Ex = life expectancy; Vx = reproductive value; Cx = stable age distribution
At Risk (Qx and Mx) = number of animals corresponding values are estimated from
r = -0.0090; lambda = 0.9910; T = 12.1

Ex not calculated because oldest female in data selection (SB# 6) is still living.

Appendix D

Individuals Excluded from Genetic Analyses

No individuals were excluded.

Appendix E

Ordered Mean Kinships

Note: This list is current to October 2016 and based on an analytical studbook. Values are subject to change with any birth, death, import, export, inclusion, or exclusion. **Average Population MK = 0.0651**

MALES					FEMALES				
SB#	**MK**	**% Known**	**Age**	**Location**	**SB#**	**MK**	**% Known**	**Age**	**Location**
5	0.0000	100	19	SEATTLE	8	0.0132	100	18	CINCINNAT
34	0.0000	100	3	TORONTO	33	0.0263	100	5	TORONTO
2	0.0132	100	20	CINCINNAT	6	0.0395	100	19	SANDIEGOZ
32	0.0263	100	11	WINNIPEG	9	0.0395	100	14	PITTS CA
43	0.0263	100	6	CLEVELAND	31	0.0395	100	13	WINNIPEG
48	0.0263	100	0	CINCINNAT	18	0.0526	100	6	ROCKTON
4	0.0395	100	19	SANDIEGOZ	19	0.0526	100	5	CHINDGREN
21	0.0526	100	4	FORTWORTH	3	0.0789	100	19	LOUISVILL
16	0.0658	100	6	LOSANGELE	10	0.0921	100	13	CLEVELAND
17	0.0658	100	6	LOSANGELE	14	0.0921	100	10	SEATTLE
1	0.0789	100	20	LOUISVILL	12	0.1053	100	11	DENVER
15	0.0789	100	9	DENVER	24	0.1053	100	2	FORTWORTH
11	0.0921	100	11	PITTS CA					
13	0.0921	100	10	ROCKTON					
28	0.1053	100	1	COLUMBUS					

Appendix F
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. Re 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 http://www.aza.org/board-policies/.

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 (λ) 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 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 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 G

Directory of Institutional Representatives

Contact Name (IR)	Institution	Email Address
Steve Chindgren	CHINDGREN Skyking Birds	stevechindgren@comcast.net
Jennifer Gainer	CINCINNAT Cincinnati Zoo & Botanical Garden	jennifer.gainer@cincinnatizoo.org
Travis Vineyard	CLEVELAND Cleveland Metroparks Zoo	tgv@clevelandmetroparks.com
Kelly Vineyard	COLUMBUS Columbus Zoo and Aquarium	kelly.vineyard@columbuszoo.org
John Azua MaryJo Willis	DENVER Denver Zoological Gardens	jazua@denverzoo.org; mjwillis@denverzoo.org
Katy Unger	FORTWORTH Fort Worth Zoo	kunger@fortworthzoo.org
Mike Maxcy	LOSANGELE Los Angeles Zoo	mike.maxcy@lacity.org
Gary Michael	LOUISVILL Louisville Zoological Garden	gary.michael@louisvilleky.gov
Teri Grendzinski	PITTS CA National Aviary	teri.grendzinski@aviary.org
Gareth Morgan	ROCKTON African Lion Safari	birds@lionsafari.com
Dave Rimlinger	SANDIEGOZ San Diego Zoo	drimlinger@sandiegozoo.org
Mark Myers	SEATTLE Woodland Park Zoo	mark.myers@Zoo.org
Kevin Kerr	TORONTO Toronto Zoo	kkerr@torontozoo.ca
Gary Lunsford	WINNIPEG Assiniboine Park Zoo	glunsford@assiniboinepark.ca