# Population Analysis & Breeding and Transfer Plan

## Little Blue Penguin (*Eudyptula minor*)
## AZA Species Survival Plan®
## Yellow Program


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

# Executive Summary
## Little Blue Penguin (*Eudyptula minor*)

The current Little Blue Penguin SSP population consists of 62 individuals (29.33.0) distributed among 3 AZA institutions. The Penguin Taxon Advisory Group set a target population size of 90 for Little Blue Penguin in their 2010 Regional Collection Plan (although this seems to be an underestimate of current institutional needs). Under AZA's sustainability designations, this population currently qualifies as a Yellow SSP Program.

The genetic analysis was re-done to incorporate historical information received during the draft comment period. The current gene diversity of the breeding population is 96%, equivalent to that of about 13 unrelated birds (FGE = 13.14). Under current population parameters and a 3% growth rate (λ = 1.03), 90% gene diversity can be maintained for 31 years, and 82% for 10 generations. When gene diversity falls below 90% in some species, it is expected that reproduction will be increasingly compromised by, among other factors, lower hatch weights and greater hatchling mortality.

**DEMOGRAPHY**

| | |
|---|---|
| Current size of population (N) – Total (Males.Females.Unknown Sex) | 62 (29.33.0) |
| Number of individuals excluded from potentially breeding population | 0 |
| Population size following exclusions | 62 (29.33.0) |
| Target population size (Kt) from Penguin TAG's 2010 RCP | 90 |
| Mean generation time (years) | 7.65 |
| Historical (1980 to present) / Potential population growth rate (λ,lambda) | 0.947 / 1.03 |

**GENETICS**

Based on the current potentially breeding population with analytical assumptions

| | Current | Potential |
|---|---|---|
| Founders | 38 | 0 |
| Founder genome equivalents (FGE) | 13.14 | 21.19 |
| Gene diversity (GD %) | 96.19 | 97.63 |
| Population mean kinship (MK) | 0.0389 | - |
| Mean inbreeding (F) | 0.0083 | - |
| Percentage of pedigree known before exclusions and assumptions | Approx. 96 | - |
| Percentage of pedigree known after exclusions and assumptions | 100 | - |
| Effective population size/census size ratio (Ne / N) | 0.3891 | - |
| Years To 90% Gene Diversity** | 31 | - |
| Years to 10% Loss of Gene Diversity** | 54 | - |
| Gene Diversity at 100 Years From Present (%)** | 79 | - |
| Gene Diversity in 10 generations (Tx10=77 years) (%)** | 82 | |

** Assuming λ = 1.03, Target size = 90

According to demographic projections, approximately 9 to 10 hatches are needed per year to maintain the population at its current size of 62 individuals. To increase the population size to the Penguin TAG's recommended target size of 90 in the next 12 years, about 11 to 13 hatches are needed per year (λ = 1.03). An import is planned for 2015 so the TAG's recommended target size may be reached earlier than this; however **due to increased demand for the birds across AZA due to new institutions coming on board, the SSP wishes to maximize breeding across existing SSP colonies.** As with most AZA managed populations, recommended pairings have been determined with consideration for mean kinship, population change in gene diversity, maximum avoidance of inbreeding, demographic goals, and the needs of individual institutions in an attempt to increase and maintain gene diversity for as long as possible.

**Summary Actions:** The SSP has provided **MateR$_x$** Mate Suitability Indices to guide participating institutions in decisions regarding pairing and the regulation of reproduction. Pairs that are rated 1-4 should be allowed to breed. There is no limit on breeding at this time.

# Table of Contents

# Acknowledgments

The Little Blue Penguin SSP planning session was via internet conferencing on 12 November 2014 and attended by:

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David Oehler, SSP Vice-Coordinator, Wildlife Conservation Society - Bronx Zoo
Cara Groome Bryan, AZA Population Management Center



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# Description of Population Status

## Little Blue Penguin (*Eudyptula minor*)

**Introduction:** The current Little Blue Penguin SSP population consists of 62 individuals (29.33.0) distributed among 3 AZA institutions. The Penguin Taxon Advisory Group set a target population size of 90 for Little Blue Penguin in their 2010 Regional Collection Plan (although this seems to be an underestimate of current institutional needs). Under AZA's sustainability designations, this population currently qualifies as a Yellow SSP Program.

Comprehensive genetic and demographic analyses of the population were performed in November 2014 on the North American Regional Little Blue Penguin Studbook (current to 1 October 2014) using PopLink 2.4, PM2000 1.213, and PMx 1.2.2. This is the third breeding and transfer plan for this population. Recommendations proposed in this Yellow SSP are non-binding; participation is voluntary.

**Analytical Population:** Thirty-six of the 62 currently living AZA individuals have some unknownness in their ancestral pedigrees. An analytical studbook was created to address some of the unknown parentage in the population's pedigree (Appendix A); after which only 4 birds remain with some unknownness. It is hoped that through more investigation into their pedigree, this unknownness may be resolved in the future. At this time, the analytical population has a pedigree that is 97.2% known. No birds were excluded from the analysis.

**Demography:** Records indicate that the first little blue penguins appeared in AZA zoos and aquariums in 1958. But the population size remained less than 20 individuals until 1997, when the population continued to rapidly increase. This population peaked at 77 individuals in 2004 and has been slightly declining since then (λ since 2004 = 0.963) (Figures 1). Imports were common in the 1990s, but have slowed to about 10 imported individuals every five years since then. The last import of 22 birds was in 2012. A potential future import is planned for 2015 from the Australasian Zoo and Aquarium Association. The first zoo or aquarium hatch was in 1984. The total population growth rate over the last 5 years has been negative overall (λ=0.99). This decline may be due to few experienced breeding pairs, past space limitations, and issues with tuberculosis (TB). At this time the SSP wishes to maximize breeding across AZA institutions in order to grow colonies and to create new colonies for new institutions joining the SSP.

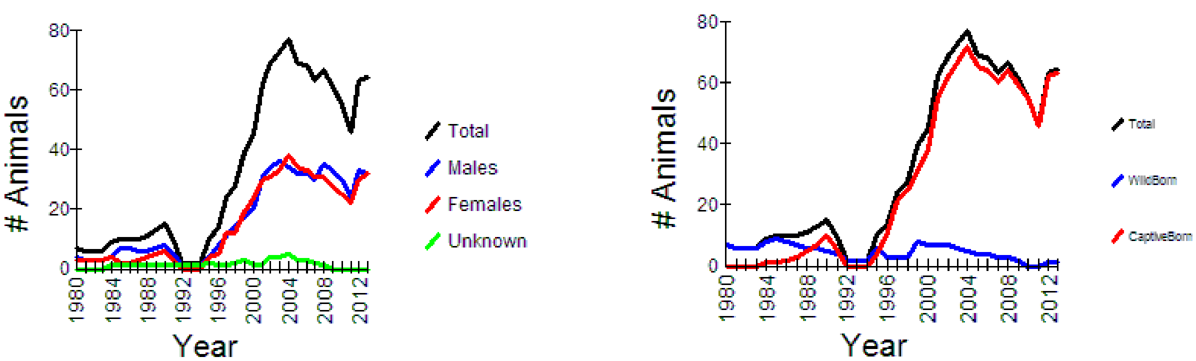


**Figure 1.** Annual census by (i) sex and (ii) hatch type for the Little Blue Penguin SSP population from 1980 through 2014.

The age pyramid has become more stable recently due to the recent importation (Figure 2). It has taken a more columnar shape and birds occupy all age classes. There is a noticeable sex bias in the lower age classes however that should be monitored. The SSP should focus on achieving consistent breeding from year to year to ensure that there will continue to be reproductive-aged animals into the future, and so that the population is not ultimately relying on importations.

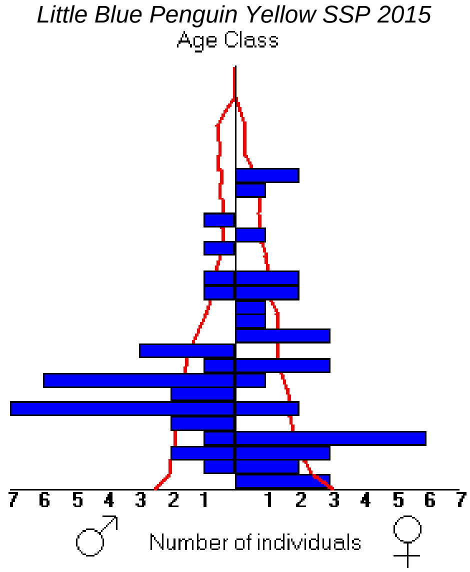


**Figure 2.** Age structure of the current Little Blue Penguin SSP population.

According to the studbook data, males have reproduced from ages 1 to 17, and females from ages 1 to 16. First-year mortality is a little high at 37% for males and 33% for females. The oldest recorded individual in AZA was an unsexed individual that lived to 26 years of age. Other than this individual, the oldest male was 16 and the oldest female was 22 years of age. Clutch size has varied from one to two eggs per clutch, with a mean of 1.24. The breeding season in zoos and aquariums extends throughout the year, but is a little more common from September through December.

Demographic projections indicate that to maintain the population at its current size of 62 individuals, approximately 9 to 10 hatches are needed per year. To increase the population size to the Penguin TAG's recommended target size of 90 in the next 12 years, about 11 to 13 hatches are needed per year ($\lambda = 1.03$). An import is planned for 2015 so the TAG's recommended target size may be reached earlier than this; however **due to increased demand for the birds across AZA due to new institutions coming on board, the SSP wishes to maximize breeding across existing SSP colonies.**

**Genetics:** This genetic analysis is based on the current studbook with an analytical overlay to address pedigree unknownness in the population. The current population is descended from 38 founders with no additional potential founders remaining (Figure 3). The current gene diversity of this population is high at 96%, equivalent to that of over 13 unrelated birds (FGE = 13.14). According to genetic projections based on the current population status and a growth rate of 3% (λ = 1.03), the population could maintain 90% gene diversity for 31 years, and 82% gene diversity over the next 10 generations. When gene diversity falls below 90%, it is expected that in some species, reproduction will be increasingly compromised by, among other factors, lower hatch weights, smaller clutch sizes, and greater hatchling mortality.

Gene diversity retention can be improved by increasing the proportion of breeding individuals (Ne/N), equalizing the representation of founders that have bred, increasing the growth rate, and importing unrelated individuals.

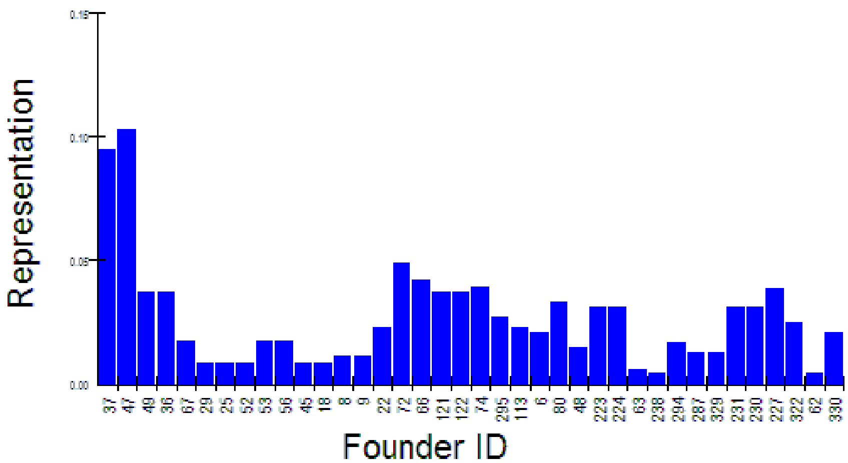


**Figure 5**. True and hypothetical founder representation of the current Little Blue Penguin SSP population.

| **GENETIC SUMMARY (based on an analytical studbook with pedigree assumptions)** | ***Previous*** | | | **Current** | |
|---|---|---|---|---|---|
| | ***2006*** | ***2009*** | ***2011*** | **2014** | **Potential** |
| Founders | *29* | *35* | *28* | 38 | 0 |
| Founder genome equivalents (FGE) | *10.45* | *10.94* | *11.71* | 13.14 | 21.19 |
| Gene diversity (GD%) | *95.21* | *95.43* | *95.52* | 96.19 | 97.63 |
| Population mean kinship (MK) | *0.0480* | *0.0457* | *0.0448* | 0.0389 | - |
| Mean inbreeding (F) | *0.0057* | *0.0058* | *0.0058* | 0.0083 | - |
| Pedigree known before assumptions and exclusions (%) | *50.7* | *73.7* | *96.3* | Approx. 96 | - |
| Pedigree known after assumptions and exclusions (%) | *89.9* | *93.2* | *100* | 100 | - |
| Effective population size / census size ratio (Ne / N) | *0.2310* | *0.1893* | *0.3473* | 0.3891 | - |
| Years To 90% Gene Diversity** | *< 10* | - | *16* | 31 | - |
| Years to 10% Loss of Gene Diversity** | - | - | *42* | 54 | - |
| Gene Diversity at 100 Years From Present (%)** | *70* | - | *75.35* | 79 | - |
| Gene Diversity in 10 generations from present (Tx10=77years) (%)** | - | - | - | 82 | |

** Assuming λ = 1.03, Target size = 90

**Management Strategy:** According to demographic projections, approximately 9 to 10 hatches are needed per year to maintain the population at its current size of 62 individuals. To increase the population size to the Penguin TAG's recommended target size of 90 in the next 12 years, about 11 to 13 hatches are needed per year ($\lambda = 1.03$). An import is planned for 2015 so the TAG's recommended target size may be reached earlier than this; however **due to increased demand for the birds across AZA with new institutions coming on board, the SSP wishes to maximize breeding across existing SSP colonies.**

Recommended pairings have been determined with consideration for mean kinship, change in population gene diversity, maximum avoidance of inbreeding, pedigree unknownness and demographic goals in an attempt to increase and maintain gene diversity for as long as possible. To help achieve this goal, breeding recommendations have been provided in the form of a matrix that ranks all possible breeding combinations within the analytical population using $MateR_x$ software. A $MateR_x$ matrix prioritizes pairs using a Mate Suitability Index (MSI) and participants are encouraged to use $MateR_x$ to guide pairings within their institutions.

At this time **the SSP has placed no limit on breeding across AZA institutions**. MSI rankings or 1-4 are recommended in order to meet demographic goals for the population. For more information on $MateR_x$, see below.

1. Recommend that all potentially breeding pairs with a MateRx MSI rating of 1, 2, 3 or 4 be allowed to breed.

2. No transfers are recommended at this time. It is possible that some interim transfers may be recommended by the SSP Coordinator once the impending import occurs as new colonies are created.

# Explanation of Recommendations Using MateR$_x$

**MateR$_x$** is analytical software developed jointly by the National Zoological Park and Lincoln Park Zoo. The primary output is a matrix of genetic ratings (Mate Suitability Indices = MSI) for every possible breeding pair in a population. MSIs allow managers to quickly discover how the genetic status of individuals in their collections compares to the rest of a managed population.

**Each MSI represents the genetic consequences for the population if a given pair was to produce offspring. There are seven values for MSIs: offspring of pairs rated 1, 2, 3 , or 4 would benefit the population's genetic situation; pairs rated 5 or 6 typically have some level of inbreeding or unknown parentage. Pairs without an MSI value (i.e., a dash [--]) should not be considered under any circumstances without consulting your PMC advisor. These MSI values are defined as:**

**1** – Very beneficial
**2** – Moderately beneficial
**3** – Slightly beneficial
4 – Average
5 – Moderately detrimental
6 – Very detrimental
"-" – no way!

**MateR$_x$** integrates four genetic factors to produce the Mate Suitability Index (MSI). These four components are currently used by PMC population advisors to develop pairing recommendations for SSPs. In decreasing order of "importance," they are:

1. the expected change in genetic diversity (increase, decrease) that would result if an offspring of a pair is added to the population;
2. the relative rareness or commonness of the parents' genetic information (i.e., the relative dissimilarity of parental mean kinships);
3. the inbreeding coefficient of offspring that would be produced by a pair; and
4. the proportion, if any, of the dam and/or sire's pedigree that is of unknown origin.

Each **MateR$_x$** MSI value represents a continuous range of rankings which PMC population advisors can use to fine tune recommendations for the maximum possible genetic benefits to a population.

Please note that unknown sex individuals cannot be included in the **MateR$_x$** matrices.

# Recommendations by Institution

**BOS NEAQ**

**New England Aquarium**
Boston, MA

Institutional notes: Institutions should encourage pairings with an MSI of 1, 2, 3, or 4. Pairings of 5, 6 or "-"are not recommended and should be discouraged. At this time there is no limit on breeding. Increased production is encouraged.

| ID | Local ID | Sex | Age | Disposition | Location | Breeding | With | Notes |
|---|---|---|---|---|---|---|---|---|
| 75 | 97037 | F | 20 | HOLD | BOS NEAQ | BREED WITH | SEE MATERX | |
| 97 | 97039 | M | 18 | HOLD | BOS NEAQ | BREED WITH | SEE MATERX | |
| 134 | 00053 | M | 14 | HOLD | BOS NEAQ | BREED WITH | SEE MATERX | |
| 135 | 00051 | F | 14 | HOLD | BOS NEAQ | BREED WITH | SEE MATERX | |
| 147 | 01054 | M | 13 | HOLD | BOS NEAQ | BREED WITH | SEE MATERX | |
| 168 | 02059 | F | 12 | HOLD | BOS NEAQ | BREED WITH | SEE MATERX | |
| 265 | 05-077 | M | 9 | HOLD | BOS NEAQ | BREED WITH | SEE MATERX | |
| 276 | 075528 | F | 8 | HOLD | BOS NEAQ | BREED WITH | SEE MATERX | |
| 277 | 075973 | M | 7 | HOLD | BOS NEAQ | BREED WITH | SEE MATERX | |
| 281 | 080780 | F | 7 | HOLD | BOS NEAQ | BREED WITH | SEE MATERX | |
| 282 | 080781 | M | 7 | HOLD | BOS NEAQ | BREED WITH | SEE MATERX | |
| 283 | 080782 | M | 7 | HOLD | BOS NEAQ | BREED WITH | SEE MATERX | |
| 284 | 080783 | M | 7 | HOLD | BOS NEAQ | BREED WITH | SEE MATERX | |
| 295 | 120454 | F | 10 | HOLD | BOS NEAQ | BREED WITH | SEE MATERX | |
| 325 | 120448 | M | 7 | HOLD | BOS NEAQ | BREED WITH | SEE MATERX | |
| 333 | 120450 | M | 5 | HOLD | BOS NEAQ | BREED WITH | SEE MATERX | |
| 334 | 120451 | M | 5 | HOLD | BOS NEAQ | BREED WITH | SEE MATERX | |
| 336 | 120447 | M | 5 | HOLD | BOS NEAQ | BREED WITH | SEE MATERX | |
| 337 | 120453 | F | 5 | HOLD | BOS NEAQ | BREED WITH | SEE MATERX | |
| 341 | 120446 | M | 4 | HOLD | BOS NEAQ | BREED WITH | SEE MATERX | |
| 342 | 120456 | F | 3 | HOLD | BOS NEAQ | BREED WITH | SEE MATERX | |
| 343 | 120455 | F | 3 | HOLD | BOS NEAQ | BREED WITH | SEE MATERX | |
| 344 | 120457 | F | 3 | HOLD | BOS NEAQ | BREED WITH | SEE MATERX | |
| 346 | 120458 | F | 3 | HOLD | BOS NEAQ | BREED WITH | SEE MATERX | |
| 347 | 120459 | F | 3 | HOLD | BOS NEAQ | BREED WITH | SEE MATERX | |
| 357 | 135110 | F | 1 | HOLD | BOS NEAQ | BREED WITH | SEE MATERX | |
| 358 | 135111 | M | 1 | HOLD | BOS NEAQ | BREED WITH | SEE MATERX | |
| 362 | 140721 | F | 0 | HOLD | BOS NEAQ | BREED WITH | SEE MATERX | |
| 363 | 140720 | F | 0 | HOLD | BOS NEAQ | BREED WITH | SEE MATERX | |
| 364 | 140723 | F | 0 | HOLD | BOS NEAQ | BREED WITH | SEE MATERX | |

| MSI (abs) | Males --> | 97 | 134 | 147 | 265 | 277 | 282 | 283 | 284 | 325 | 333 | 334 | 336 | 341 | 358 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Females --> | BREED: 1,2,3. 4s OK too. DO NOT BREED 5,6,"-" | BOS NEAQ | BOS NEAQ | BOS NEAQ | BOS NEAQ | BOS NEAQ | BOS NEAQ | BOS NEAQ | BOS NEAQ | BOS NEAQ | BOS NEAQ | BOS NEAQ | BOS NEAQ | BOS NEAQ | BOS NEAQ |
| 75 | BOS NEAQ | 4 | - | - | - | 5 | 5 | 5 | 4 | 5 | 4 | 5 | 4 | 5 | 4 |
| 135 | BOS NEAQ | 4 | 5 | 5 | 6 | 6 | 6 | 6 | 4 | 4 | 4 | 4 | 4 | 4 | 3 |
| 168 | BOS NEAQ | 4 | - | - | - | 6 | 6 | 6 | 4 | 5 | 4 | 5 | 4 | 5 | 4 |
| 276 | BOS NEAQ | - | - | - | 4 | 4 | 4 | 4 | - | 4 | 4 | 4 | 4 | 4 | - |
| 281 | BOS NEAQ | - | - | - | - | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| 295 | BOS NEAQ | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | - |
| 337 | BOS NEAQ | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | - | 4 | - | 4 | - | 3 |
| 342 | BOS NEAQ | 4 | 4 | 4 | 4 | 2 | 2 | 2 | 2 | 4 | - | 4 | - | 4 | 2 |
| 343 | BOS NEAQ | 3 | 4 | 4 | 4 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 1 |
| 344 | BOS NEAQ | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | - | 2 | - | 2 | - | 3 |
| 346 | BOS NEAQ | 4 | 4 | 4 | 4 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 1 |
| 347 | BOS NEAQ | 4 | 4 | 4 | 4 | 2 | 2 | 2 | 2 | 4 | - | 4 | - | 4 | 2 |
| 357 | BOS NEAQ | - | 5 | 5 | 4 | 4 | 4 | 4 | - | 4 | 4 | 4 | 4 | 4 | 4 |
| 362 | BOS NEAQ | - | 5 | 5 | 4 | 4 | 4 | 4 | - | 4 | 4 | 4 | 4 | 4 | 4 |
| 363 | BOS NEAQ | - | 5 | 5 | 4 | 4 | 4 | 4 | - | 4 | 4 | 4 | 4 | 4 | 4 |
| 364 | BOS NEAQ | 4 | 4 | 4 | 4 | - | - | - | 2 | 4 | 2 | 4 | 2 | 4 | 3 |

**CINCINNAT**

**Cincinnati Zoo & Botanical Garden**
Cincinnati, OH

Institutional notes: Institutions should encourage pairings with an MSI of 1, 2, 3, or 4. Pairings of 5, 6 or "-" are not recommended and should be discouraged. At this time there is no limit on breeding. Increased production is encouraged.

| ID | Local ID | Sex | Age | Disposition | Location | Breeding | With | Notes |
|---|---|---|---|---|---|---|---|---|
| 70 | 200071 | F | 21 | HOLD | CINCINNAT | BREED WITH | SEE MATERX | |
| 71 | 200068 | F | 21 | HOLD | CINCINNAT | BREED WITH | SEE MATERX | |
| 105 | 202015 | F | 17 | HOLD | CINCINNAT | BREED WITH | SEE MATERX | |
| 115 | 202016 | M | 17 | HOLD | CINCINNAT | BREED WITH | SEE MATERX | |
| 117 | 202017 | M | 16 | HOLD | CINCINNAT | BREED WITH | SEE MATERX | |
| 137 | 200222 | F | 14 | HOLD | CINCINNAT | BREED WITH | SEE MATERX | |
| 151 | 201087 | F | 13 | HOLD | CINCINNAT | BREED WITH | SEE MATERX | |
| 208 | 203030 | F | 11 | HOLD | CINCINNAT | BREED WITH | SEE MATERX | |
| 251 | 204165 | F | 10 | HOLD | CINCINNAT | BREED WITH | SEE MATERX | |
| 252 | 204166 | F | 10 | HOLD | CINCINNAT | BREED WITH | SEE MATERX | |
| 268 | 206000 | M | 9 | HOLD | CINCINNAT | BREED WITH | SEE MATERX | |
| 270 | 206006 | M | 9 | HOLD | CINCINNAT | BREED WITH | SEE MATERX | |
| 272 | 206193 | F | 8 | HOLD | CINCINNAT | BREED WITH | SEE MATERX | |
| 274 | 206304 | F | 8 | HOLD | CINCINNAT | BREED WITH | SEE MATERX | |
| 275 | 207000 | M | 8 | HOLD | CINCINNAT | BREED WITH | SEE MATERX | |
| 305 | 208191 | M | 6 | HOLD | CINCINNAT | BREED WITH | SEE MATERX | |
| 310 | 211076 | M | 5 | HOLD | CINCINNAT | BREED WITH | SEE MATERX | |
| 324 | 212084 | M | 7 | HOLD | CINCINNAT | BREED WITH | SEE MATERX | |
| 328 | 212085 | M | 6 | HOLD | CINCINNAT | BREED WITH | SEE MATERX | |
| 331 | 212082 | F | 5 | HOLD | CINCINNAT | BREED WITH | SEE MATERX | |
| 332 | 212083 | M | 5 | HOLD | CINCINNAT | BREED WITH | SEE MATERX | |
| 335 | 212086 | M | 5 | HOLD | CINCINNAT | BREED WITH | SEE MATERX | |
| 340 | 212087 | M | 4 | HOLD | CINCINNAT | BREED WITH | SEE MATERX | |
| 345 | 212088 | M | 3 | HOLD | CINCINNAT | BREED WITH | SEE MATERX | |
| 349 | 212003 | F | 3 | HOLD | CINCINNAT | BREED WITH | SEE MATERX | |
| 351 | 213007 | F | 2 | HOLD | CINCINNAT | BREED WITH | SEE MATERX | |
| 359 | 213125 | F | 1 | HOLD | CINCINNAT | BREED WITH | SEE MATERX | |

| MSI (abs) | Males --> | 324 | 117 | 328 | 332 | 268 | 270 | 335 | 275 | 340 | 305 | 345 | 310 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Females --> | BREED: 1,2,3. 4s OK too. DO NOT BREED 5,6,"-" | CINCINNAT | CINCINNAT | CINCINNAT | CINCINNAT | CINCINNAT | CINCINNAT | CINCINNAT | CINCINNAT | CINCINNAT | CINCINNAT | CINCINNAT | CINCINNAT |
| 331 | CINCINNAT | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 4 | 6 | 4 | 4 | 4 |
| 151 | CINCINNAT | 2 | 2 | 3 | 4 | 1 | - | 1 | 4 | 4 | - | 3 | 4 |
| 70 | CINCINNAT | 4 | 4 | 4 | 5 | 4 | 4 | 4 | - | 5 | 4 | 4 | 4 |
| 208 | CINCINNAT | 1 | 4 | 3 | 4 | 1 | 1 | 1 | 4 | 4 | 2 | 4 | 1 |
| 251 | CINCINNAT | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 4 | 4 | 4 |
| 252 | CINCINNAT | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 4 | 4 | 4 | 4 |
| 272 | CINCINNAT | 3 | 4 | 3 | 4 | 4 | 2 | 4 | - | 4 | 4 | 3 | 2 |
| 349 | CINCINNAT | 5 | 5 | 5 | 5 | 5 | 5 | 5 | - | 5 | 5 | 5 | 5 |
| 351 | CINCINNAT | 4 | 4 | - | 4 | 3 | 3 | - | 4 | 4 | 3 | 4 | 3 |
| 274 | CINCINNAT | 2 | 2 | 3 | 4 | - | 1 | 4 | 4 | 4 | - | 3 | 2 |
| 359 | CINCINNAT | 4 | 4 | - | 4 | 3 | 3 | - | 4 | 4 | 3 | 4 | 3 |
| 105 | CINCINNAT | 1 | 4 | 4 | 4 | 1 | 3 | 2 | 4 | 4 | 3 | 4 | 2 |
| 71 | CINCINNAT | 4 | 4 | 5 | 5 | 4 | 4 | 4 | 5 | 5 | 4 | 5 | 4 |
| 137 | CINCINNAT | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 4 | 4 | 4 |

**DALLAS WA**

**Dallas World Aquarium**
Dallas, TX

Institutional notes: Institutions should encourage pairings with an MSI of 1, 2, 3, or 4. Pairings of 5, 6 or "-" are not recommended and should be discouraged. At this time there is no limit on breeding. Increased production is encouraged.

| ID | Local ID | Sex | Age | Disposition | Location | Breeding | With | Notes |
|---|---|---|---|---|---|---|---|---|
| 166 | 11A071 | F | 13 | HOLD | DALLAS WA | BREED WITH | SEE MATERX | |
| 308 | 13A064 | M | 5 | HOLD | DALLAS WA | BREED WITH | SEE MATERX | This bird has unknown parentage. Research into its origin is recommended.to resolve this unknownness. |
| 350 | 13A065 | M | 2 | HOLD | DALLAS WA | BREED WITH | SEE MATERX | |
| 352 | 13H024 | M | 2 | HOLD | DALLAS WA | BREED WITH | SEE MATERX | |
| 355 | 13AO67 | F | 2 | HOLD | DALLAS WA | BREED WITH | SEE MATERX | |
| 356 | 13A066 | F | 2 | HOLD | DALLAS WA | BREED WITH | SEE MATERX | |

| MSI (abs) | Males --> | 350 | 352 | 308 |
|---|---|---|---|---|
| Females --> | BREED: 1,2,3. 4s OK too. DO NOT BREED 5,6,"-" | DALLAS WA | DALLAS WA | DALLAS WA |
| 356 | DALLAS WA | 4 | 4 | - |
| 166 | DALLAS WA | - | - | - |
| 355 | DALLAS WA | 6 | 4 | - |

# Appendix A
## Pedigree Assumptions

Hypothetical Individuals

| Studbook ID | Sire | Dam | Notes |
|---|---|---|---|
| HYP1 | 70 | 71 | Hypothetical dam created to represent MULT3 as the potential dams present at SYDNEY at the time of estimated conception. |
| HYP2 | 225 | 254 | Hypothetical dam to represent MULT (dam of 318) |

Analytical Data for True Individuals

| Studbook ID | Field | TRUE | Overlay | Notes |
|---|---|---|---|---|
| 227 | Dam | UNK | WILD | This bird is more than likely wild hatched from Tasmania, South Australia, Victoria, or New South Wales. |
| | Sire | UNK | WILD | |
| 72 | Dam | UNK | WILD | This bird is more than likely wild hatched from Tasmania, South Australia, Victoria, or New South Wales. |
| | Sire | UNK | WILD | |
| 74 | Dam | UNK | WILD | This bird is more than likely wild hatched from Tasmania, South Australia, Victoria, or New South Wales. |
| | Sire | UNK | WILD | |
| 56 | Dam | UNK | WILD | This bird is more than likely a wild hatched bird that was sent from Australia to JURONG and then sent to OMAHA. |
| | Sire | UNK | WILD | |
| 53 | Dam | UNK | WILD | This bird is more than likely a wild hatched bird that was sent from Australia to JURONG and then sent to OMAHA. |
| | Sire | UNK | WILD | |

# Appendix B
## Summary of Data Exports

Project: LittleBlue2014
Report compiled under Population Management 2000, version 1.213
8:41:14 AM, 11/12/2014

Date to be used for calculations: 11/12/2014

Demographic data from: C:\Documents and Settings\cgroome\My Documents\PopLink\PopLink Databases\LITLEBLU2014\mXXLITLEBLU2014.prn and C:\Documents and Settings\cgroome\My Documents\PopLink\PopLink Databases\LITLEBLU2014\fXXLITLEBLU2014.prn

Genetic data from: C:\Documents and Settings\cgroome\My Documents\PopLink\PopLink Databases\LITLEBLU2014\XXLITLEBLU2014.ped

Studbook information:
Data exported on: 11/12/2014
Data compiled by: Heather Urquhart
Contact info:
Data current thru: 10/1/2014
Scope of data: North American RegionalYHOSTCNew England Aquarium

Demographic filter conditions:
Association = AZA.FED During 1/1/1980 - 11/12/2014 Status = Living

Genetic filter conditions:
Association = AZA.FED
As of 11/12/2014
Status = Living

MateRx was created using absolute MK. No bins were changed.

Last-minute Data Changes:
- #321 BOS NEAQ died
- #115 CINCINNAT died

# Appendix C
## Animals Excluded from Genetic Analysis

None



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

# Appendix D
## Life Tables

**Males**

| Age (x) | Qx | Px | lx | Mx | Vx | Ex | Risk (Qx) | Risk (Mx) |
|---|---|---|---|---|---|---|---|---|
| 0 | 0.37 | 0.63 | 1 | 0 | 1.227 | 7.78 | 76.2 | 50 |
| 1 | 0.02 | 0.98 | 0.63 | 0.02 | 1.52 | 8.86 | 56.1 | 55.6 |
| 2 | 0.12 | 0.88 | 0.617 | 0.11 | 1.527 | 8.447 | 62.9 | 57.3 |
| 3 | 0.06 | 0.94 | 0.543 | 0.14 | 1.479 | 8.201 | 63.8 | 60.7 |
| 4 | 0.09 | 0.91 | 0.511 | 0.21 | 1.372 | 7.781 | 64.4 | 61.4 |
| 5 | 0.12 | 0.88 | 0.465 | 0.12 | 1.229 | 7.57 | 54.8 | 51 |
| 6 | 0.04 | 0.96 | 0.409 | 0.2 | 1.146 | 7.161 | 46.5 | 45 |
| 7 | 0.07 | 0.93 | 0.393 | 0.1 | 0.948 | 6.518 | 41.3 | 39.8 |
| 8 | 0.14 | 0.86 | 0.365 | 0.25 | 0.897 | 6.156 | 37 | 33.4 |
| 9 | 0.1 | 0.9 | 0.314 | 0.14 | 0.698 | 5.87 | 29.9 | 29.4 |
| 10 | 0.19 | 0.81 | 0.283 | 0.26 | 0.617 | 5.68 | 27 | 24.3 |
| 11 | 0.21 | 0.79 | 0.229 | 0.17 | 0.422 | 5.842 | 23.3 | 21.4 |
| 12 | 0.22 | 0.78 | 0.181 | 0.03 | 0.304 | 6.163 | 18.5 | 15.6 |
| 13 | 0.21 | 0.79 | 0.141 | 0 | 0.332 | 6.583 | 14 | 12.7 |
| 14 | 0.1 | 0.9 | 0.111 | 0.11 | 0.375 | 6.658 | 10 | 9.1 |
| 15 | 0.24 | 0.76 | 0.1 | 0 | 0.301 | 6.786 | 8.5 | 6.8 |
| 16 | 0.38 | 0.62 | 0.076 | 0.23 | 0.408 | 8.272 | 5.2 | 4.4 |
| 17 | 0 | 1 | 0.047 | 0.22 | 0.22 | 9.5 | 2.4 | 2.4 |
| 18 | 0 | 1 | 0.047 | 0 | 0 | 8.5 | 1.2 | 1.2 |
| 19 | 0 | 1 | 0.047 | 0 | 0 | 7.5 | 0.5 | 0.5 |
| 20 | 0 | 1 | 0.047 | 0 | 0 | 6.5 | 0.5 | 0.5 |
| 21 | 0 | 1 | 0.047 | 0 | 0 | 5.5 | 0.5 | 0.5 |
| 22 | 0 | 1 | 0.047 | 0 | 0 | 4.5 | 0.5 | 0.5 |
| 23 | 0 | 1 | 0.047 | 0 | 0 | 3.5 | 0.5 | 0.5 |
| 24 | 0 | 1 | 0.047 | 0 | 0 | 2.5 | 0.5 | 0.5 |
| 25 | 0 | 1 | 0.047 | 0 | 0 | 1.5 | 0.5 | 0.5 |
| 26 | 1 | 0 | 0.047 | 0 | 0 | 1 | 0.5 | 0.4 |
| 27 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 28 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Qx = mortality; Px = survival; Lx = cumulative survivorship; Mx = fecundity; Vx = expected future reproduction

r = -0.0536
lambda = 0.9478
T = 7.94
N = 29.00
N(at 20 yrs) = 9.92

**Females**

| Age (x) | Qx | Px | lx | Mx | Vx | Ex | Risk (Qx) | Risk (Mx) |
|---|---|---|---|---|---|---|---|---|
| 0 | 0.33 | 0.67 | 1 | 0 | 1.198 | 7.128 | 82.7 | 57.9 |
| 1 | 0.13 | 0.87 | 0.67 | 0.04 | 1.51 | 8.168 | 63.7 | 59.8 |
| 2 | 0.15 | 0.85 | 0.583 | 0.14 | 1.616 | 8.328 | 57.8 | 52.5 |
| 3 | 0.14 | 0.86 | 0.495 | 0.27 | 1.635 | 8.575 | 49.3 | 46.2 |
| 4 | 0.12 | 0.88 | 0.426 | 0.2 | 1.485 | 8.714 | 45.8 | 43.5 |
| 5 | 0.09 | 0.91 | 0.375 | 0.25 | 1.36 | 8.628 | 40.9 | 38.9 |
| 6 | 0.05 | 0.95 | 0.341 | 0.22 | 1.131 | 8.211 | 38.9 | 37.7 |
| 7 | 0.16 | 0.84 | 0.324 | 0.2 | 0.961 | 8.044 | 38.6 | 35.5 |
| 8 | 0.13 | 0.87 | 0.272 | 0.12 | 0.844 | 8.251 | 31.5 | 30.3 |
| 9 | 0.11 | 0.89 | 0.237 | 0.02 | 0.779 | 8.247 | 27.3 | 26.2 |
| 10 | 0 | 1 | 0.211 | 0.26 | 0.762 | 7.695 | 21.8 | 21.8 |
| 11 | 0.05 | 0.95 | 0.211 | 0.09 | 0.488 | 6.866 | 21.8 | 21.8 |
| 12 | 0.15 | 0.85 | 0.2 | 0.11 | 0.417 | 6.509 | 20.6 | 19.4 |
| 13 | 0.25 | 0.75 | 0.17 | 0.16 | 0.362 | 6.851 | 15.8 | 13 |
| 14 | 0 | 1 | 0.128 | 0.05 | 0.223 | 6.826 | 10 | 10 |
| 15 | 0 | 1 | 0.128 | 0.11 | 0.163 | 5.826 | 9.5 | 9.5 |
| 16 | 0.32 | 0.68 | 0.128 | 0.06 | 0.06 | 5.746 | 9.5 | 8.2 |
| 17 | 0 | 1 | 0.087 | 0 | 0 | 5.862 | 5.2 | 5.2 |
| 18 | 0.18 | 0.82 | 0.087 | 0 | 0 | 5.343 | 5.5 | 4.6 |
| 19 | 0 | 1 | 0.071 | 0 | 0 | 4.82 | 4.5 | 4.5 |
| 20 | 0 | 1 | 0.071 | 0 | 0 | 3.82 | 3.7 | 3.7 |
| 21 | 0 | 1 | 0.071 | 0 | 0 | 2.82 | 1.7 | 1.7 |
| 22 | 0.67 | 0.33 | 0.071 | 0 | 0 | 2.737 | 1.5 | 0.8 |
| 23 | 0 | 1 | 0.023 | 0 | 0 | 3.5 | 0.5 | 0.5 |
| 24 | 0 | 1 | 0.023 | 0 | 0 | 2.5 | 0.5 | 0.5 |
| 25 | 0 | 1 | 0.023 | 0 | 0 | 1.5 | 0.5 | 0.5 |
| 26 | 1 | 0 | 0.023 | 0 | 0 | 1 | 0.5 | 0.4 |
| 27 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 28 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Qx = mortality; Px = survival; Lx = cumulative survivorship; Mx = fecundity; Vx = expected future reproduction

r = -0.0553
lambda = 0.9462
T = 7.37
N = 33.00
N(at 20 yrs) = 10.91

# Appendix E
## Ordered Mean Kinship List

*Note: This list is current to November 2014, and values are subject to change with any hatch, death, import, export, inclusion, or exclusion. Unknown sex individuals appear on both the male and female side of the mean kinship list.*

Population MK = 0.0389

### Males

| SB# | MK | %Known | Age | Location |
|---|---|---|---|---|
| 117 | 0.011 | 100.0 | 16 | CINCINNAT |
| 324 | 0.019 | 100.0 | 7 | CINCINNAT |
| 268 | 0.022 | 100.0 | 9 | CINCINNAT |
| 335 | 0.026 | 100.0 | 5 | CINCINNAT |
| 270 | 0.028 | 100.0 | 9 | CINCINNAT |
| 310 | 0.028 | 100.0 | 5 | CINCINNAT |
| 358 | 0.028 | 100.0 | 1 | BOS NEAQ |
| 305 | 0.031 | 100.0 | 6 | CINCINNAT |
| 333 | 0.032 | 100.0 | 5 | BOS NEAQ |
| 336 | 0.032 | 100.0 | 5 | BOS NEAQ |
| 284 | 0.034 | 100.0 | 7 | BOS NEAQ |
| 282 | 0.035 | 100.0 | 7 | BOS NEAQ |
| 283 | 0.035 | 100.0 | 7 | BOS NEAQ |
| 277 | 0.037 | 100.0 | 7 | BOS NEAQ |
| 328 | 0.037 | 100.0 | 6 | CINCINNAT |
| 97 | 0.038 | 100.0 | 18 | BOS NEAQ |
| 345 | 0.038 | 100.0 | 3 | CINCINNAT |
| 352 | 0.039 | 100.0 | 2 | DALLAS WA |
| 332 | 0.042 | 100.0 | 5 | CINCINNAT |
| 265 | 0.045 | 100.0 | 9 | BOS NEAQ |
| 275 | 0.045 | 100.0 | 8 | CINCINNAT |
| 340 | 0.048 | 100.0 | 4 | CINCINNAT |
| 334 | 0.050 | 100.0 | 5 | BOS NEAQ |
| 341 | 0.050 | 100.0 | 4 | BOS NEAQ |
| 325 | 0.052 | 100.0 | 7 | BOS NEAQ |
| 147 | 0.055 | 100.0 | 13 | BOS NEAQ |
| 350 | 0.055 | 100.0 | 2 | DALLAS WA |
| 134 | 0.059 | 100.0 | 14 | BOS NEAQ |
| 308 | 0.500 | 0.0 | 5 | DALLAS WA |

### Females

| SB# | MK | %Known | Age | Location |
|---|---|---|---|---|
| 295 | 0.014 | 100.0 | 10 | BOS NEAQ |
| 105 | 0.019 | 100.0 | 17 | CINCINNAT |
| 208 | 0.024 | 100.0 | 11 | CINCINNAT |
| 274 | 0.024 | 100.0 | 8 | CINCINNAT |
| 346 | 0.024 | 100.0 | 3 | BOS NEAQ |
| 151 | 0.026 | 100.0 | 13 | CINCINNAT |
| 343 | 0.026 | 100.0 | 3 | BOS NEAQ |
| 272 | 0.031 | 100.0 | 8 | CINCINNAT |
| 342 | 0.032 | 100.0 | 3 | BOS NEAQ |
| 347 | 0.032 | 100.0 | 3 | BOS NEAQ |
| 356 | 0.035 | 100.0 | 2 | DALLAS WA |
| 349 | 0.036 | 50.0 | 3 | CINCINNAT |
| 357 | 0.036 | 100.0 | 1 | BOS NEAQ |
| 362 | 0.036 | 100.0 | 0 | BOS NEAQ |
| 363 | 0.036 | 100.0 | 0 | BOS NEAQ |
| 351 | 0.036 | 100.0 | 2 | CINCINNAT |
| 359 | 0.036 | 100.0 | 1 | CINCINNAT |
| 364 | 0.036 | 100.0 | 0 | BOS NEAQ |
| 344 | 0.037 | 100.0 | 3 | BOS NEAQ |
| 276 | 0.038 | 100.0 | 8 | BOS NEAQ |
| 331 | 0.040 | 87.5 | 5 | CINCINNAT |
| 337 | 0.040 | 87.5 | 5 | BOS NEAQ |
| 135 | 0.041 | 100.0 | 14 | BOS NEAQ |
| 355 | 0.046 | 100.0 | 2 | DALLAS WA |
| 281 | 0.050 | 100.0 | 7 | BOS NEAQ |
| 166 | 0.051 | 100.0 | 13 | DALLAS WA |
| 252 | 0.053 | 100.0 | 10 | CINCINNAT |
| 137 | 0.055 | 100.0 | 14 | CINCINNAT |
| 251 | 0.055 | 100.0 | 10 | CINCINNAT |
| 168 | 0.057 | 100.0 | 12 | BOS NEAQ |
| 70 | 0.063 | 100.0 | 21 | CINCINNAT |
| 75 | 0.063 | 100.0 | 20 | BOS NEAQ |
| 71 | 0.067 | 100.0 | 21 | CINCINNAT |

# Appendix F
## Descriptive Survival Statistics Report

LITTLE BLUE PENGUIN Studbook
Eudyptula minor
North American RegionalYHOSTCNew England Aquarium YLASTACCSC 364YLASTEDITC 338YLASTTEMPC YMNEMONICC Studbook

Studbook data current as of 10/1/2014

Compiled by
Heather Urquhart

PopLink Studbook filename: LITLEBLU2014
PopLink User Who Exported Report: cgroome
Date of Export: 11/24/2014
Data Filtered by: Association = AZA.FED AND StartDate = 1/1/1980 AND EndDate = 11/24/2014
PopLink Version: 2.4

**REPORT OVERVIEW:**

Based on this analysis, if a LITTLE BLUE PENGUIN survives to its first birthday, its median life expectancy is 7.9 years. Please see the body of the report for more details.

**BACKGROUND ON ANALYSES:**

These analyses were conducted using animals that lived during the period 1 January 1980 to 24 November 2014 at institutions within AZA. 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.

Although for many species, including humans, survival statistics often differ for males and females, for these analyses male and female statistics were not statistically different[1]; these results therefore include pooled data from males, females, and unknown sex individuals.

**SUMMARY OF ANALYSES:**

SURVIVAL STATISTICS

The dataset used for analysis includes partial or full lifespans of 191 individuals, 121 (63.4%) of which had died by 24 November 2014.

If a LITTLE BLUE PENGUIN survives to its first birthday, its **median life expectancy**[2] is **7.9 years of age**. Given the quality of the data - how many animals are in the database and how many have died - there is a 95% chance that the true median falls between 5.9 and 8.9 years of age (i.e., these are the 95% confidence limits). Only 25% of LITTLE BLUE PENGUIN can be expected to survive to be 12.6 years or older.

**First-year (infant) survival**[3] for LITTLE BLUE PENGUIN is 63%. The year after birth/hatching is a period of relatively low survival for many species and life histories.

The **maximum longevity**[4] observed for LITTLE BLUE PENGUIN is **26.7 years**; this longevity record is based on an individual which was DEAD as of the analysis end date (studbook number 20, sex = Unknown, origin = Wild Hatch, birth date estimate = Year).[5]

The correct interpretation of these statistics is that, if it survives the first year of life, the 'typical' LITTLE BLUE PENGUIN will live 7.9 years; that half of all LITTLE BLUE PENGUIN can be expected to die before they reach 7.9 and half will live longer than 7.9; that only 25% of all LITTLE BLUE PENGUIN can be expected to live 12.6 years; and that it is rare but possible for LITTLE BLUE PENGUIN to live 26.7 years.

The median life expectancy, confidence interval, first-year survival, and maximum longevity may change as more data are accumulated, the population's age structure changes, or management practices improve.

While both median life expectancy and maximum longevity are discussed in this report, it is more appropriate to rely on median life expectancy to place the age of any one individual in context. To put these statistics in perspective, median life expectancy from age one for people in the United States is 77.5 years and the maximum longevity (documented worldwide) is 122 years[6]. Therefore, if a person lived to be 85 years old, the appropriate context is that they lived well beyond the median life expectancy (77.5), not that they fell short of the maximum longevity (122).

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 passed all of the following data quality 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? **PASS**
3. Is the 95% Confidence Interval (CI) bounded? **PASS**
4. Is the sample size in the first age class of analysis (e.g. the first day of analysis) greater than 30 individuals? **PASS**
5. Is the length of the 95% CI < 33% of the maximum longevity? **PASS**

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

---

[1] Statistical significance was determined by comparing 84% confidence intervals around median life expectancy for males and females, with 8 unknown sex individuals proportionally incorporated into the analysis. For this population, overlapping confidence intervals indicated that data could be pooled. See the PopLink manual for more details.

[2] 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, 55 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.

[3]For reference, first-year survival is provided. For this studbook and the selected demographic window, 55 individuals did not survive to their first birthday and were excluded from the estimates provided above (median life expectancy, 95% confidence limits, and age to which 25% of individuals survive).

[4] Maximum longevity is the age of the oldest known individual for this species, living or dead. It is not necessarily the biological maximum age, but only reflects the individuals included in the dataset.

[5] 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.

[6] Median life expectancy for people is estimated from: Xu, Jiaquan, Kochanek KD, Murphy SL, and Tejada-Vera B. 2007. Deaths: Final Data for 2007. National vital statistics reports; vol 58 no 19. Hyattsville, MD: National Center for Health Statistics. Jeanne Calment of France was the oldest documented and fully validated human and died at 122 years and 164 days; from: http://www.grg.org/Adams/Tables.htm. Accessed August 9, 2007.

# 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).

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 ($\lambda$) 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 .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 hatch to the beginning of a specific age class.

**Mx**, **Fecundity** – The average number of same-sexed young born to animals in that age class. Because SPARKS is typically using relatively small sample sizes, SPARKS calculates 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. Alternatively, the proportion of individuals that die during age class *x*. 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"). Qx = 1-Px

**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).

**FOKE, First Order Kin Equivalents** – The number of first-order kin (siblings or offspring) that would contain the number of copies of an individual's alleles (identical by descent) as are present in the zoo-born population. Thus an offspring or sib contributes 1 to FOKE; each grand-offspring contributes 1/2 to FOKE; each cousin contributes 1/4 to FOKE. FOKE = 4*N*MK, in which N is the number of living animals in the zoo population.

**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 Contribution --** Number of copies of a founder's genome that are present in the living descendants. Each offspring contributes 0.5; each grand-offspring contributes 0.25, etc.

**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 Genome Surviving** – The sum of allelic retentions of the individual founders (i.e., the product of the mean allelic retention and the number of founders).

**Founder Representation** -- Proportion of the genes in the living, descendant population that are derived from that founder. I.e., proportional Founder Contribution.

**GU, Genome Uniqueness** – Probability that an allele sampled at random from an individual is not present, identical by descent, in any other living individual in the population. GU-all is the genome uniqueness relative to the entire population. GU-Desc is the genome uniqueness relative to the living non-founder, descendants.

**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.

**Kinship Value (KV) –** The weighted mean kinship of an animal, with the weights being the reproductive values of each of the kin. The mean kinship value of a population predicts the loss of gene diversity expected in the subsequent generation if all animals were to mate randomly and all were to produce the numbers of offspring expected for animals of their age.

**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.

**Mean Kinship (MK)** – The mean kinship coefficient between an animal and all animals (including itself) in the living, zoo-born population. The mean kinship of a population is equal to the proportional loss of gene diversity of the descendant (zoo-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.

**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 | Phone | Fax |
|---|---|---|---|---|
| Heather Urquhart | BOS NEAQ - New England Aquarium, Boston, MA | hurquhart@neaq.org | 617-226-2229 | 617-720-5098 |
| Robert Webster | CINCINNAT - Cincinnati Zoo & Botanical Garden, Cincinnati, OH | Robert.Webster@cincinnatizoo.org | 513.475.6153 | 513.559.7790 |
| Paula B. Carlson | DALLAS WA - Dallas World Aquarium, Dallas, TX | ppshark@aol.com | 214-720-2224 x400 | 214-720-2242 |
| David Oehler | NY BRONX - Bronx Zoo/Wildlife Conservation Society, Bronx, NY | doehler@wcs.org | 718-220-5159 | 718-220-7114 |
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