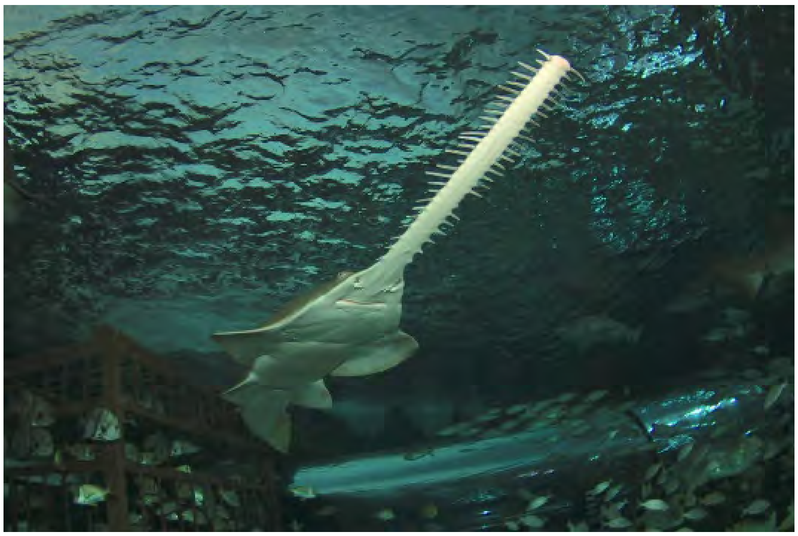
Population Analyses & Breeding and Transfer Plans

Sawfish (*Pristis pectinata, P. pristis & P. zijsron*)
AZA Species Survival Plan®
Red Programs



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5 March 2020

PMC Population Management Center

LINCOLN PARK ZOO.

ASSOCIATION OF ZOOS & AQUARIUMS

Executive Summary

Species Survival Plan® for Sawfish (*Pristis pectinata, P. pristis, P. zijsron*)

At the time of analyses, the AZA Sawfish populations consist of three species—smalltooth sawfish (*Pristis pectinata*), largetooth sawfish (*Pristis pristis*), and longcomb sawfish (*Pristis zijsron*). There are currently 11 (4 males, 7 females) smalltooth sawfishes at three AZA facilities, 15 (9.6) largetooth sawfishes at seven AZA institutions, and 11 (7.4) longcomb sawfishes at six AZA institutions. The Marine Fishes Taxon Advisory Group (TAG) set target population sizes for these populations in their 2017 Regional Collection Plan (RCP). However, after conversations with the TAG Chair and SSP Coordinators, it was decided to set a target size of 18 animals for the largetooth population, and a goal of 13 sawfishes each for the longcomb and smalltooth populations. Due to these species being currently classified as Critically Endangered on the IUCN Red List, these populations all qualify as Red SSP Programs under AZA's current sustainability designations.

Due to the limited amount of breeding in these populations, only limited genetic and demographic analyses could be performed and presented at this time. Currently, the largetooth and longcomb populations consist entirely of potential founders, 15 and 11, respectively. No breeding has occurred yet for these two sawfish species. Smalltooth sawfish have only had one birth event; therefore, there are two founders represented and five potential founders remaining in the smalltooth population. Due to the small population sizes, minimal reproduction and lack of data in the life tables, genetic projections cannot be performed for these populations. Several management strategies could improve gene diversity such as increasing the population growth rate, increasing the effective population size (number of animals breeding), recruiting potential founders already in the managed populations and importing new founders.

Demography[1]

	Smalltooth (*P. pectinata*)	Largetooth (*P. pristis*)	Longcomb (*P. zijsron*)
Current size of population (N) – Total (Males.Females.Unknown Sex)	11 (4.7)	15 (9.6)	11 (7.4)
Number of individuals excluded from genetic analyses	0 (0.0)	0 (0.0)	0 (0.0)
Population size following exclusions	11 (4.7)	15 (9.6)	11 (7.4)
Target population size (Kt) updated 2019	13	18	13
Mean generation time (T, years)[2]	--	--	--
Population growth rates (λ, lambda)[3]: Historical / 5-year / Projected	- / 0.983 / -	- / 0.951 / -	- / 1.000 / -

[1]Calculated using the studbook "Sawfish_13Oct19+Overlay_2May2016"
[2]Generation times could not be accurately calculated for the three species due to limited demographic data
[3]Historical from life tables (AZA: 1985, 1997, 2002 – present); 5-year from PopLink census; Projected from PMx stochastic 20-year projections

As a result of the relatively short amount of time sawfishes have been in aquariums compared to their predicted long lifespans, demographic data may not represent the true biology of this species. Due to the lack or limited amount of breeding in the SSP populations, it is not possible at this time to project or estimate how many births are needed annually to maintain the populations. Any successful breeding for these species will be beneficial for establishing genetically and demographically stable populations. Historically these populations have remained small with only one institution producing offspring for one species. The SSP is currently developing an understanding of the complex factors affecting breeding success and highly encourages institutions to participate in reproductive monitoring of their animals. Comparing these factors between institutions is necessary to determine relevant variables involved in breeding. Once this species' breeding biology and needs are understood, the SSP can communicate with institutions to ensure best practices are used across institutions.

Summary Actions: The SSP recommends four smalltooth, four largetooth, and three longcomb sawfish females be placed in breeding situations. No transfers are recommended at this time.

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Acknowledgments

The Sawfish planning meeting was held 24 October 2019 via internet conferencing
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Cover photo courtesy of Ripley's Aquarium of Myrtle Beach

This plan was prepared and distributed with the assistance of the AZA Population Management Center in Chicago.
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Description of Population Status

Species Survival Plan® for Sawfish (*Pristis pectinata, P. pristis, P. zijsron*)

Introduction: At the time of analyses, the AZA Sawfish populations consist of three species—smalltooth sawfish (*Pristis pectinata*), largetooth sawfish (*P. pristis*), and longcomb sawfish (*P. zijsron*). There are currently 11 (4 males, 7 females) smalltooth sawfishes at three AZA facilities, 15 (9.6) largetooth sawfishes at seven AZA institutions, and 11 (7.4) longcomb sawfishes at six AZA institutions. The Marine Fishes Taxon Advisory Group (TAG) set target population sizes for these populations in their 2017 Regional Collection Plan (RCP); however, after conversations with the TAG Chair and SSP Coordinators, it was decided to set a target size of 18 animals for the largetooth population, and a goal of 13 sawfishes each for the longcomb and smalltooth populations. Due to these species being currently classified as Critically Endangered on the IUCN Red List, these populations all qualify as Red SSP Programs under AZA's sustainability designations.

Comprehensive genetic and demographic analyses of these populations were performed in October 2019 resulting in the second breeding and transfer plans for the three sawfish species. Analyses of an analytical version of the AZA Regional Sawfish Studbook (current to 04 October 2019) were performed using PopLink 2.4 and PMx V1.6.0.20190628. Recommendations contained in this plan supersede those of previous plans.

Status and Conservation: *Pristis pectinata, P. pristis and P. zijsron* are all listed as Critically Endangered (assessed 2012 and 2013) on the IUCN Red List due to drastic declines in their population sizes. These declines are due to past overfishing, with the current threat being the high amount of incidental bycatch these species experience from other fisheries. The US Fish & Wildlife Service lists the three species as Endangered under the US Endangered Species Act. All three species are listed as CITES Appendix I.

Analytical Population: The current pedigrees of the three sawfish populations are 100% known and no individuals were excluded from the potentially breeding populations or genetic analyses. Therefore, the potentially breeding population of smalltooth sawfish consists of 11 (4.7) animals, the largetooth 15 (9.6) and the longcomb totals 11 (7.4), each with a 100% known (100% certain) pedigree. It should also be noted that all wild caught sawfish have unknown ages. In order to include these animals in the demographic analyses, a +/- 1 year age estimate assumption was applied to all unknown age sawfish (Appendix A).

Demography

Smalltooth sawfish (*Pristis pectinata*): The first recorded smalltooth sawfish entered North America in 1968; however, the population did not begin to grow until the late 1980s (Fig. 1). The North American population remained small increasing slightly over the years due to import events, the last of which occurred in 1999. A peak population size of 13 sawfishes was reached in 2012 due to the species first and only birth event. The smalltooth sawfish is the only sawfish species in AZA to have given birth in a zoo or aquarium with a litter of four pups born in 2012 at Atlantis, Paradise Island in the Bahamas. Since this time, the population has decreased by 1.7% in the last five years ($\lambda = 0.983$) due to two deaths and no births.

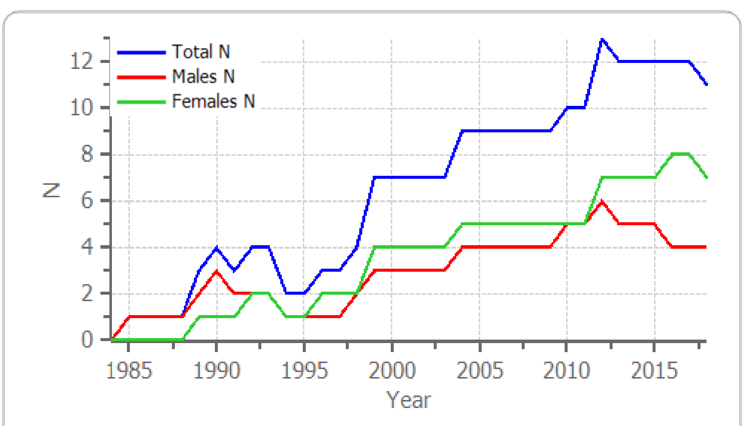


Figure 1. Population census of the AZA population of smalltooth sawfish by sex from 1984 to present.

Largetooth sawfish (*Pristis pristis*): According to the studbook, the first recorded largetooth sawfish entered an AZA institution in 1997, when a single female arrived at Ocean Park Corporation in Hong Kong. The first largetooth sawfishes in North American institutions came to Ripley's Aquarium of Myrtle Beach and Ripley's Aquarium of the Smokies in 1999. Over the next decade, the population grew to a peak size of 18 sawfishes by 2008 due entirely to import events, the last of which occurred that same year (Fig. 2). This population has yet to have its first recorded birth in zoos or aquariums. The largetooth sawfish population has been decreasing an average of 4.9% per year over the past five years (λ = 0.951), due to the lack of animals entering the population via imports or births, and four deaths.

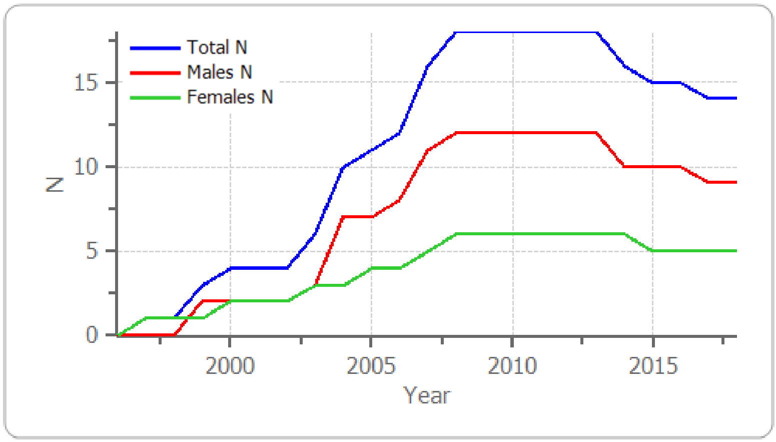


Figure 2. Population census of the AZA population of largetooth sawfish by sex from 1997 to present.

Longcomb sawfish (*Pristis zijsron*): Longcomb is the newest AZA sawfish population, with the first recorded animals entering in 2002. The population grew quickly to its peak population size of 13 sawfishes after import events that occurred yearly until 2005 (Fig. 3). No sawfish have been imported into the population since this time. This longcomb sawfish population has yet to have its first recorded birth in a zoo or aquarium. With no births or deaths occurring in the longcomb sawfish population over the last five years, it has remained stable (λ = 1.000) at 11 sawfishes.

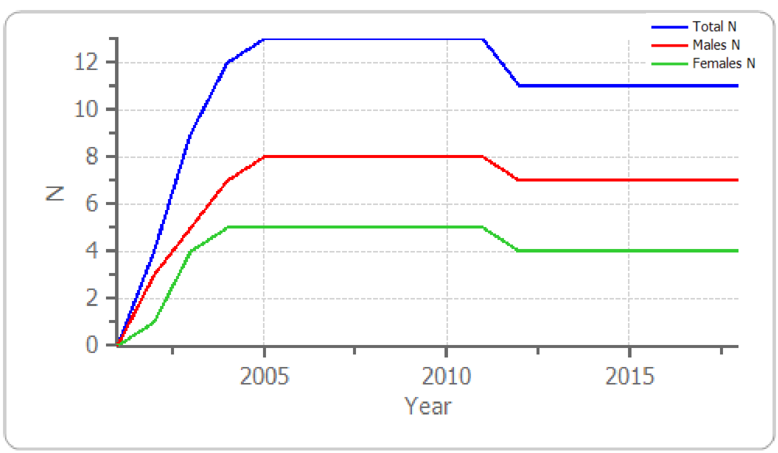
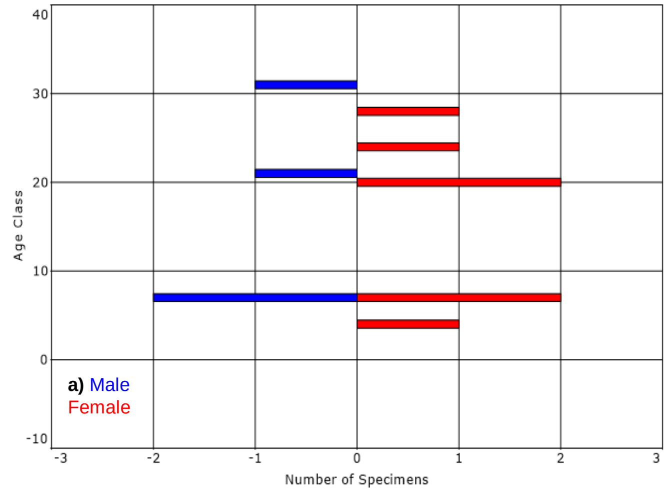
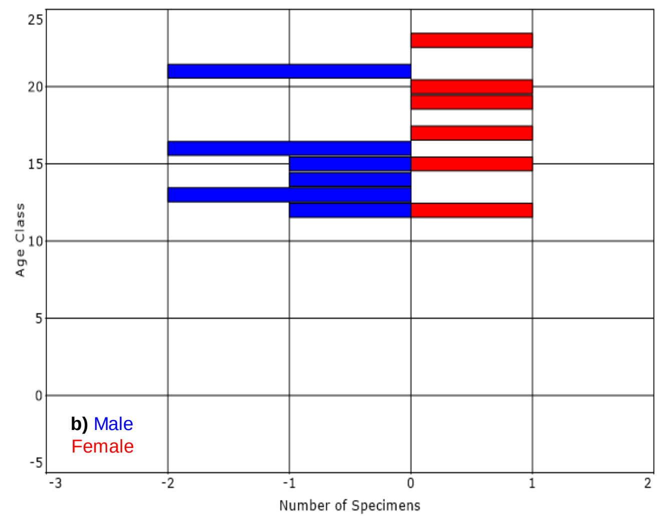


Figure 3. Population census of the AZA population of longcomb sawfish by sex from 2001 to present.

The current age structures of the sawfish populations are not stable due to many empty age classes, lack of younger animals, the uneven sex ratios and the overall small population sizes (Fig. 4a, b, c). All ages recorded in the studbook for individuals imported from the wild are estimates due to the difficulty of aging older animals. The overall small population sizes and gaps throughout the structures, especially in the younger age classes, reflect the lack of or low breeding success in the populations. Smalltooth are the only species to have bred in an aquarium; however, there has only been one birth event of four pups (2.2) in 2012. The overall small population sizes are concerning for the demographic health of the populations. With few or no young animals and most animals in the older age classes, there is a concern that no animals will be available to replace the older animals that are lost naturally to attrition. Currently, the largetooth and longcomb populations have a slight male sex bias and the smalltooth has a female sex bias. Obtaining animals from the wild is difficult; therefore, once breeding begins and becomes reliable in these populations, 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 out of the population. This will allow institutions to become less dependent on wild imports in the future. With these long-lived species, there is time to create more stable distributions by slowly filling in the youngest age classes to create future breeders.

Demographic data for these populations are lacking and may not represent the true life histories of these species due to their short histories in zoos and aquariums relative to their estimated long lifespans. Additionally, most individuals in the populations are of unknown age due to their wild origins and difficulty of accurately determining ages in these species. Consequently, demographic data are insufficient to produce robust life tables and do not allow for demographic analyses. The oldest recorded sawfish for all three populations are wild caught and have unknown age estimates. A smalltooth female lived to at least 29 years old with the oldest currently living at 28, while the oldest male lived to 45 with the current oldest living being 31. The oldest largetooth female and male are still living at 23 and 21 years old respectively. The oldest male and female longcomb are still living at 18 years old. Maximum longevities for these species in the wild and aquariums are not yet known, though all species are believed to live into their 30s or beyond (Brame et al. 2019, Peverell 2009). Data for sawfish were not of sufficient robustness to analyze and report median life expectancies (Appendix F).





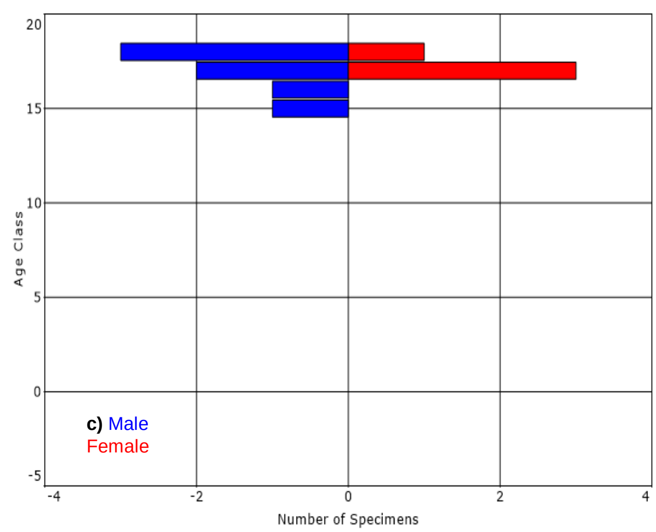


Figure 4. Age structures for the AZA populations of (a) smalltooth sawfish (4.7), (b) largetooth sawfish (9.6), and (c) longcomb sawfish (7.4). Note the different scales of the axes between the populations.

Only one successful breeding event has occurred in one out of the three sawfish species in the aquarium populations and limited data is available about the reproductive life history of these species in the wild. Presently, there is not enough data to definitively determine when these species reach sexual maturity or for how long they remain reproductive. The only successful breeding event occurred in the smalltooth population and the sire and dam were an estimated 14 and 17 years old, respectively. Based on the literatue, sawfish species are assumed to reach sexual maturity between the ages of 7 to 11 years old (10–12 feet long) (Brame et al. 2019, Elhassan 2018, Peverrell 2009). Males appear to sexually mature earlier and at a smaller size than females. It is anticipated sawfishes may be able to breed throughout their lives. Female sawfish are ovoviviparus and give birth to live young after a gestation period of several months to one year. The one recorded litter in the studbook had four pups, but it is believed that litter sizes can reach up to 14 (Brame et al. 2019, Elhassan 2018). Parthenogensis has been recorded in the wild for smalltooth sawfish, though it has not been recorded in aquariums (Brame et al. 2019). Seasonality for these species is unknown, but it is believed that breeding is based on environmental cues such as water temperature and photoperiod.

Genetics: Due to small population sizes, minimal/lack of reproduction and deficiency of data in the life tables, genetic analyses and projections could not be performed at this time. Currently, the largetooth and longcomb populations consist entirely of potential founders, 15 and 11, respectively. No breeding has occurred yet for these two sawfish species. Smalltooth sawfish have only had one birth event; therefore, there are two founders represented and five potential founders remaining in the smalltooth population. Any pairings producing offspring will be beneficial to the populations and institutions should focus on husbandry and breeding to begin working towards genetically stable populations.

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 populations would produce equal representation among founder lineages. Generation time in this species is estimated to be long and will improve gene diversity retention with consistent breeding. Lastly, maintaining a high effective size ratio (proportion of population breeding) will also help retain more gene diversity through time. The recruitment of any animals from the wild could also increase gene diversity and demographically help stabilize the currently small populations. To better meet genetic goals, the populations should focus on successful breeding and husbandry and recruiting additional founders to improve genetic diversity.

Recommendations for Genetic Management: The following recommendations are adapted from the Amphibian Ark Population Management Guidelines (available here).

- Potential founders (wild born individuals that have yet to breed) should be paired with one another with the goal of producing an equal number of offspring from each founder to equalize family sizes.
- Once founders have successfully reproduced, keep these pairs together; do not mix and match unnecessarily. If potential founder pairs are unsuccessful, then try other pairings and other available manipulations to encourage reproduction.
- Prioritize breeding the parental generation (founders) before their offspring.
    - Parents are more genetically valuable than their offspring.
    - However, it is important to attempt breeding the second generation before all founders die to test husbandry methods.
- Population growth rates should be carefully monitored to ensure that future genetic and demographic goals are not compromised due to lack of holding space for these long-lived animals. A flux of offspring may lead to a halt in breeding as the populations reach their institutional carrying capacities. Sufficient space should be reserved for breeding all founder lines to an equal representation, if possible.

Management Strategy: At the time of analyses, the smalltooth sawfish population consists of 11 (4.7) sawfish at three AZA institutions, 15 largetooth sawfish (9.6) at seven AZA institutions, and 11 (7.4) longcomb sawfish at six AZA institutions. As a result of the relatively short amount of time sawfish have been tracked in aquariums compared to their predicted long lifespans, demographic data may not represent the true biology of this species. Due to the limited/lack of breeding in the AZA populations, it is not possible at this time to project or estimate how many births are needed annually to maintain the populations. Efforts should focus on improving overall husbandry for these species and reproductive success. Any successful breeding will be beneficial for establishing genetically and demographically stable populations. The SSP is currently developing an understanding of the complex factors affecting breeding success and highly encourages institutions to participate in reproductive monitoring of their animals. Comparing these factors between institutions is necessary to determine relevant variables involved in breeding. Once these species' breeding biology and needs are understood, the SSP can communicate with institutions to ensure best practices are used across institutions.

1. The SSP recommends four smalltooth, four largetooth, and three longcomb sawfish females be placed in breeding situations.
    a. Institutions recommended to breed are expected to hold offspring for at least one year.
    b. Offspring should be moved immediately once born and reared in a separate tank from the parents and other fish to increase survivorship.
    c. Please contact the SSP Coordinators after each litter to discuss future actions.

2. The SSP recommends no transfers at this time.

3. Breeding is difficult for these sawfish species. Research needs to be conducted to better understand the reproductive needs of these species, in order to more consistently produce offspring. The SSP is currently developing an understanding of husbandry and of the complex factors affecting breeding success and highly encourages institutions to participate in monitoring of their animals. Comparing these factors between institutions is necessary to determine relevant variables involved in successful breeding. Please contact the SSP Coordinators with any husbandry successes or challenges.
    a. Determine if your institution is able to participate in testing of methodologies that would help develop techniques to increase the ability to breed large sawfishes (i.e. artificial fertilization).

4. The Elasmobranch Husbandry Manual is available at the following website https://sites.google.com/site/elasmobranchhusbandry/manual. Please contact the SSP Coordinators for further information.

5. Institutions interested in obtaining or placing sawfish should contact the SSP Coordinators to coordinate transfers that will best facilitate demographic and genetic stability.

Citations & Resources

Brame AB, Wiley TR, Carlson JK, Fordham SV, Grubbs RD, Osborne J, Scharer RM, Bethea DM, Poulakis GR (2019) Biology, ecology, and status of the smalltooth sawfish *Pristis pectinata* in the USA. Endangered Species Research 39: 9-23

Elhassan IS (2018) Occurrence of the green sawfish *Pristis zijsron* in the Sudanese Red Sea with observations on reproduction. Endangered Species Research 36: 41-47

Harrison LR, Dulvy NK (2014) Sawfish: A Global Strategy for Conservation. IUCN Species Survival Commission's Shark Specialist Group. Vancouver, Canada

Peverell, SC (2009) Sawfish (Pristidae) of the Gulf of Carpentaria, Queensland, Australia. Masters (Research) Thesis, James Cook University

Scharer RM, Patterson III WF, Carlson JK, Poulakis GR (2012) Age and Growth of Endangered Smalltooth Sawfish (*Pristis pectinata*) Verified with LA-ICP-MS Analysis of Vertebrae. PLoS ONE 7(10): e47850

Summary of Breeding and Transfer Recommendations
by Studbook ID

Smalltooth Sawfish (*Pristis pectinata*)

SB ID	Location	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
22	ORLANDO	ppec8926m	M	30	HOLD	ORLANDO	BREED WITH	23	
23	ORLANDO	ppec9301f	F	28	HOLD	ORLANDO	BREED WITH	22	
24	PARADISL	UNK	F	24	HOLD	PARADISL	BREED WITH	25	
25	PARADISL	UNK	M	21	HOLD	PARADISL	BREED WITH	24, 27, 28	
27	PARADISL	UNK	F	20	HOLD	PARADISL	BREED WITH	25	
28	PARADISL	UNK	F	20	HOLD	PARADISL	BREED WITH	25	
43	PARADISL	UNK	F	7	HOLD	PARADISL	DO NOT BREED		
44	PARADISL	UNK	F	7	HOLD	PARADISL	DO NOT BREED		
45	PARADISL	UNK	M	7	HOLD	PARADISL	DO NOT BREED		
46	PARADISL	UNK	M	7	HOLD	PARADISL	DO NOT BREED		
47	VERA CRAQ	UNK	F	4	HOLD	VERA CRAQ	DO NOT BREED		

Largetooth Sawfish (*Pristis pristis*)

SB ID	Location	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1	BALTIM AQ	504002	M	16	HOLD	BALTIM AQ	DO NOT BREED		
2	ABERDE HK	UNK	F	23	HOLD	ABERDE HK	BREED WITH	12	
3	RIPLEYSSC	MB-PM-99-01-M	M	21	HOLD	RIPLEYSSC	DO NOT BREED		
4	GATLINBAQ	GB-PM-99-03-M	M	21	HOLD	GATLINBAQ	BREED WITH	5, 11	
5	GATLINBAQ	GB-PM-00-01-F	F	20	HOLD	GATLINBAQ	BREED WITH	4, 10, 14	
7	LANDRYSAQ	UNK	F	17	HOLD	LANDRYSAQ	DO NOT BREED		
8	BALTIM AQ	504003	M	16	HOLD	BALTIM AQ	DO NOT BREED		
10	GATLINBAQ	GB-PM-17-01-M	M	15	HOLD	GATLINBAQ	BREED WITH	5, 11	
11	GATLINBAQ	GB-PM-15-01-F	F	15	HOLD	GATLINBAQ	BREED WITH	4, 10, 14	
12	ABERDE HK	UNK	M	14	HOLD	ABERDE HK	BREED WITH	2	
13	DALLAS WA	UNK	M	13	HOLD	DALLAS WA	BREED WITH	18	
14	GATLINBAQ	GB-PM-17-02-M	M	13	HOLD	GATLINBAQ	BREED WITH	5, 11	
17	DALLAS WA	UNK	M	12	HOLD	DALLAS WA	BREED WITH	18	
18	DALLAS WA	UNK	F	12	HOLD	DALLAS WA	BREED WITH	13, 17	
48	OCEAN VAL	MIG12-29012385	F	19	HOLD	OCEAN VAL	DO NOT BREED		

Longcomb Sawfish (*Pristis zijsron*)

SB ID	Location	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
29	OCEANJRNY	UNK	M	18	HOLD	OCEANJRNY	BREED WITH	34	
30	OCEANJRNY	UNK	M	18	HOLD	OCEANJRNY	BREED WITH	34	
31	RIPLEYCAN	MB-PZ-02-01-M	M	18	HOLD	RIPLEYCAN	BREED WITH	32	
32	RIPLEYCAN	GB-PZ-02-01-F	F	18	HOLD	RIPLEYCAN	BREED WITH	31	
33	SHEDD AQ	PZ1	F	17	HOLD	SHEDD AQ	DO NOT BREED		
34	OCEANJRNY	UNK	F	17	HOLD	OCEANJRNY	BREED WITH	29, 30	
35	SHARKREEF	572	M	17	HOLD	SHARKREEF	BREED WITH	37	
36	SHARKREEF	571	M	17	HOLD	SHARKREEF	BREED WITH	37	
37	SHARKREEF	573	F	17	HOLD	SHARKREEF	BREED WITH	35, 36	
42	GA AQUAR	UNK	M	15	HOLD	GA AQUAR	DO NOT BREED		
49	OCEAN VAL	RNV18-00455	M	16	HOLD	OCEAN VAL	DO NOT BREED		

Breeding and Transfer Recommendations by Institution

ABERDE HK

Ocean Park Corporation

Aberdeen, Hong Kong SAR, China

Largetooth Sawfish (*Pristis pristis*)

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
2	UNK	F	23	HOLD	ABERDE HK	BREED WITH	12	
12	UNK	M	14	HOLD	ABERDE HK	BREED WITH	2	

BALTIM AQ

National Aquarium in Baltimore, Inc.

Baltimore, MD

Largetooth Sawfish (*Pristis pristis*)

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
1	504002	M	16	HOLD	BALTIM AQ	DO NOT BREED		
8	504003	M	16	HOLD	BALTIM AQ	DO NOT BREED		

DALLAS WA

Dallas World Aquarium

Dallas, TX

Largetooth Sawfish (*Pristis pristis*)

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
13	UNK	M	13	HOLD	DALLAS WA	BREED WITH	18	
17	UNK	M	12	HOLD	DALLAS WA	BREED WITH	18	
18	UNK	F	12	HOLD	DALLAS WA	BREED WITH	13, 17	

GA AQUAR

Georgia Aquarium

Atlanta, GA

Longcomb Sawfish (*Pristis zijsron*)

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
42	UNK	M	15	HOLD	GA AQUAR	DO NOT BREED		

GATLINBAQ

Ripley's Aquarium of the Smokies

Gatlinburg, TN

Largetooth Sawfish (*Pristis pristis*)

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
4	GB-PM-99-03-M	M	21	HOLD	GATLINBAQ	BREED WITH	5, 11	
5	GB-PM-00-01-F	F	20	HOLD	GATLINBAQ	BREED WITH	4, 10, 14	
10	GB-PM-17-01-M	M	15	HOLD	GATLINBAQ	BREED WITH	5, 11	
11	GB-PM-15-01-F	F	15	HOLD	GATLINBAQ	BREED WITH	4, 10, 14	
14	GB-PM-17-02-M	M	13	HOLD	GATLINBAQ	BREED WITH	5, 11	

LANDRYSAQ

Landry's (Houston) Downtown Aquarium

Houston, TX

Largetooth Sawfish (*Pristis pristis*)

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
7	UNK	F	17	HOLD	LANDRYSAQ	DO NOT BREED		

OCEAN VAL

L'Oceanografic

Valencia, Spain

Largetooth Sawfish (*Pristis pristis*)

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
48	MIG12-29012385	F	19	HOLD	OCEAN VAL	DO NOT BREED		

Longcomb Sawfish (*Pristis zijsron*)

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
49	RNV18-00455	M	16	HOLD	OCEAN VAL	DO NOT BREED		

OCEANJRNY

Landry's Downtown Aquarium - Denver

Denver, CO

Longcomb Sawfish (*Pristis zijsron*)

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
29	UNK	M	18	HOLD	OCEANJRNY	BREED WITH	34	
30	UNK	M	18	HOLD	OCEANJRNY	BREED WITH	34	
34	UNK	F	17	HOLD	OCEANJRNY	BREED WITH	29, 30	

ORLANDO

Sea World Orlando

Orlando, FL

Smalltooth Sawfish (*Pristis pectinata*)

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
22	ppec8926m	M	30	HOLD	ORLANDO	BREED WITH	23	
23	ppec9301f	F	28	HOLD	ORLANDO	BREED WITH	22	

PARADISL

Atlantis, Paradise Island

Paradise Island, Nassau, New Providence, Bahamas

Smalltooth Sawfish (*Pristis pectinata*)

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
24	UNK	F	24	HOLD	PARADISL	BREED WITH	25	
25	UNK	M	21	HOLD	PARADISL	BREED WITH	24, 27, 28	
27	UNK	F	20	HOLD	PARADISL	BREED WITH	25	
28	UNK	F	20	HOLD	PARADISL	BREED WITH	25	
43	UNK	F	7	HOLD	PARADISL	DO NOT BREED		
44	UNK	F	7	HOLD	PARADISL	DO NOT BREED		
45	UNK	M	7	HOLD	PARADISL	DO NOT BREED		
46	UNK	M	7	HOLD	PARADISL	DO NOT BREED		

RIPLEYCAN

Ripley's Aquarium of Canada

Toronto, Ontario, Canada

Longcomb Sawfish (*Pristis zijsron*)

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
31	MB-PZ-02-01-M	M	18	HOLD	RIPLEYCAN	BREED WITH	32	
32	GB-PZ-02-01-F	F	18	HOLD	RIPLEYCAN	BREED WITH	31	

RIPLEYSSC

Ripley's Aquarium of Myrtle Beach

Myrtle Beach, SC

Largetooth Sawfish (*Pristis pristis*)

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
3	MB-PM-99-01-M	M	21	HOLD	RIPLEYSSC	DO NOT BREED		

SHARKREEF

Shark Reef at Mandalay Bay

Las Vegas, NV

Longcomb Sawfish (*Pristis zijsron*)

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
35	572	M	17	HOLD	SHARKREEF	BREED WITH	37	
36	571	M	17	HOLD	SHARKREEF	BREED WITH	37	
37	573	F	17	HOLD	SHARKREEF	BREED WITH	35, 36	

SHEDD AQ

John G. Shedd Aquarium

Chicago, IL

Longcomb Sawfish (*Pristis zijsron*)

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
33	PZ1	F	17	HOLD	SHEDD AQ	DO NOT BREED		

VERA CRAQ

Acuario de Veracruz, A.C.

Veracruz, Mexico

Smalltooth Sawfish (*Pristis pectinata*)

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
47	UNK	F	4	HOLD	VERA CRAQ	DO NOT BREED		

Appendix A
Analytical Assumptions

Analytical Data for True Specimens

Studbook ID	Field	TRUE	Overlay
1	Birth Date Est.	Unknown	+/- 1 Year
2	Birth Date Est.	Unknown	+/- 1 Year
3	Birth Date Est.	Unknown	+/- 1 Year
4	Birth Date Est.	Unknown	+/- 1 Year
5	Birth Date Est.	Unknown	+/- 1 Year
7	Birth Date Est.	Unknown	+/- 1 Year
8	Birth Date Est.	Unknown	+/- 1 Year
10	Birth Date Est.	Unknown	+/- 1 Year
11	Birth Date Est.	Unknown	+/- 1 Year
12	Birth Date Est.	Unknown	+/- 1 Year
13	Birth Date Est.	Unknown	+/- 1 Year
14	Birth Date Est.	Unknown	+/- 1 Year
17	Birth Date Est.	Unknown	+/- 1 Year
18	Birth Date Est.	Unknown	+/- 1 Year
22	Birth Date Est.	Unknown	+/- 1 Year
23	Birth Date Est.	Unknown	+/- 1 Year
24	Birth Date Est.	Unknown	+/- 1 Year
25	Birth Date Est.	Unknown	+/- 1 Year
27	Birth Date Est.	Unknown	+/- 1 Year
28	Birth Date Est.	Unknown	+/- 1 Year
29	Birth Date Est.	Unknown	+/- 1 Year
30	Birth Date Est.	Unknown	+/- 1 Year
31	Birth Date Est.	Unknown	+/- 1 Year
32	Birth Date Est.	Unknown	+/- 1 Year
33	Birth Date Est.	Unknown	+/- 1 Year
34	Birth Date Est.	Unknown	+/- 1 Year
35	Birth Date Est.	Unknown	+/- 1 Year
36	Birth Date Est.	Unknown	+/- 1 Year
37	Birth Date Est.	Unknown	+/- 1 Year
42	Birth Date Est.	Unknown	+/- 1 Year
47	Birth Date Est.	Unknown	+/- 1 Year
48	Birth Date Est.	Unknown	+/- 1 Year
49	Birth Date Est.	Unknown	+/- 1 Year

Appendix B
Summary of Data Exports

PMx Project: Sawfish_23Oct2019
Created: 2019-10-23 by PMx version 1.6.0.20190628
File: C:\PMxProjects\Sawfish_23Oct2019.pmxproj
Description: All species of sawfish included in Demo

Primary data file
Data File Name: XXSawfish_13Oct19.ped
Common Name: Sawfish
Scientific Name:
Data Source: PopLink
Studbook Name: Sawfish_13Oct19
Exported On: 2019-10-23
Software version: PopLink 2.4
Current through: 2014-11-11
Compiled by: Stacia White
Scope: Regional
Dates: 2019-10-23
Association: AZA.FED
Other Filters: Status = Living
User: alawless

Moves data file
Data File Name: XXSawfish_13Oct19genetics.csv
Common Name: Sawfish
Scientific Name:
Data Source: PopLink
Studbook Name: Sawfish_13Oct19
Exported On: 2019-10-23
Software version: PopLink 2.4
Current through: 2014-11-11
Compiled by: Stacia White
Scope: Regional
Dates: 2019-10-23
Association: AZA.FED
Other Filters: Status = Living
User: alawless

Moves data file
Data File Name: XXSawfish_13Oct19demog.csv
Common Name: Sawfish
Scientific Name:
Data Source: PopLink
Studbook Name: Sawfish_13Oct19
Exported On: 2019-10-23
Software version: PopLink 2.4
Current through: 2014-11-11
Compiled by: Stacia White
Scope: Regional
Dates: 1985-01-01 to 2019-10-23 (Smalltooth Demo Window = 1985-2019, Largetooth = 1997-2019, Longcomb = 2002-2019)
Locations: N.AMERICA/VERA CRAQ/OCEAN VAL/ABERDE HK
Other Filters: Status = Living
User: alawless

Locations data file
Data File Name: location.txt

Demographic input files
Census1 file: Exchcens.txt

Appendix C
Animals Excluded from Genetic Analyses

No individuals were excluded from the genetic analyses or potentially breeding populations.

Appendix D
Life Tables

There was insufficient demographic data to produce robust life tables.

Appendix E
Ordered Mean Kinship Lists

No births have occurred in the largetooth or longcomb populations and only one birth event has occurred in the smalltooth population; therefore, no mean kinship values were calculated.

Appendix F
Descriptive Survival Statistics Report

Sawfish Studbook
AZA Regional Studbook

Studbook data current as of 11/11/2014

Compiled by Stacia White
swhite@ripleys.com

PopLink Studbook filename: Sawfish_13Oct19 + Overlay_2May2016
PopLink User Who Exported Report: alawless
Date of Export: 11/12/2019
Data Filtered by: StartDate = 1/1/1985 AND EndDate = 11/12/2019
PopLink Version: 2.4

REPORT OVERVIEW:

Data for Sawfish **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 1985 to 12 November 2019 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 48 individuals, 10 (20.8%) of which had died by 12 November 2019. 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 (12 November 2019); 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
22	Male	Wild Born	31.0	+/- 1 Year	alive at end of window
23	Female	Wild Born	28.1	+/- 1 Year	alive at end of window
24	Female	Wild Born	24.8	+/- 1 Year	alive at end of window
2	Female	Wild Born	23.5	+/- 1 Year	alive at end of window
25	Male	Wild Born	21.9	+/- 1 Year	alive at end of window
3	Male	Wild Born	21.5	+/- 1 Year	alive at end of window
4	Male	Wild Born	21.3	+/- 1 Year	alive at end of window
27	Female	Wild Born	20.9	+/- 1 Year	alive at end of window
28	Female	Wild Born	20.9	+/- 1 Year	alive at end of window
5	Female	Wild Born	20.5	+/- 1 Year	alive at end of window

10 Oldest Dead Individuals

Studbook ID	Sex	Birth Type	Age at Death	Birth Date Est.
19	Male	Wild Born	45.0	+/- 1 Year
21	Female	Wild Born	29.8	+/- 1 Year
20	Male	Wild Born	29.2	+/- 1 Year
26	Male	Wild Born	18.6	+/- 1 Year
6	Male	Wild Born	15.6	+/- 1 Year
9	Male	Wild Born	10.3	+/- 1 Year
38	Female	Wild Born	10.0	+/- 1 Year
39	Male	Wild Born	9.4	+/- 1 Year
16	Female	Wild Born	8.4	+/- 1 Year
15	Male	Wild Born	7.4	+/- 1 Year

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? **PASS**
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 (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 H
Directory of Institutional Representatives

Contact Name (IR)	Institution	Email
Walter Tang	ABERDE HK – Ocean Park Corporation, Aberdeen, Hong Kong SAR, China	walter.tang@oceanpark.com.hk
Alan Henningsen	BALTIM AQ – National Aquarium in Baltimore, Inc., Baltimore, MD	ahenningsen@aqua.org
Paula Carlson	DALLAS WA – Dallas World Aquarium, Dallas, TX	paula@dwazoo.com
Chris Schreiber	GA AQUAR – Georgia Aquarium, Atlanta, GA	cschreiber@georgiaaquarium.org
Frank Bulman	GATLINBAQ – Ripley's Aquarium of the Smokies, Gatlinburg, TN	bulman@ripleys.com
Jim Prappas	LANDRYSAQ – Landry's Downtown Aquarium, Houston, TX	jprappas@ldry.com
Nate Jaros	LONG B AQ – Long Beach Aquarium of the Pacific, Long Beach, CA	njaros@lbaop.org
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