SeaWorld's Killer Whale Program: a highly successful ex-situ megafauna breeding program and the future of...

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SeaWorld's Killer Whale Program:

a highly successful ex-situ megafauna breeding program and the future of zoological scientific endeavors with this increasingly threatened species

SeaWorld's decades of husbandry practices with killer whales which evolved using science-based advancements has enabled tremendous strides in our understanding of the species' physiology, health, and care. Over that history, SeaWorld's investment in facilities and its rapid learning curve resulted in a healthy, sustainable, zoological killer whale population; one that ultimately has indistinguishable survivorship and mortality rates from wild populations (Robeck et al. 2015). This program could truly represent an example of one of the most successful and rapidly developed ex-situ megafauna programs in the history of zoos and aquariums.

The first killer whale brought into captivity occurred in 1961 at Marineland of the Pacific. From that point forward until 1977, more than 25 different institutions were involved in legally collecting close to 60 whales from the Pacific Northwest. At the time of collection, no understanding of sympatric ecotypes had been developed and given the nuisance label held by killer whales at that time, the potential impacts of collections on local ecotypes were not well understood by the facilities or by the governmental agencies who approved these collections. SeaWorld's first collection occurred in 1965 and at that time the company consisted of one small marine research center and aquarium in San Diego, CA (now SeaWorld San Diego, SWSD). Without any prior knowledge of the species' biology and husbandry requirements, killer whales were cared for as large bottlenose dolphins and placed in mixed species pools. The original pool at SWSD was ~120 thousand gallons, relatively paltry compared to today's standards, and with the arrival of a second animal in 1966 and the popularity of the species, construction on an additional pool containing ~1.2 million gallons was begun and finally completed by the mid 70s. A total of 11 animals were collected from the Pacific Northwest by SeaWorld from 1965 to 1976. An additional six animals were collected from the North Atlantic during 1977 to 1978. Altogether, SeaWorld's killer whale program was established with the collection of only 17 animals from the wild, with the last collection taking place almost 40 years ago in 1978. At the time of this last collection SeaWorld was one of approximately 25 other facilities around the world which were attempting to develop suitable habitats for housing these animals in zoological facilities.

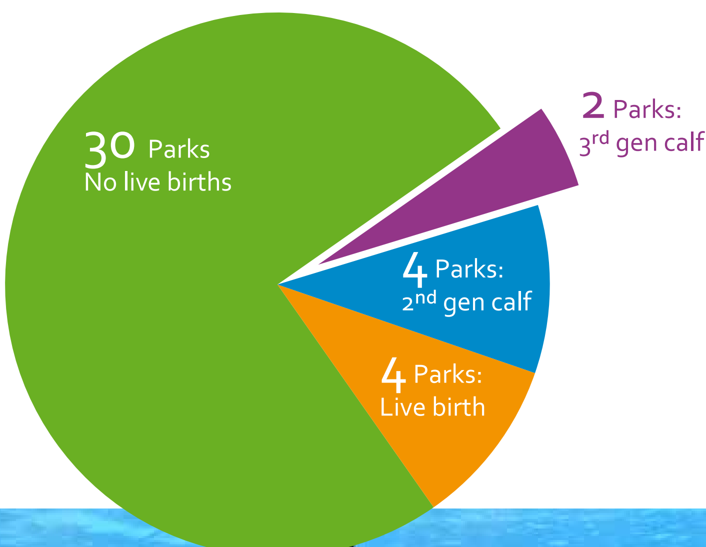

Figure 1

Total number of facilities that have ever housed killer whales and the relative proportion of the facilities that were able to successfully produce live calves, second and third generation (gen) animals. For purposes of this illustration, SeaWorld parks are counted as individual parks and include SeaWorld California, Florida, Texas and Loro Parque (Spain). All of SeaWorld parks have experienced either second or third generation calf production.

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A picture of Kalia and calf, and Kalia's sibling Makani, Amaya represents the last killer whale calf to be born at SeaWorld of San Diego.

One of the first facilities to house killer whales, Marineland of the Pacific, was also the first to experience a successful live birth. The first live calf was delivered in February1977 to a female named Corky 2. The calf lived for 17 days. Corky 2 gave birth to four more live calves from Oct of 1978 until July 1985, that lived for 16, 10, 46 and 26 days, respectively. Other than the calves born from Corky 2, the only other live calf produced during this timeframe occurred in 1982 in Japan. However, this calf also died soon after birth, living for only 10 days. Complications associated with failure of passive transfer and lack of nutrition were most likely the underlying causes of death for most if not all of these calves. It was this lack of successful nursing that led SeaWorld to believe that larger and deeper pools were one of the components necessary to facilitate normal nursing behavior. As a result, the company built two approximately 5-million gallon pools in Orlando and San Diego, respectively. These pools had a maximum depth from 36 to 40 feet and represented the largest killer whale zoological habitats in the world at that time. The completion of these habitats coincided with the sexual maturation of a group of females collected from Iceland in 1977. The first live birth at SeaWorld occurred in the new Orlando habitat on 9/26/1985 and it resulted in the first calf that was successfully reared beyond the age of weaning (age 2). Three more calves were successfully reared in 1988 and another in 1989. All of these five initial calves were female; all but one went on to successfully raise their own calf to post-weaning (age). The birth of a calf surviving beyond weaning age was restricted to SeaWorld facilities until 1992 when this milestone was also achieved by a Canadian aquarium. A year later, the first 2nd generation calf (on the dam's side) was born at SeaWorld and continues to thrive today, and the first 3rd generation killer whale born to second generation parents occurred in 2010 (Figure 1). The 25 year interval between the first successful captive birth and the birth of a 3rd generation killer whale calf reflects the fast evolution of SeaWorld's husbandry practices and the adaption of this species to the zoological environment. This milestone exceeds that of other slowly reproducing megafauna. For example, the time periods from the first successful zoological birth until the birth of the first 3rd generation calf for the Southern white rhino (*Ceratotherium simum simum*), greater one-horned rhino (*Rhinoceros unicornis*) and the Asian elephant (*Elephas maximus*) were 36, 45 and 98 years, respectively (intervals computed from Charlton 2015, Keele 2010, Kennedy 2016).

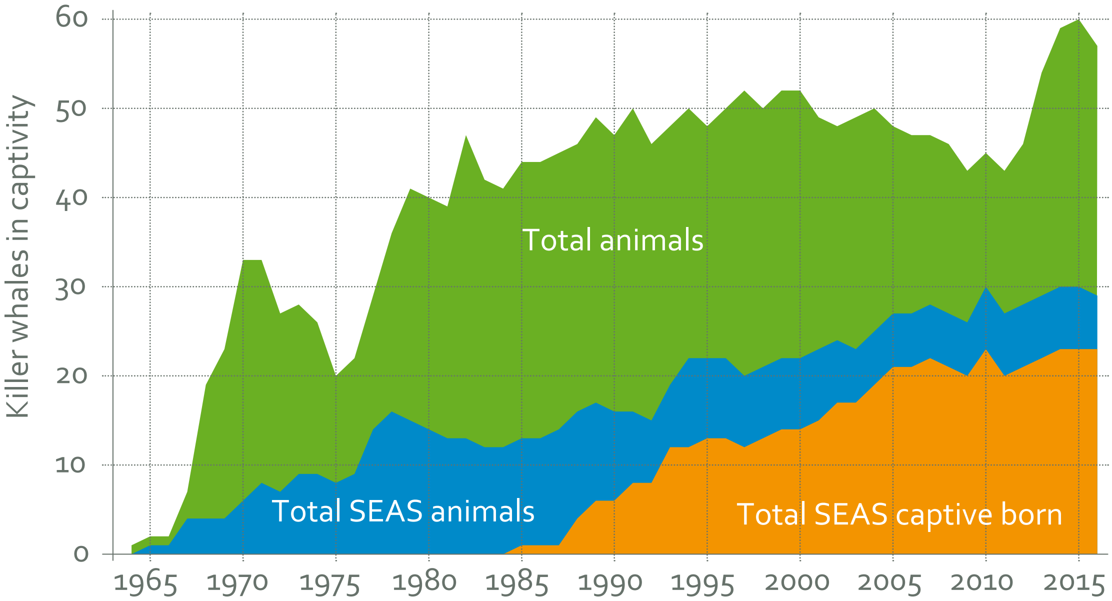

Figure 2

Killer whales in captivity. Total global killer whale population demonstrating both the relative success of SeaWorld's program in terms of the proportion of total animals, but also the relative success of SeaWorld's breeding program.

It is also worth noting that none of the killer whale females collected from the Pacific Northwest ever successfully raised a calf at any facility in the world. The lack of successful reproduction by females of this ecotype is not understood but may be due to the timing of their collection in relation to the overall dearth of knowledge concerning care during which time they attained sexual maturity. Conversely, males from the Pacific Northwest did go on to sire offspring with females from the North Atlantic, and these ecotype-crossbred females went on to successfully conceive and rear calves.

As the SeaWorld killer whale population, and the understanding of their care and health continued to grow, the need for more space was considered appropriate and a 3rd major expansion occurred around 1996 (beyond the addition of a new park complete with a 5 million gallon pool in 1988 at SeaWorld San Antonio). These additional pools to the San Diego and Orlando parks added an extra 1.7 and 1.3 million gallons of total volume, respectively, to bring the total volume of both facilities well over 6 million gallons. The population grew to over 25 animals and a partnership was formed with Loro Parque in Spain in 2005. This collaboration resulted in a new ~6 million gallon facility built to create an additional killer whale habitat for the continued expansion of the population toward a sustainable size relative to demographics and gene diversity (Figure 2)

While natural reproduction was the foundation for the successful development of a breeding population within SeaWorld Parks, as early as 1985, SeaWorld husbandry directors realized that artificial insemination (AI) would improve its ability to manage the captive population's genetic diversity. Toward this goal, a number of basic research projects were initiated which included understanding the species' basic reproductive physiology, training of semen collection, developing methods for semen cryopreservation, and establishing ovulation detection techniques (For review see Robeck and O'Brien 2005). Although progress was rapidly made with regard to understanding the reproductive physiology of female killer whales, reliable semen collection methods proved to be difficult to attain. Early semen collection attempts in the late 80s and early 90s resulted in a few samples but nothing consistent, and it created erroneous expectations of how future attempts should be made. Systematic research allowing the development of effective semen preservation methods were ultimately realized in 2000 when the first regular samples were collected from the male, Tilikum at SeaWorld Orlando. Through these efforts, we were able to collect sufficient samples to develop short-term sperm (chilled) preservation and long term (cryopreservation) preservation methods. Together with knowledge gained from research on female reproductive physiology, the first successful AI (pregnancy which resulted in a birth) in any cetacean was in March 2000, with the calf born in 2001 after a 552 day gestation to the female Kasatka (located at SeaWorld San Diego; Robeck et al. 2004). Soon after, a second advancement was achieved in AI using cryopreserved semen with the calf born in May 2002. For this and all inseminations performed to date, females were trained using positive reinforcement to station poolside and could swim away at any time during the procedure.

Continued work on developing semen collection training techniques resulted in a repeatable method being attained by 2005 (Fripp et al. 2005). With the new tools for managing population genetics and social structures now developed within SeaWorld parks (i.e. animals no longer needed to be moved for breeding purposes), efforts were made to partner with other facilities for the exchange of semen to facilitate the preservation of this genetic diversity and the formation of a cooperative sperm cryobank. Partnerships were formed with Kamogawa SeaWorld (Kamogawa, Chiba, Japan) and Marineland of Antibes (Antibes, France), at the time, the only aquaria in the world other than SeaWorld to have demonstrated successful rearing of 2nd generation killer whales. Training of males for semen collection was already successful at Kamogawa SeaWorld and the partnership simply included sharing of cryopreservation techniques and exchange of semen for cryobank storage and AI. SeaWorld partnered with another aquarium, Mundo Marino located in Argen-

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Kasatka and calf.

tina, housing a stranded killer whale (Kshamenk) who had been deemed non-releasable. This male originating from the South Atlantic Ocean, represented a genetic background which could prove valuable for maintaining the genetic diversity of captive killer whales. SeaWorld collaborating with the staff of Mundo Marino to facilitate best practice training methods for husbandry behaviors including semen collection. Cryopreservation equipment and techniques were taught to the veterinary staff and scientific collaborations were performed for the improvement of these techniques and for an increased understanding of male gamete biology and fertility (Robeck et al. 2011). Semen imported from this male resulted in two calves being born at SeaWorld San Diego and San Antonio in 2013. Both of these births marked an important milestone for the development of collaborative global gamete sharing, having to overcome multiple scientific and permitting obstacles prior to being accomplished, and they represent the last two AIs performed at SeaWorld.

SeaWorld's killer whale population currently includes six young females. While these animals will never have the experience of bonding to and raising a calf (above), and will slowly lose the social structures and population diversity that has taken more than five decades to establish, they will continue to receive the very same high level of care and attention that they have known their whole lives.

Zoological environments provide unparalleled access to wild species for robust and longitudinal study. However, the anti-zoo movement puts at great risk to the invaluable scientific programs that focus on establishing healthy sustainable populations and that in turn allow us to understand, protect, rescue and rehabilitate wildlife. For the killer whale, a species that is becoming increasingly threatened in the wild due to anthropogenic stressors (e.g. Hickie et al. 2007), its removal from the zoological environment will result in the loss of important knowledge of their biology. This includes characterizing the dynamics of maternal-offspring transfer of toxic compounds during gestation and lactation, a study which would help provide critical scientific evidence needed by lawmakers for implementing policy concerning environmental pollutants.

SeaWorld's experience is a warning to other zoological facilities whose research and conservation activities are also vulnerable to the actions of those groups with an anti-zoo ideology. Wildlife conservation work done by accredited zoos around the world must overcome the negative sentiment expressed by the minority if we are to help save animals and their ever diminishing ecosystems.

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