Tursiops truncatus EEP

Key figures with regard to longevity of individual animals and sustainability of the collection of bottlenose dolphins managed within the European Endangered Species Program (EEP).

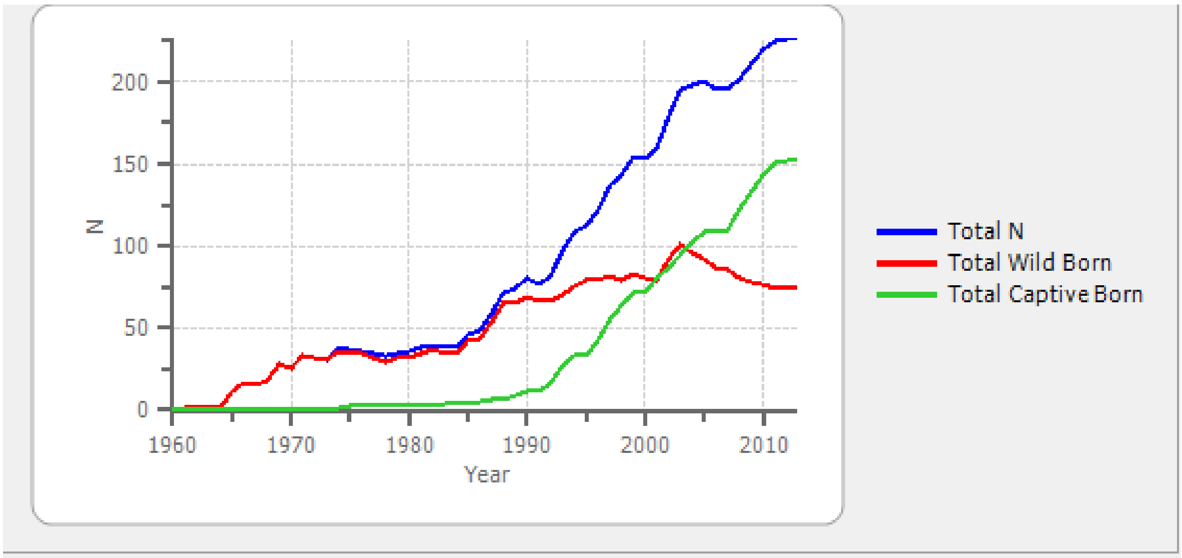
INTRODUCTION

The European Association of Zoos and Aquaria has different levels of management for the species held by its members. The EEP program is the most intensive management program. At the base of this program is the studbook, which is a concise archive of all events of the individual animals within the EEP (births, transfers, deaths, pedigree etc). This database is analyzed with specialized software programs like SPARKS (developed under the auspices of the International Species Information System ISIS) and PMx (developed under the auspices of the Chicago Zoological Society and the Smithsonian Institution).

The bottlenose dolphin studbook contains 835 animals. With a known pedigree of more than 95% it is one of the most complete and precisely kept studbooks within the zoo community. It is the most suitable scientific instrument for answering questions about keeping bottlenose dolphins under human care in Europe.

GENERAL TRENDS

Number (N) of dolphins: Total, and subdivision into wild and captive born



The graph above demonstrates several matters:

1. From 1964 onwards, there is a general increase within the EEP population up to 232 animals

2. The number of wild born animals increased in the collection until 2003, which was the last year animals were taken from the wild to be introduced into the EEP. From then onwards,

the number of wild born animals decreases due to natural mortality.

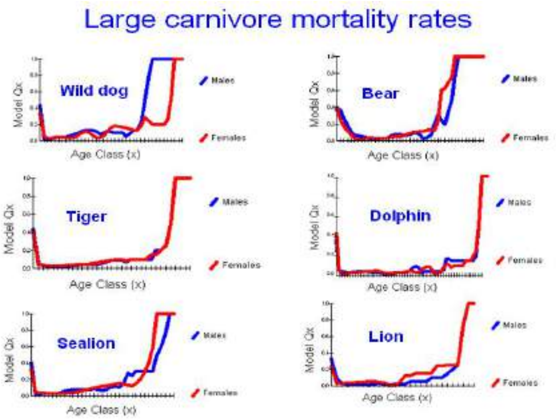
3. From 1990 onwards, successful reproduction increases and the number of animals born in zoos rises.

4. At present, approximately 1/3 of the collection is born in the wild and 2/3 of the collection is born in zoos.

LONGEVITY

Mortality in dolphins is characterized by a significant mortality in the first month of life and thereafter an annual mortality of between 3 and 4%.

- Neonatal mortality has decreased from 77% in the decade 1980 to 1990 to 48 and 47% in the periods 1990 to 2000 and 2000 to 2012 and further to 44% in the period 2007 to 2012. (neonatal mortality includes stillbirths and abortions and is mortality in the first 30 days of life)
- This mortality pattern is very similar to that of other large predators under human care (see graph kindly provided by L Bingaman Lackey ISIS).



- No reliable bottlenose data from the wild are available for comparison because much neonatal mortality in the wild goes unnoticed and unreported

In order to compare longevity within the EEP with the wild and bottlenose dolphins kept in the US, the median life expectancy from 1 year of age is suitable (Defined as: to what age do 50% of the animals survive of all animals that have survived their first year). Average life expectancy is not suitable as this number cannot be calculated (yet) because many animals of the first generation are still living.

The table below displays values from the wild, US and EEP populations. Please see the attached essay (How do we know how long Atlantic bottlenose dolphins typically live in the wild and in human care, Willis 2011) references to the original data.

	US Zoo 1973-1987	US Zoo 1973-2003	US Zoo 1995-2003	EEP Zoo 1964-2011	EEP Zoo 1990-2011	Wild Texas coast	Wild Sarasota Bay	Wild Mississippi Sound	Wild Indian river lagoon
Median life expectancy (from 1 year)	9,55	22,75	34,3	13	22	10,9	17,4	8,6	8,3 – 16,7

The data demonstrate:

- Dolphins in zoos within the EEP live remarkably longer than in the wild
- The longevity of dolphins has greatly increased since the beginning of keeping dolphins under human care
- In the US, where these animals have been kept under human care since the 1930s and several generations of data are available, longevity is higher.

SUSTAINABILITY

An important question is: Can the present EEP collection maintain itself without resorting to taking animals from the wild? To answer this question, all events within the collection since 1980 have been analyzed. Based on the observed mortality and fecundity for each age class and each gender, combined with the present constitution of the collection, future potential development is predicted by the value Lambda. Lambda for the EEP collection is 1.004. Expected population development going forward is an annual increase of 0,4 %, based on mortality and fecundity since 1980, and explicitly independent of wild imports.

Two important notes have to be made:

1. The number of animals has only increased since the sixties. Many institutions are now nearly fully occupied, so in consequence approximately one quarter of the fertile females is purposely being kept from reproduction. A large potential exists to increase the number of births should this be necessary.

2. In order to reliably calculate fecundity and mortality for each age class for each gender, a large number of animals is required. Hence the period 1980 to present was chosen for analysis. However, mortality has decreased and fecundity has increased since 1980. This improvement has not been taken into account in the present calculation of Lambda.

In conclusion, the present EEP collection is sustainable and can be maintained by its own reproduction. Animals in human care are expected to live markedly longer than in the wild (an increase of 30 to 150% based on median life expectancy of 1 year old animals).

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How Do We Know How Long Atlantic Bottlenose Dolphins Typically Live in the Wild and in Human Care?

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Alliance of Marine Mammal Parks and Aquariums
June, 2011

Calculating the lifespans of animals both in the wild as well as in human care takes many years of accumulated data. As an example, in North America one of the first Atlantic bottlenose dolphins born in human care is still living at 58 years of age, and thus 58 years is not sufficient to determine this animal's lifespan. This means we do not yet know how long a dolphin could live in human care in North America. However, not knowing the maximum lifespan, also called the longevity record, does not prevent or preclude estimation of the typical lifespan.

It is important to clearly define the term "typical lifespan." As stated above, the longevity record is the longest reported lifespan. For humans that record is 122 years, 164 days. Obviously, the longevity record is not typical. The average lifespan in a population or species would be the average age at death. Unfortunately, the average may not be typical. Averages provide a good summary of data when the data conform to a normal distribution, otherwise known as the "bell shaped curve." However, survival data seldom fit that pattern. Take for example a species that has 95% per year survival. The average lifespan in this case is 19.5 years, but only about 35% of the animals will live that long. If "typical" is defined as the age to which half of the animals are expected to live, then the "typical" would be the median lifespan. In this example the median is 13.5 years.

Use of medians to summarize data that do not conform to the normal distribution is common. For example, economists report "median incomes" because just one very high wage earner can greatly affect the average income, but in terms of the median that very high wage earner is just one more salary above the median. Another reason to use the median in calculating lifespans is that good estimates of the median are possible even when many animals in the population are still living.

For wild populations of bottlenose dolphins there are four long-term, published studies of demography, each in a different location: Sarasota Bay, Florida (Wells and Scott, 1990), the Indian River Lagoon system, Florida (Stolen and Barlow, 2003), the Mississippi Sound Region of the North-Central Gulf of Mexico (Mattson, et al., 2006), and Coastal Texas (Neuenhoff, 2009).

Although neither the average nor median lifespan is explicitly reported in any of these four studies, the data necessary to calculate the median lifespan is included. In the Indian River Lagoon and Coastal Texas studies, the median lifespan can be read directly from their Life Tables. Median lifespan is defined as the age to which 50% of animals live, and thus the age at which the term l_x (age specific survival) equals 0.50 is the median lifespan.

In the Indian River lagoon system that age is 5 years (their Table 1). However, for their Tables 2 and 3 Stolen and Barlow (2003) produced Life Tables for males and females separately and adjusted the values to account for the likelihood that the population was increasing in size during the study. If the smoothed q_x values adjusted for population growth from their Tables 2 and 3 are converted into l_x values (see Footnote 1) the median life expectancy from birth is 9.9 and 20.0 years for males and females, respectively. Median life expectancy from a year of age is 12.2 and 21.2 years for males and females, respectively. To be comparable to the other studies that did not report separate male and female Life Tables it is assumed the birth sex ratio is 1:1 and so the male and female values are averaged. For the Indian River Lagoon population the range of median life expectancy based on their Tables 1 – 3 is given in Table 1 below.

In the Coastal Texas waters the median life expectancy is approximately 5.5 years (their Appendix A[1]). In the study on the animals from the Mississippi River Sound region no Life Table is provided; however, it is still possible to calculate median lifespan from the data provided in their Figure 5 using the same methods as were used in the other two studies. The estimated median lifespan for that population was 7.4 years.

The Sarasota Bay population study used very different methods of examining the demography of the wild population. The other three studies used tooth aging on stranded carcasses and converted those data into Life Tables. The Sarasota Bay study used mark-resight data, and used those data to calculate an annual survival rate (ASR - more details given below). The estimated median life expectancy from birth in that population is 12.9 years.

Although the range of values reported in Table 1 vary considerably, all four studies used valid, peer reviewed techniques, and thus the results reported in Table 1 should be considered four valid and independent estimates of the median lifespans of wild dolphins. Regardless, as the methodology used by Wells and Scott (1990) is the same as that used for the population of dolphins in human care in the U.S.A. described below, it is the most relevant for a comparisons of the life expectancies of wild dolphins to those in human care.

Table 1: Estimates for how long Atlantic Bottlenose dolphins live in the wild. Linear interpretation was used to calculate a more precise value than is found in the Life Tables. Citations for the studies are given in the text.

Study Area	Study Duration	Sample Size	Median Lifespan (from birth)	Median Lifespan (from 1 year)	Maximum observed age
Indian River Lagoon	1978-1997	220	5.0 – 15.0 years	8.3 – 16.7 years	35
Sarasota Bay	1980-1987	116	12.9[2]	17.4 years[3]	Not reported
Mississippi Sound	1986-2003	111	7.4 years	8.6 years	30
Texas Coast	1991-2007	280	5.5 years[1]	10.9 years	44

The values for median lifespans for wild dolphins in Table 1 may seem surprisingly, even suspiciously, low. An Internet search using the keywords "Dolphin Lifespan" will yield dozens of websites with reported lifespans of 30 to 40 years. It is clear that in the majority of these reports it is the maximum lifespan that is being reported. The maximum age of an animal found in each of the three studies of wild dolphins is also included in Table 1, and 30 to 40 years is a reasonable estimate of maximum lifespan in wild dolphin populations. Reporting wild dolphin lifespans of 30 to 40 years is roughly the equivalent of reporting human lifespans of 100 to 122 years.

Although all four studies include neonate mortality, it is generally acknowledged that it is likely that neonate mortality has been underestimated in wild populations because very young dolphins are more easily missed than older, larger dolphins both in terms of carcass recovery as well as mark-resighting. It is relatively common in studies of wild populations to not calculate lifespan from birth, but rather from an age at which it is assumed complete data are available. In Table 1 median lifespans are also reported starting from a year of age. This calculation is done in the Life Table by setting l_1 equal to 1, and then recalculating the remaining l_x values using the regular procedure (see Footnote 1).

The data for calculation of the median lifespan for Atlantic bottlenose dolphins in human care in the United States are available in the National Marine Fisheries Service Marine Mammal Inventory Report (MMIR). The MMIR was initiated in 1973 as part of the Marine Mammal Protection Act of 1972. Since that time all facilities in the United States that have marine mammals in their care are required to annually report on those animals to the US Government for the MMIR. There have been a number of studies conducted on these data. DeMaster and Drevenek (1988) and Small and DeMaster (1995) are probably the two most frequently cited studies using these data, but these two studies are now somewhat dated.

More recently Innes (2005) and Innes, et al. (2005) analyzed the MMIR data, and also did comparisons over time. In all four cases the authors calculated an Annual Survival Rate (ASR) from a year of age instead of lifespan. The rationale for this is given in each study, but converting the ASR into a median lifespan is quite simple. The ASR is the probability an animal survives from one year to the next. This then is equivalent to the p_x, or more commonly $(1-q_x)$, that is used in all Life Tables. With the ASR method it is assumed that the survival rate is a constant with age, and so after the first age class (age 0 to 1) in the Life Table each q_x is simply 1-ASR.

Table 2 contains the ASRs and corresponding median lifespans from the three studies. All three were based on the data in the MMIR and used the same methodology, but note that the time frame differs in each. Innes (2005) and Innes et al. (2005) broke down the calculations into time blocks and showed that the median lifespan of dolphins in US facilities has been increasing. Innes' estimate of the ASR for the time period 1995 - 2003 is 0.98 which corresponds to a median lifespan of just over 34 years. A statistical comparison of median life expectancies between studies requires more information than is provided, but an ASR of 0.98 is outside of the 95% confidence interval reported by Wells and Scott (1990): [0.961 ± 1.96*0.0079].

Table 2: Median lifespan estimates from three studies using the United States National Marine Fisheries Service Marine Mammal Inventory Report.

Study	Time Span	Sample Size	Annual Survival Rate	Median Lifespan (from 1 year)
DeMaster and Drevenak, 1988	1973-1987	864	0.93	9.55
Small and DeMaster, 1995	1988-1992	Not reported	0.951	13.80
Innes, 2005	1973-2003	872	0.97	22.75
Innes, 2005	1995-2003	Not reported	0.98	34.3

Conclusions

Studies of lifespans of wild animals are relatively rare, and thus comparisons of the lifespans of wild animals to those in human care are often impossible. Atlantic bottlenose dolphins are an exception as there are four long-term studies of wild populations which allow estimation of lifespans. These four studies are each on a different population, and one of the three studies uses a very different method of data collection. The values of median life expectancy from a year of age range from 8.3 to 17.4 years. It is not possible to determine whether this over two-fold difference in the estimates reflects differences in the populations and/or the methodologies.

The data for dolphins in human care are available in a single database, the National Marine Fisheries Service Marine Mammal Inventory Report (MMIR). Using the value based on MMIR data from 1973 – 2003 the median life expectancy of a year old Atlantic bottlenose dolphin in human care is longer than the longest reported value for a wild population (22.5 vs 17.4 years). Innes (2005) also documented that the Annual Survival Rate (ASR) has been increasing over time. If just the more recent data are analyzed (1995 – 2003) Innes (2005) found that the ASR had increased to 0.98 which corresponds to a median lifespan of 34.3 years.

Just as the estimates of lifespan for the population of dolphins in human care have been changing over time, so too may the estimates for the wild population. The 1990 study of the Sarasota Bay population by Wells and Scott was based on 116 dolphins. That study has continued and the accumulation of data since 1987 may also show a pattern of change. However, unlike the population in human care, there is not an *a priori* expectation that the median lifespan of wild dolphins would increase over time unless there have been ongoing improvements in their habitat.

At this point in time it is clear that dolphins in human care are expected to live longer than their counterparts in the wild. Based on recent research and the longest estimate of median lifespan for a wild population, the estimated median lifespan of dolphins in human care is now nearly double the value for wild dolphins (34.3 vs 17.4 years).

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Footnotes

[1] In Appendix A and C of this study the values for l_x were calculated incorrectly, and this makes it appear as though males have a longer median lifespan than females. As per their Table 9: $q_x = (l_x - l_{x+1})/l_x$ and thus $l_{x+1} = l_x(1-q_x)$. Unfortunately, in Appendix A and C the equation: $l_{x+1} = l_x(1-q_{x+1})$ was used instead. The calculations are correct in Appendix B. In the text and table above the corrected numbers are given.

[2] This value is calculated using the young of the year ASR of 0.803 and the ASR of 0.961 for all subsequent age classes from Wells and Scott (1990).

[3] This value is calculated using the ASR of 0.961 reported in Wells and Scott (1990).