Generation length and percent mature estimates for IUCN assessments of cetaceans

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Abstract

We estimated generation length and percent mature for 58 cetacean species to assess their status using criteria developed by the IUCN. We first reviewed the literature and types of data available and then developed a set of simple rules to ensure consistent use of the best available data to estimate these parameters. The method we developed estimated percent mature for the current population and the generation length for the pre-disturbance population using a simple 5-parameter demographic model based on age of first reproduction, inter-birth interval, maximum age of reproductive females, calf survival rate, and non-calf survival. When parameter estimates were not available for a species, we used available estimates from congeners. The maximum age of females was estimated based on the relationship between maximum length of females and maximum age of females for all species with data available. Generation length and percent mature were not calculated if data for the first two model parameters were unavailable for any congener (n = 29). Model-based estimates of these parameters were very close to the estimates for 6 species calculated from empirical data.

Introduction

The most comprehensive listing of risk status of species is the Red List maintained by the World Conservation Union (IUCN). Species are categorized according to a set of criteria (IUCN 2001), which the IUCN is currently using to systematically update all species listings by taxonomic group. Here, we consider the Cetacea, the portion of the order Cetartiodactyla that includes whales, dolphins and porpoises. Data gathering is especially onerous for these species because of their remote habitats in all oceans of the world, their long lives, and the difficulty in obtaining age specific data. The criteria most often used for cetaceans are "A", which takes the general form: "An observed, estimated, inferred or suspected population size reduction equal to or greater than X% over the last Y years or three generations, whichever is the longer….", and "D", which takes the form "Population size estimated to number fewer than Y mature individuals." Cetacean abundance estimates usually refer to total abundance, with no means of determining the proportion of that abundance that consists of mature individuals. Therefore, the percent mature must be estimated. Data are either insufficient or non-existent for nearly all species to directly estimate generation length (T) and percent mature (P).

The IUCN definitions for the relevant parameters are:

1 Available from authors at: 8604 La Jolla Shores Drive, La Jolla, CA 92037 USA

"*Mature Individuals*: The number of mature individuals is the number of individuals known, estimated or inferred to be capable of reproduction.

Generation: Generation length is the average age of parents of the current cohort (i.e. newborn individuals in the population). Generation length therefore reflects the turnover rate of breeding individuals in a population. Generation length is greater than the age at first breeding and less than the age of the oldest breeding individual, except in taxa that breed only once. Where generation length varies under threat, the more natural, i.e. pre-disturbance, generation length should be used."

We develop a method to calculate values of these two parameters (T and P) using the best available data, a series of rules to deal with missing data or data from multiple sources, and a simple demographic model. For species without empirical data on the average age of mature individuals, we use a five-parameter demographic model to estimate both the percent mature of the current population and the generation length of the pre-disturbance population.

Methods

We first compiled a table for the 87 recognized species of cetaceans documenting relevant demographic data available in the literature and some unpublished data provided by researchers (IUCNCetacean2007.xls available as supplemental material at http://swfsc.noaa.gov/BarbTaylorPubs.aspx). Direct estimates of the generation length (T), calculated from the average age of mature females, were available for 6 species.

T and P can also be estimated using a simplified Leslie matrix with the following parameters: calf survival (S_0), non-calf survival (S_A), age of first birth (AFR), interbirth interval (IBI), and oldest age of a reproducing female (O). In the four known cases with reproductive senescence (killer whales, two pilot whale species and sperm whales) an additional parameter was needed for the oldest individual (G). Only two species (common bottlenose dolphins and killer whales) had data for all parameters and then only for a single population.

Estimating O – Nearly all species had an estimate of the maximum length of females (L). The regression of the log of maximum length on maximum age (n = 30) was highly significant (F-test $p << 0.001$, $R^2 = 0.48$) (Figure 1). A few species with empirical estimates for maximum age were omitted from the regression. The bowhead whale is an extreme outlier, with an age of maturity of around 16 years and a numerous whales aged at over 100 years old (George et al. 1999). Others (e.g. Commerson's dolphin and Hector's dolphin) were omitted because samples came from populations known to have experienced high levels of bycatch for some time prior to the studies so it is likely that the oldest individuals were no longer available to be sampled. We assumed no reproductive senescence (i.e. the oldest age of females and oldest age of reproducing females were identical) except for sperm whales, pilot whales and killer whales. Oldest age for those species was: sperm whales—75 (Best et al. 1984), pilot whales—60 (Olson and Reilly 2002), and killer whales—75 (Paul Wade[1] personal communication). Generation length or the

1 Paul Wade, National Marine Mammal Laboratory, 7600 Sand Point Way NE, Seattle, WA, USA

average age of mature females (T) does not depend on the maximum post-reproductive age, but proportion mature (P) does. When empirical estimates for O were missing, we used the regressed coefficients for O on L (intercept = 20.93, slope =29.31) to estimate oldest age.

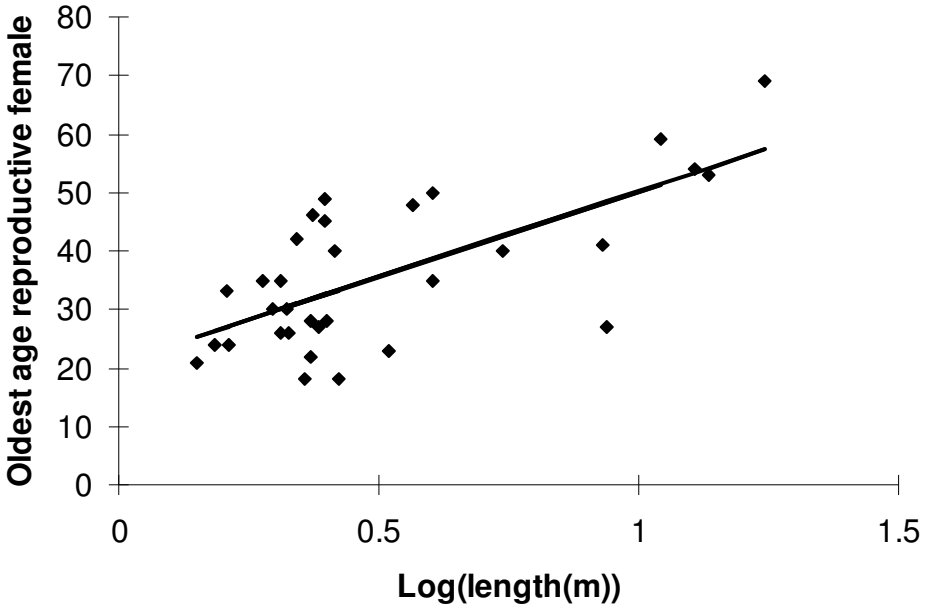

Figure 1. Empirical points and regression line for relationship between length (L)and oldest age of reproductive females (O).

Estimating AFR -- We used empirical estimates for AFR when they were available. Many species had estimates of age at attainment of sexual maturity and gestation length. In those cases, we added gestation length to age at sexual maturation and rounded up to the nearest integer. For example, for gray whales the age at sexual maturation is 8 and the gestation length is 13.75 months, so AFR = 10. No relationship was found between body length and either of the reproductive parameters AFR and IBI (Figures 2 and 3). Leslie matrices model females only, so birth rates reflect the birth of females. We assume parity in sex ratio of calves at birth and therefore calculate annual birth rates (used in the Leslie matrix) as (1/IBI)/2. It should be noted that this is a fairly rough calculation as some values were direct calculations from photo-identification studies while others were estimates based on examinations of dead animals (female reproductive tracts). The specification of the Leslie matrix assumed post-birth census and started with age zero. As such, the birth term (F_x, where x = age) was also multiplied by the survival rate of mothers (S_A). Stable age distribution was calculated using standard matrix methods (Caswell 1991). When a range of values was given for any of these parameters, either within a single study or across several studies, we used the average. When these parameters were missing we used averaged values from congeners when available. We made some exceptions when genetic data (LeDuc 1999) or expert opinion (W. Perrin) suggested that apparent congeners were not so closely related. We made no estimate for AFR for *Lagenorhynchus australis* and *Lagenorhynchus cruciger*, and we used only *Stenella longirostris* as the congener for *Stenella clymene*. When no values from congeners were available, no estimate was made of T or P.

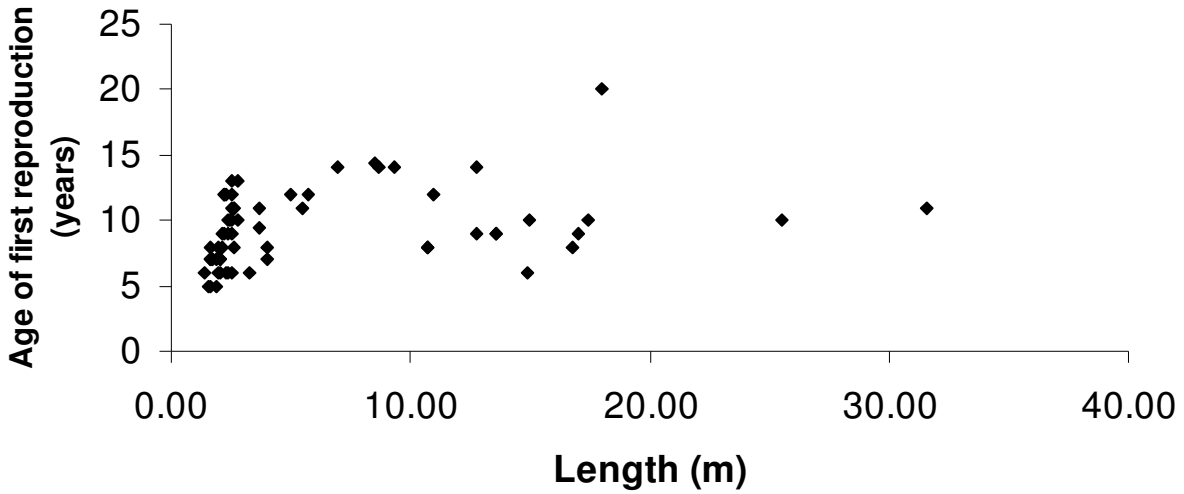

Figure 2. Age at first reproduction (years; A) compared with maximum female body length (m).

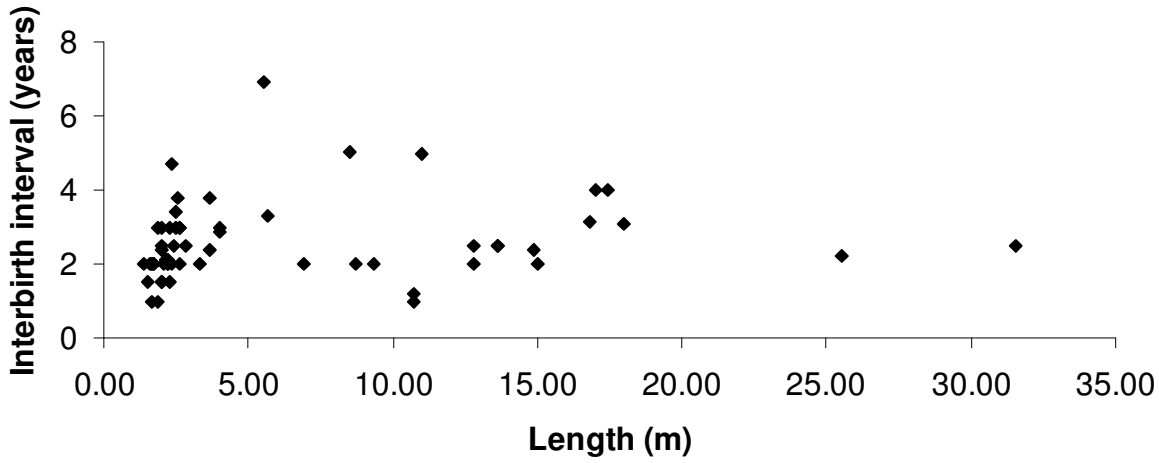

Figure 3. Interbirth interval (years; IBI) compared with maximum female body length (m).

Estimating survival rates -- When estimates were available for either survival parameter, these were used in calculating T and P. When S_A was unavailable, we used a default value based on oldest age (O) using the following rule:

If $O \geq 60$ then $S_A = 0.986$ (from southern right whales, Best et al. 2001)
If $50 \leq O < 60$ then $S_A = 0.96$ (from humpback whales)
If $O < 50$ then $S_A = 0.95$ (from bottlenose dolphins).

Data on calf survival are sparse and for some cases were available for small populations with known decreases in survival of either calves, non-calves or both because of human-caused mortality in fishing nets. We considered only the following cases to represent a natural ratio

between calf and non-calf survival rates: southern right whales, humpback whales, and bottlenose dolphins. Although there are logical correlates between calf survival and other parameters like inter-birth interval (indicative of the magnitude of parental care) and longevity, the data were inadequate to estimate such relationships. We therefore simply averaged the ratio of calf to non-calf survival for these three cases and multiplied that value (0.84) by the non-calf survival rate for all cases without empirical estimates of calf survival.

There were two cases with fairly disparate estimates for the same parameter within a species but from different areas. Killer whales (*Orcinus orca*) have considerable taxonomic uncertainty and in any case have "ecotypes" with strong dietary specialization and sometimes different body size and social structure. Because life history parameters are likely to be correlated, we used a single population with complete data (southern resident killer whales) rather than averaging between what may even be separate species or subspecies. Common bottlenose dolphins (*Tursiops truncatus*) are also dietary specialists and have a large range in sizes across their global range. For the same reasons, we used a single population with complete data for all parameters: the Sarasota Bay, Florida population. Because Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) are very similar ecologically and morphologically to common bottlenose dolphins, we used the parameters for *T. truncatus* for that species for all five parameters rather than the defaults.

Model estimates of T and P -- With values for these five parameters, a Leslie matrix was used to calculate stable age distribution and the population growth rate (r) for each species (Caswell 1989). The percent mature (P) and average age of reproductive females (T) was calculated from this stable age distribution. Percent mature (P) is the proportion of the total population from age of sexual maturity (generally AFR -1 when gestation is less than one year) to oldest age (O for all except the three species mentioned above which have reproductive senescence). Generation length (T) is the average age of females aged between AFR and O. To obtain the pre-disturbance generation length (T when r=0) we changed the birth rate to obtain a stable population where births and deaths are equal (r = 0).

Results and Discussion

Primary results with the model parameter values used (Table 1) and sources (Appendix) are also given in IUCNcetacean2007.xls (http://swfsc.noaa.gov/BarbTaylorPubs.aspx). Calculated values for population growth rate (r) fall within reasonable ranges (Figure 4). Only three species have negative growth rates (all at -1%/year). Commerson's dolphin (*Cephalorhynchus commersonii*) has unusually low survival rates that were estimated from the age distribution of animals killed in fishing nets. Thus, a negative growth rate for this population is entirely possible. Pacific white-sided dolphin (*Lagenorhynchus obliquidens*) had an atypically long putative interbirth interval (4.7 yr) that should be suspect for an animal of this size. The Atlantic spotted dolphin (*Stenella frontalis*) has one of the few empirically estimated calf survival rates (Herzing 1997) that is lower than the default rate. Adjustments to achieve zero growth were made via the birth parameter, and resulted in only a very small change in T from 18.6 to 18.3 years.

The percent mature (P) values fall within a surprisingly large range (Figure 5). For many of the recovering populations, particularly for large whales, the current values (in black bars) are much smaller than would be expected for a stable population (in white bars). For example, bowhead whales (*Balaena mystecetus*) have a percent mature (P) that is 26% higher once their age distribution returns to stable.

Generation lengths (Figure 6) fall within a relatively small range with the exception of that for the bowhead whale (T = 52). Generation lengths are generally longer for the recovering populations of large whales than is actually likely to be the case for current populations, which are largely composed of young individuals (Table 1).

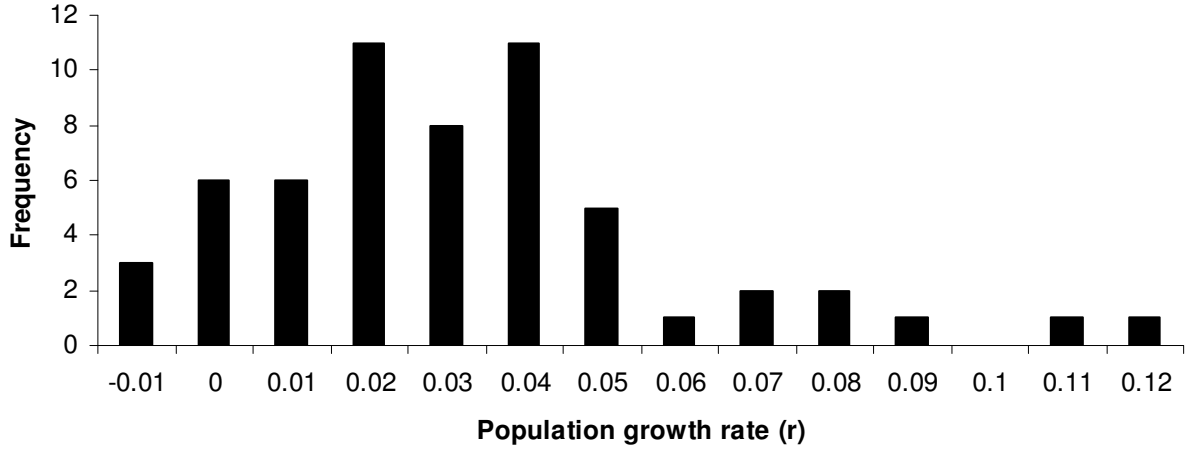

Figure 4. Population growth rates (r) using the values in Table 1 for the five parameters .

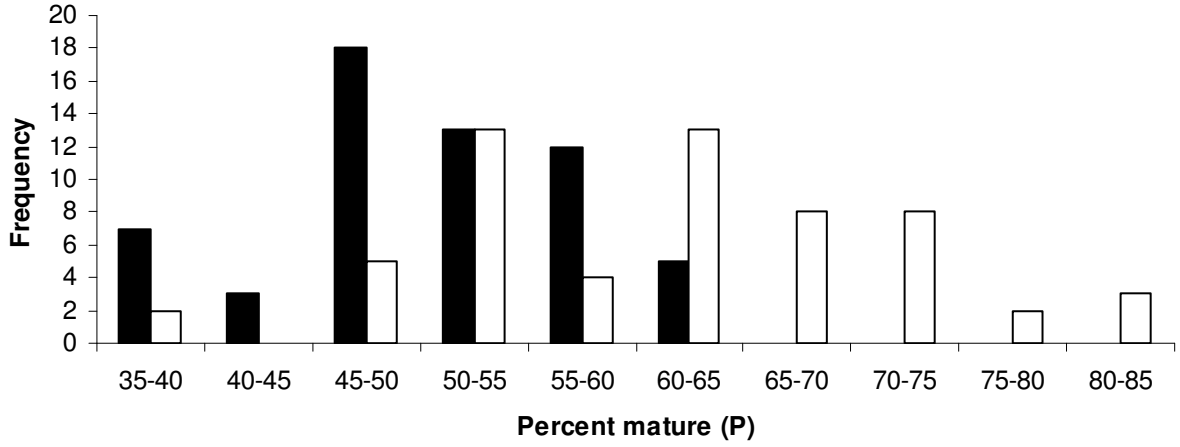

Figure 5. Percent mature (P) for the 58 species with sufficient data to make estimates, with current estimated values at the growth rates shown in Figure 4 in black bars and estimated for stable populations (r = 0) in white bars.

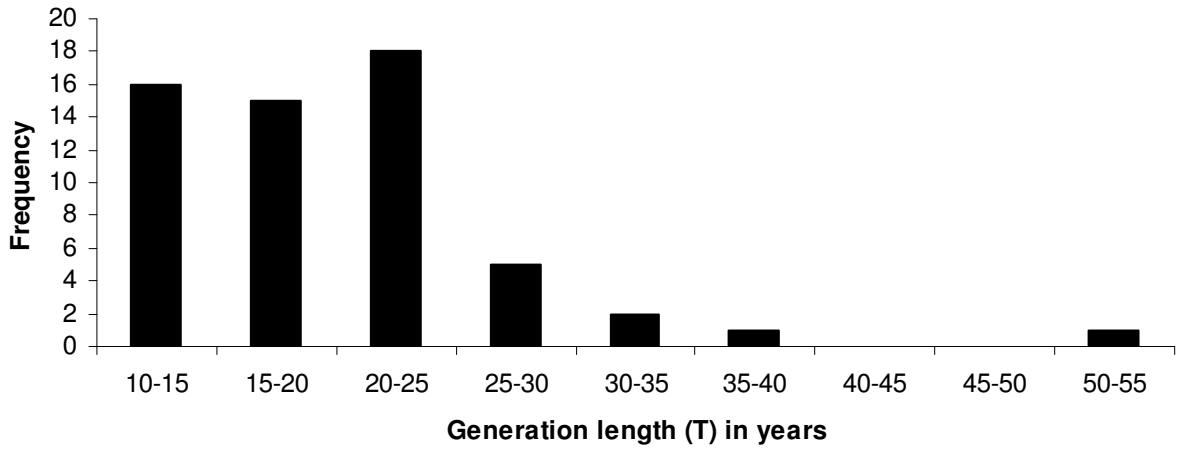

Figure 6. Generation length (T) for the 58 species with sufficient data to make estimates.

Table 1. Values for the five-parameter model together with output for growth rate (r) and estimates of generation length (T) and percent mature (P) for current conditions (at the calculated r) and pre-disturbance conditions (when r = 0). Parameters are: AFR—age of first reproduction, IBI—interbirth interval, O--oldest age of a reproducing female, O_e –oldest age of a reproducting female but estimated from the relationship in Figure 1, S_0—calf survival rate, S_A—annual non-calf survival rate, r—population growth rate given the preceeding parameters, T(r)—generation length at that value of r, P(r)—percent mature at that value of r, and T(r=0)—generation length under pre-disturbance conditions with an assumed stable population. The parameters used in IUCN criteria are in bold: P(r) and T(r=0). Empirical estimates are in bold with sources in the Appendix.

Species	AFR	IBI	O	Oe	S_0	S_A	r	T(r)	**P(r)**	**T(r=0)**	P(r=0)
Balaena mysticetus	**20**	**3.10**	**118**	58	0.823	0.980	0.03	37.2	39	52.3	65
Balaenoptera acutorostrata	8	**1.00**		51	0.806	0.960	0.09	13.0	38	22.1	71
Balaenoptera bonaerensis	**8**	**1.20**		51	0.806	0.960	0.08	13.7	41	22.1	71
Balaenoptera borealis	**9**	**2.50**	**53**	54	0.806	0.960	0.04	18.4	52	23.3	68
Balaenoptera edeni	**9**	**2.50**		53	**0.840**	**0.925**	0.00	18.0	51	18.4	52
Balaenoptera musculus	**11**	2.50		65	0.819	0.975	0.05	21.7	48	30.8	72
Balaenoptera omurai	9	2.50		54	0.806	0.960	0.04	18.5	52	23.5	68
Balaenoptera physalus	**10**	**2.24**		62	0.806	0.960	0.04	19.6	48	25.9	66
Berardius arnuxii	14	2.00		49	0.798	0.950	0.02	22.8	38	24.7	47
Berardius bairdii	**14**	2.00	**54**	53	0.806	0.960	0.03	23.4	38	27.1	53
Caperea marginata				45	0.760	0.960					
Cephalorhynchus commersonii	**7**	2.00		28	**0.673**	**0.914**	-0.01	13.0	55	12.7	53
Cephalorhynchus eutropia	7	2.00		27	0.798	0.950	0.04	12.5	54	14.0	64
Cephalorhynchus heavisidii	7	2.00		28	0.798	0.950	0.04	12.6	54	14.4	65
Cephalorhynchus hectori	**7**	**2.00**		27	0.788	**0.938**	0.03	12.5	54	13.5	61
Delphinapterus leucas	**7**	**2.88**	**35**	39	0.798	0.950	0.02	14.9	61	16.4	68
Delphinus capensis	9	2.10		31	0.798	0.950	0.03	15.2	48	16.5	58
Delphinus delphis	**9**	**2.10**	**26**	31	0.798	0.950	0.02	14.1	48	14.8	54
Eschrichtius robustus	**10**	**2.00**		55	**0.700**	**0.950**	0.03	19.3	47	22.9	60

Species	AFR	IBI	O	Oe	S_0	S_A	r	T(r)	**P(r)**	**T(r=0)**	P(r=0)
Eubalaena australis	**8**	**3.12**		57	**0.910**	**0.986**	0.06	18.1	58	28.8	83
Eubalaena glacialis	**10**	**4.00**	**69**	57	**0.880**	**0.990**	0.05	23.3	58	35.7	83
Eubalaena japonica	9	4.00		57	0.895	0.988	0.05	21.0	60	29.8	82
Feresa attenuata				32	0.760	0.950					
Globicephala macrorhynchus	**11**	**6.90**	**40**	43	0.828	0.986	0.01	22.7	53	23.5	53
Globicephala melas	**12**	**3.30**	**40**	43	0.828	0.986	0.04	21.1	46	24.0	51
Grampus griseus	**11**	**2.40**		37	0.798	0.950	0.02	18.6	46	19.6	53
Hyperoodon ampullatus	14	**2.00**	**27**	48	0.798	0.950	0.00	17.8	36	17.8	36
Hyperoodon planifrons	14	2.00		46	0.798	0.950	0.02	22.4	38	24.0	46
Indopacetus pacificus				21	0.798	0.950					
Inia geoffrensis	**6**	**1.50**	**18**	31	0.798	0.950	0.05	9.2	52	10.2	63
Kogia breviceps	**6**	**2.00**	**23**	36	0.798	0.950	0.04	10.8	57	12.1	67
Kogia sima	**6**	**2.00**	**22**	32	0.798	0.950	0.04	10.6	57	11.7	66
Lagenodelphis hosei	**8**	**2.00**	**18**	33	0.798	0.950	0.01	11.0	49	11.1	51
Lagenorhynchus acutus	**10**	**2.50**	**27**	32	0.798	0.950	0.01	15.5	48	15.8	51
Lagenorhynchus albirostris	10	2.50		34	0.798	0.950	0.02	17.2	49	18.1	55
Lagenorhynchus australis				30	0.798	0.950					
Lagenorhynchus cruciger				29	0.798	0.950					
Lagenorhynchus obliquidens	**10**	**4.70**	**46**	32	0.798	0.950	-0.01	21.8	61	21.2	59
Lagenorhynchus obscurus	**7**	**2.40**	**35**	30	0.798	0.950	0.03	14.2	57	16.4	68
Lipotes vexillifer	6			33	0.798	0.950					
Lissodelphis borealis	**12**	**2.00**	**42**	31	0.798	0.950	0.02	19.8	41	21.6	51
Lissodelphis peronii	12	2.00		31	0.798	0.950	0.02	17.7	40	18.3	46
Megaptera novaeangliae	**6**	**2.36**		55	**0.760**	**0.960**	0.05	14.5	62	21.5	79
Mesoplodon bidens				41	0.798	0.950					
Mesoplodon blainvillei				21	0.798	0.950					
Mesoplodon bowdoini				41	0.798	0.950					
Mesoplodon carlhubbsi				42	0.798	0.950					
Mesoplodon densirostris				40	0.798	0.950					
Mesoplodon europaeus				42	0.798	0.950					
Mesoplodon ginkgodens				41	0.798	0.950					
Mesoplodon grayi				42	0.798	0.950					
Mesoplodon hectori				39	0.798	0.950					
Mesoplodon layardii				44	0.798	0.950					
Mesoplodon mirus				42	0.798	0.950					
Mesoplodon perrini				21	0.798	0.950					
Mesoplodon peruvianus				38	0.798	0.950					
Mesoplodon stejnegeri				43	0.798	0.950					
Mesoplodon traversii				21	0.798	0.950					
Monodon monoceros	**8**	**3.00**	**50**	39	0.806	0.960	0.03	17.9	58	21.9	71
Neophocaena phocaenoides	**8**	**2.00**	**33**	27	0.798	0.950	0.04	14.4	50	16.5	63
Orcaella brevirostris	**9**		**28**	32	0.798	0.950					
Orcaella heinsohni	9			21	0.798	0.950					
Orcinus orca	**14**	**5.02**	**41**	48	**0.910**	**0.990**	0.02	24.0	43	25.7	40
Peponocephala electra	**13**			34	0.910	0.990					
Phocoena dioptrica	6	1.50		30	0.798	0.950	0.07	11.0	52	14.4	71
Phocoena phocoena	**5**	**1.00**	**24**	27	0.798	0.950	0.11	8.3	50	11.9	73

Species	AFR	IBI	O	Oe	S_0	S_A	r	T(r)	**P(r)**	**T(r=0)**	P(r=0)
Phocoena sinus	**6**	**2.00**	**21**	25	0.798	0.950	0.04	10.4	57	11.4	66
Phocoena spinipinnis	6	1.50		30	0.798	0.950	0.07	11.0	52	14.4	71
Phocoenoides dalli	**5**	**1.00**	**35**	29	0.798	0.950	0.12	8.7	50	15.1	77
Physeter macrocephalus	**12**	**5.00**	**59**	51	0.828	0.986	0.03	26.5	56	31.9	65
Platanista gangetica	**9**		**28**	33	0.798	0.950					
Pontoporia blainvillei	**5**	**1.50**	**24**	26	0.798	0.950	0.08	9.3	57	11.9	73
Pseudorca crassidens	**12**			41	0.910	0.990					
Sotalia fluviatilis	8	**2.50**	**30**	30	0.798	0.950	0.02	14.6	54	15.6	61
Sotalia guianensis	**8**	**2.00**	**30**	30	0.798	0.950	0.04	14.0	50	15.6	61
Sousa chinensis	**11**	**3.00**	**40**	33	0.798	0.950	0.01	19.8	50	20.4	54
Sousa teuszii	11	3.00	**0**	33	0.798	0.950	0.00	18.3	50	18.4	51
Stenella attenuata	**13**	**3.00**	**45**	33	0.798	0.950	0.00	22.7	47	23.1	49
Stenella clymene	7	3.00		29	0.798	0.950	0.02	14.0	61	14.7	65
Stenella coeruleoalba	**11**	**3.38**	**49**	33	0.798	0.950	0.01	21.8	53	22.5	56
Stenella frontalis	**12**	**3.00**		31	**0.760**	0.950	-0.01	18.6	48	18.3	46
Stenella longirostris	**7**	**3.00**	**26**	30	0.798	0.950	0.01	13.3	61	13.7	64
Steno bredanensis	**10**		**32**	33	0.798	0.950					
Tasmacetus shepherdi				45	0.798	0.950					
Tursiops aduncus	9.5	3.80		33	0.760	0.950	0.00	20.6	60	21.1	62
Tursiops truncatus	**9.5**	**3.80**	**48**	37	**0.760**	**0.950**	0.00	20.6	60	21.1	62
Ziphius cavirostris				46	0.798	0.950					

Comparisons of estimated T to the empirical T for the five species with empirical data are quite favorable (Table 2).

Table 2. Comparisons of generation time T from empirical longitudinal studies to demographic estimates of T for the current growth rate (r) and when r = 0. All estimates of population growth rate (r) using the demographic parameters in Table 1 are positive. Empirical estimates could come from populations that would not be considered "pre-disturbance" and thus may underestimate T at a pre-disturbance state.

Species	**Empirical T**	**r calculated**	**T at r**	**T (r=0)**
Delphinapterus leucas	16[1]	0.02	14.9	16.4
Delphinus delphis	12.8[2]	0.02	14.1	14.8
Stenella attenuata	19.9[3] [4]	0.00	22.7	23.1
Stenella coeruleoalba	18.1[5]	0.01	21.8	22.5
Stenella longirostris	13.2[6]	0.01	13.3	13.7
Tursiops truncatus	21.5[7]	0.00	20.6	21.1

1 Burns and Seaman 1986
2 Danil and Chivers 2007
3 Myrick et al. 1986
4 Also 19.2 Kasuya personal communication
5 Kasuya personal communication
6 Chivers 2002
7 Wells personal communication

Conclusion

The method presented here uses a 5-parameter Leslie matrix model and incorporates the data most commonly available for cetaceans to estimate T and P. The primary advantage of this method is that estimates of percent mature and generation length can be updated as additional data become available. Furthermore, the calculations and decisions about data treatment are transparent and can be revised at any time on the basis of new information. We propose that the database and calculations used in these analyses be maintained by the IUCN Cetacean Red List Authority to facilitate updating these parameters as new information becomes available so that future assessments each species risk status are as up to date as possible.

The method also reveals species that are in dire need of further research before their current status can be assessed. For example, 18 of the 22 species of beaked whales lack sufficient data to estimate T or P and yet are of conservation concern because of recent stranding events linked with anthropogenic noise (Cox et al. 2006).

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Appendix

Sources for the five parameter model: calf survival (S_0), non-calf survival (S_A), age of sexual maturity, AFR = age of first reproduction,gestation length, IBI = interbirth interval, oldest reprod female = oldest reproducing female using empirical data, maximum female length. For species with no empirical estimates of AFR, age of sexual maturity and gestation length summed and rounded up to arrive at the AFR that appears in Table 1. When multiple sources appear in the table below or when a single source gives a range of values for a parameter like age of sexual maturity, the average is used in Table 1. Species with no information other than maximum female length are omitted from the table. Horizonal lines within the table are placed for visual clarity. Note that some species that appear in Table 1 do not appear in this source Appendix as all data were derived from closely related species. An example would be Balaenoptera omurai. Note that such species will almost certainly lack data for IUCN assessments.

Species	calf survival (S_0)	Non-calf survival (S_A)	Age of sexual maturity	AFR	Gestation length	IBI	Oldest age reprod female	Maximum female length
Balaena mysticetus		1	2		3	4	2	5
Balaenoptera acutorostrata					6	7		7
Balaenoptera bonaerensis			6 8 9		6	9		9
Balaenoptera borealis			10		3	11	10	12
Balaenoptera edeni	13	13	13		3	3		14
Balaenoptera musculus		15	16		3			17
Balaenoptera physalus		18	3		3	19		20
Berardius arnuxii					21			21
Berardius bairdii			22		23		23	23
Cephalorhynchus commersonii	24	24	25		25		24	25
Cephalorhynchus eutropia								26
Cephalorhynchus heavisidii								27
Cephalorhynchus hectori	28	28		29		29	29	30
Delphinapterus leucas		31			32	32	32	33
Delphinus capensis								34
Delphinus delphis			35		36 37 35	35	36	35

Species	calf survival (S0)	Non-calf survival (SA)	Age of sexual maturity	AFR	Gestation length	IBI	Oldest age reprod female	Maximum female length
Eschrichtius robustus	38	38	3		3	3		3
Eubalaena australis	39	39	39		3	39		40
Eubalaena glacialis	41	42	43		3	43	43	40
Eubalaena japonica								
Globicephala macrorhynchus			44	44	44 45	44	44	37
Globicephala melas			46 37		37	47		37
Grampus griseus			48		48	48		37
Hyperoodon ampullatus					23	23	23	23
Hyperoodon planifrons								23
Inia geoffrensis			49		49	49	50	50
Kogia breviceps			51		51	51	51	52
Kogia sima			51			51	51	52
Lagenodelphis hosei			53		53	53	53	54
Lagenorhynchus acutus			55		55	55	55	55
Lagenorhynchus albirostris								56
Lagenorhynchus obliquidens			57 58		57	59	59	58 59
Lagenorhynchus obscurus			60	60	60	61	60	60
Lipotes vexillifer			62					
Lissodelphis borealis			63	63	63	63	63	64
Lissodelphis peronii								65
Megaptera novaeangliae	66	67	68		3	67		69
Monodon monoceros			32	32	32	70	32	32
Neophocaena phocaenoides			71 72 73		74	75	72	72
Orcaella brevirostris			76				76	77
Orcinus orca	78	79		80	37	37 81	78	37
Peponocephala electra			82		82			82
Phocoena dioptrica								83
Phocoena phocoena			84		74	84	85	86
Phocoena sinus			87			87	87	87
Phocoena spinipinnis					88			89
Phocoenoides dalli			90		90		74	90
Physeter macrocephalus		91		92	92	92	93	91

Species	calf survival (S0)	Non-calf survival (SA)	Age of sexual maturity	AFR	Gestation length	IBI	Oldest age reprod female	Maximum female length
Platanista gangetica			94		50		50	94
			95 96		48 96			
Pontoporia blainvillei			97		97	96 97	98	96
Pseudorca crassidens			99					
					100			
					101			
Sotalia fluviatilis					102	103	100	100
Sotalia guianensis			104		104	104	105	104
			106					
Sousa chinensis			107	107	106	106	106	107
Stenella attenuata			108	109	110	108 110	111	110
Stenella clymene								112
			113					
			114			113 114		
Stenella coeruleoalba			115		116	115	111	117
Stenella frontalis	118		118			118		119
Stenella longirostris			120		120	120	121	120
							122	
Steno bredanensis			122				123	122
Tursiops aduncus					37			
Tursiops truncatus	124	124	124	124	124	124	124	124

1. (Zeh et al. 2002) 2. (George et al. 1999) 3. (Lockyer 1984) 4. (Nerini et al. 1984) 5. (Rugh and Sheldon 2002) 6. (Best 1982) 7. (Kato 1992) 8. (Kato and Sakuramoto 1991) 9. (Lockyer 1981) 10. (Best and Lockyer 2002) 11. (Mizroch et al. 1984) 12. (Lockyer 1974) 13. (IWC 1997) 14. (Best 1977) 15. (Ramp et al. 2006) 16. (Mizroch et al. 1984) 17. (Sears 2002) 18. (IWC 1992) 19. (Agler et al. 1993) 20. (Aguilar 2002) 21. (Balcomb 1989) 22. (Kasuya et al. 1997) 23. (Mead 1984) 24. (Lockyer et al. 1998) 25. (Goodall et al. 1988) 26. (Goodall 1994) 27. (Best 1988) 28. (DuFresne 2005) 29. (Slooten and Ladd 1991) 30. (Slooten and Dawson 1994) 31. (Heide-Jørgensen and Teilmann 1994) 32. (Hay1984) 32a. (Hay 1984) 33. (Brodie 1989) 34. (Heyning and Perrin 1994) 35. (Danil and Chivers 2007) 36. (Ferrero and Walker 1995) 37. (Perrin and Reilly 1984) 38. (Bradford et al. 2006) 39. (Best et al. 2001) 40. (Kenney 2002) 41. (Kraus 1990) 42. (Caswell et al. 1999) 43. (Hamilton et al 1998) 44. (Kasuya and Marsh 1984) 45. (Kasuya and Matsui 1984) 46. (Bloch and Lastein 1993) 47. (Sergeant 1962) 48. (Kruse et al. 1999) 49.

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