Suggested Guidelines for Recovery Factors for Endangered Marine Mammals under the Marine Mammal Protection Act

Barbara L. Taylor[1], Michael Scott[2], John E. Heyning[3], and Jay Barlow[1]
[1]Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 93028 U.S.A.
[2]Interamerican Tropical Tuna Commission, 8604 La Jolla Shores Drive, La Jolla, CA 93028 U.S.A.
[3]Natural History Museum of LA Co., 900 Expo Blvd., Los Angeles, CA 90007 U.S.A.

The 1994 revisions to the Marine Mammal Protection Act (MMPA) require that human-caused mortality be reduced to less than the "potential biological removal" (PBR) level for each population stock of marine mammals in U.S. waters. PBR was defined in the Act as the product of a minimum estimate of abundance (N_{min}) ***times*** one half of the maximum net productivity of a stock (½ R_{max}) ***times*** a recovery factor (F_r) between 0.1 and 1.0. The PBR guidelines currently set the default recovery factor for endangered species at 0.1 (Wade and Angliss 1997). The idea behind the use of a recovery factor for endangered species was to allow a small kill while striving to allow recovery from a dangerously low abundance as quickly as possible. Experience implementing the PBR scheme has highlighted the need for further gradations of the F_r to match the differing levels of risk facing the suite of species classified as endangered. For example, right whales in both the North Pacific and North Atlantic continue to remain at perilously low abundance and require the maximum protection the MMPA will allow ($F_r = 0.1$). On the other hand, most stocks of humpback whales in these same ocean basins are known to be increasing and already are at much lower risk than when they were originally listed as endangered. In response to recommendations by the Pacific Scientific Review Group, we hereby suggest new guidelines to set recovery factors for endangered marine mammals.

We propose a table to standardize setting the default F_r for these differing risk levels. This table accounts for absolute abundance, trends in abundance, and some commonly used categorical risk factors such as vulnerability to catastrophes. Below we justify the critical values used in the table.

Abundance

When populations become very small, in the low hundreds, they are subject to more risks than large populations. For example, the remaining population may be spatially restricted and subject to catastrophes such as natural and human-caused disasters. Social systems may be disrupted as has been seen for monk seals (Ralls et al. 1997). For cetaceans, particularly those without known areas of breeding concentration like the blue whale, finding a mate may even become difficult. At what abundance do these problems start? With monk seals it appears these difficulties began even before the species declined to its current abundance level of 1,400. Ralls et al. 1997 use the effective population size of 500 suggested by Mace and Lande (1991) as the abundance criteria for southern sea otters. This effective population size translates to a census population size of 1,850. Because the special risk factors facing small populations are unknown and in some cases unknowable for most endangered species (and all cetaceans), we find it biologically justifiable to use monk seals and sea otters to suggest a lower abundance threshold for extinction safety and therefore recommend a lower abundance threshold for the table based between monk seals and California sea otters at 1,500. In keeping with the logic used in the PBR management scheme, we recommend that the abundance estimate be on N_{min} for a specific stock, which (following the MMPA definition of N_{min}) assures a high probability that the true abundance is at least at the abundance threshold level of 1,500.

Trends

In addition to low abundance, extinction risk is largely determined by population growth rate as indicated by trends in abundance. Clearly we should be less concerned about a species that is known to be increasing than a species that is known to be declining or for which there are no abundance trend data. The recovery factors should reflect differing risks by treating populations with different trends accordingly. Stocks that belong to species that are listed as Endangered and have a statistically significant ongoing decline should receive the highest level of protection (F_r = 0.1). Species with unknown trends should be placed in risk categories somewhere in between known declines and known increases in terms of risk (see elaboration under *Vulnerability* section). We suggest the following definitions: “Known to be declining means a significant negative trend with " = 0.25", “Known to be increasing means a significant positive trend with " = 0.05", and “Unknown trend are data that can lead to neither of the previous definitions.” The differences in the significance criterion levels (") reflect a precautionary approach whereby a declining population would easily receive the lowest recovery factor but more time or precision would be required for a similarly increasing population to receive the highest recovery factor.

For stocks with unknown trends, population size can decrease appreciably before that decrease is detected. An example is the western stock of Steller sea lions which had declined by more than 50% before a decline was widely recognized. Table 1 shows the number of years it would take to detect a 10%/year decline (approximating the Steller sea lion case) for different levels of precision (as calculated by the program *TRENDS.EXE* (Gerrodette 1993) using exponential growth, CV % 1/sqrt(N) and a z-test), assuming that surveys will only occur once every four years. Similarly, even for a previously increasing population, such as harbor seals in Hood Canal , conditions can change and that population can begin to decrease. Greater population size can be a buffer that allows time to detect a decrease in abundance before the population decreases below the critical abundance threshold (1,500). A population whose abundance can be more precisely estimated is also at less of a risk of declining below this critical threshold before the decline is detected because a decline will be detected earlier (Table 1). Therefore we propose higher recovery factors for endangered populations whose abundance (and associated precision) put them out of risk from declining to below critical thresholds before a decline is detected.

To set the critical abundance and precision thresholds for F_r of populations that are increasing or of unknown trends, we use the probability of detecting a 10% per year decline (again using " = 0.25) before the population decrease below a critical threshold (1,500). Table 1 shows that, if population size (N) is over 5,000 and the coefficient of variation in abundance (CV(N)) is less than 0.5, a decline of 10% per year will be detected before the population decrease below 1,500. Similarly, if population size (N) is over 7,500 and the CV(N) is less than 0.8, a decline of 10% per year will be detected before the population decrease below 1,500. For simplicity, we base our proposed F_r thresholds on these two simple categories of abundance and precision:

N < 5,000 for abundance estimates with CVs # 0.5 and N < 7,500 for CVs > 0.5.

Table 1. The estimated number of years to detect a 10%/year decline (r = -0.1 where r is the exponenetial growth rate) for different levels of precision (coefficients of variation in abundance (N)) and the estimated population size at the start of trend monitoring that would be required to result in a population at the critical abundance threshold (1,500) at the time that a trend becomes statistically significant. Type I error (") and Type II error ($) are set to be equal, and results for values of 0.05 and 0.25 are presented.

	" = $ = 0.05		" = $ = 0.25	
coefficient of variation (N)	yrs. of surveys every 4 yrs to detect r = -0.1	initial N to end at 1,500	yrs. of surveys every 4 yrs to detect r = -0.1	initial N to end at 1,500
0.1	12	4,980	8	3,338
0.2	16	7,430	12	4,980
0.3	20	11,084	12	4,980
0.4	24	16,535	12	4,980
0.5	32	36,799	12	4,980
0.6	36	54,897	16	7,429
0.7	40	81,897	16	7,429
0.8	44	122,176	16	7,429

Species with increasing abundances above both the abundance and trend thresholds that are known to be increasing would receive the lowest risk F_r ($F_r = 0.5$). All other cases would be subject to a further risk evaluation that considers other forms of risk based on vulnerability to extinction.

Vulnerability

Species can have additional properties that make them more vulnerable to extinction. Although establishing a factor for Vulnerability ends up not affecting any cases in the North Pacific (Table 3), we felt extending increased protection to cases with risk factors known to increase extinction probability was a wise precaution. Species that we considered to be vulnerable were either relatively high in abundance and increasing (bowhead whales, western stock) or already receiving the maximum protection allowed under the MMPA (monk seals and North Pacific right whales eastern stock).

The following factors should be considered when deciding whether a species should be regarded as "vulnerable" for the purposes of increasing the safety factor embodied in F_r. The first consideration is whether the species is vulnerable to a natural or human-caused catastrophe. Species with single populations within a restricted geographical range are considered vulnerable. For example, species with a distinctly nearshore distribution (such as California sea otters) or with small a small geographical range over at least part of the year are considered vulnerable. As a rule of thumb, we propose that vulnerable to catastrophe be defined as greater than 50% of the species within a range vulnerable to a potential catastrophe at any point in time. The type of catastrophe will need to be considered on a case by case basis. Other risk factors commonly considered to increase extinction risk are less common in marine mammal endangered species and are expected to seldom if ever be used. For example, species whose abundance has at one time become small enough that detrimental effect from genetic losses might be possible are still at small population size and are already receiving maximal protection. Finally, populations that naturally experience large fluctuations in abundance are known to be more vulnerable to extinction, but again, this type of population dynamics is not common for marine mammals.

Table 2. Values of F_r within species listed as Endangered.

N_{min} Category	Decreasing	Trend Unknown		Increasing	
		Vulnerable	Not Vuln	Vulnerable	Not Vuln
$N_{min} < 1,500$	$F_r = 0.1$	$F_r = 0.1$	$F_r = 0.1$	$F_r = 0.1$	$F_r = 0.1$
CV # 0.5 **AND** $1,500 < N_{min} < 5,000$ **OR** CV > 0.5 **AND** $1,500 < N_{min} < 7,500$	$F_r = 0.1$	$F_r = 0.1$	$F_r = 0.2$	$F_r = 0.1$	$F_r = 0.3$
CV # 0.5 **AND** $N_{min} > 5,000$ **OR** CV > 0.5 **AND** $N_{min} > 7,500$	$F_r = 0.1$	$F_r = 0.2$	$F_r = 0.4$	$F_r = 0.5$	$F_r = 0.5$

Conclusions

The Recovery Factor Table (Table 2) accounts for all the most important risk factors (low abundance, trends in abundance and vulnerability factors) in a transparent fashion. The cutoff values for the criteria are empirically based for the small population size criteria or are based on realistic management constraints and observed serious rates of decline. Resulting suggested values for F_r for listed Endangered species in the North Pacific (Table 3) give a more flexible treatment of risk that should allow strong recovery without unnecessary constraints on human-caused mortality.

Table 3. Abundance, precision, trend and recovery factors for endangered species in the North Pacific (stock in parentheses) together with the proposed F_r that would result from using Table 2. The cases that would involve a change from current values are highlighted in bold in the final column.

species(stock)	N_{min}	CV	trend	current F_r	vulnerable ?	proposed F_r
Hawaiian monk seal	1,437	0.09	?	0.1	Y	0.1
Steller sea lion (western)	34,595	?	declining	0.15	N	**0.1**
North Pacific right whale (eastern)	<1,500	?	unknown	0.1	Y	0.1
blue whale (eastern N. Pacific)	1,716	0.27	unknown	0.1	N	**0.2**
fin whale (CA/OR/WA)	1,581	0.19	unknown	0.1	N	**0.2**
sperm whale (CA/OR/WA)	1,026	0.33	unknown	0.1	N	0.1
bowhead whale (western arctic)	7,738	0.07	increasing	0.5	Y	0.5
humpback whale (eastern N. Pacific)	774	0.12	increasing?	0.1	N	0.1
humpback whale (central N. Pacific)	3,698	0.10	increasing	0.1	N	**0.3**
humpback whale (western N. Pacific)	367	0.08	unknown	0.1	?	0.1

References

Gerrodette, T. 1993. Trends: software for a power analysis of linear regression. Wildl. Soc. Bull. 21:515-516.

Mace, G. M. and R. Lande. 1991. Assessing extinction threats: toward a reevaluation of IUCN threatened species categories. Conservation Biology 5:148-157.

Ralls, K., D. P. DeMaster, and J. A. Estes. 1996. Developing a criterion for delisting the southern sea otter under the U.S. Endangered Species Act. Conservation Biology 10:1528-1537.

Wade, P. R. 1997. Calculating limits to the human-caused mortality of cetaceans and pinnipeds. Marine Mammal Science 14:1-37.

Wade, P., and R. Angliss. 1997. Guidelines for assessing marine mammal stocks: Report of the GAMMS Workshop. NOAA Tech. Memo. NMFS-OPR-12.