Provisional Compilation of Information for the MSYR Review

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Introduction

At the 2006 Annual Meeting a subgroup met to consider a review of MSY rates for baleen whales (Appendix 1). The Committee agreed with the group's conclusion that enough new information had been obtained since the last review of MSY rates in 1993 to merit a new review. The subgroup recommended that a list of cases to be considered in the review should be drawn up in advance. This list should include both existing estimates in primary papers, analyses *in prep.* and other relevant data sets for which analysis would be desirable. This note is a compilation of information drawn to our attention to date.

Trans-species analyses and general issues

The Scientific Committee has conducted two reviews of MSY rates in the last 20 years, in 1989 and 1993:

IWC. 1990. Report of the subcommittee on biological parameters and MSY rates. *Rep. int. Whal. Commn* 40:119-130.

IWC. 1994. Report of the working group on MSY rates. *Rep. int. Whal. Commn* 44:181-189.

The relative plausibility of different MSY rates was also discussed in 2003 in the context of the RMP Implementation for North Pacific minke whales:

IWC. 2004. Report of the subcommittee on the Revised Management Procedure. *J. Cetacean Res. Manage.* 6(Suppl.):82-83.

The following is a selection of general papers considered at these previous discussions. Older papers which have been superseded by later versions by the same authors are not included.

Best P.B. 1993. Increase rates in severely depleted stocks of baleen whales. *ICES J. Mar. Sci.* 50(2):169-186.

Butterworth, D.S. 2004. Comparative demographic parameters for baleen whales with implications for SYR(1+) for minke whales. Report of the subcommittee on the Revised Management Procedure, Appendix 7. *J. Cetacean Res. Manage.* 6(Suppl.):100.

Butterworth, D.S. and Punt, A.E. 2003. MSYR - should the information which has become available since selections were made for RMP development in 1987 have changed perceptions on the likely range and relative plausibilities of values for this parameter for baleen whales? Paper SC/55/RMP 10. *[Updated verison now available as SC/59/RMP8]*

Butterworth, D.S. and Punt, A.E. 1992. The Scientific Committee `...agreed that the

MSY rate would most likely lie between 1 and 4%' - but which MSY rate? *Rep. int. Whal. Commn* 42:583-91.

Cooke, J.G. 2004. Inferences on maximum sustainable yield rates of baleen whale populations. Report of the subcommittee on the Revised Management Procedure, Appendix 6. *J. Cetacean Res. Manage.* 6 (Suppl.):98-99.

Cooke, J.G. and de la Mare, W.K. 1994. Some aspects of the estimation and modelling of baleen whale sustainable yields. *Rep. int. Whal. Commn* 44:451-7.

de la Mare, W.K. 1990. Inferring net recruitment rates from changes in demographic parameters: a sensitivity analysis. *Rep. int. Whal. Commn* 40:525-9.

de la Mare, W.K. 1990. Estimating yields from monitoring the recovery of depleted whale stocks. *Rep. int. Whal. Commn* 40:553-69.

de la Mare, W.K. 1994. Some analyses of the dynamics of reduced mammal populations. *Rep. int. Whal. Commn* 44:459-66.

Fowler C.W. and Baker J.D. 1991. A review of animal population dynamics at extremely reduced population levels. *Rep. int. Whal. Commn* 41:545-554.

Fowler C.W. 1994. Further consideration of non-linearity in density-dependence among large mammals. *Rep. int. Whal. Commn* 44:385-392.

Holt, S. 1990. Are measurements of increase rates of depleted stocks useful in estimating MSY rate? *Rep. int. Whal. Commn* 40:517-24.

McCall, A.D. and Tatsukawa K. 1994. Theoretical effects of habitat selection on distribution and productivity of whales. *Rep. int. Whal. Commn* 44:407-12.

The concept of MSYR does not commonly feature in the wider scientific lierature. A search for this and related terms yielded few relevant results. However, there is a large body of literature on population dynamics some of which may be relevant to the MSYR issue. A useful general text is:

Lande R., Engen S., and Sæther B.-E.. 2003. *Stochastic population dynamics in ecology and conservation*. Oxford series in ecology and evolution. Oxford: Oxford University Press.

Information by species/stock

The available information by species is documented here and summarised in Table 1. There are two kinds of estimates: (i) raw trend estimates; (ii) model-based MSYR estimates. The latter are typically derived from fitting a model to a combination of abundance estimates, historical catches, and sometimes age composition and CPUE data.

Blue whales *Balaenoptera musculus*

North Atlantic

Rate of increase 1969-88 5.2% (SE 1.1%) from incidental sightings from whaling boats west of Iceland (Sigurjónsson and Gunnlaugsson 1990). Rate of increase 1987-2001 9% (95% CI 2-17%) from NASS sightings surveys of central and northeastern North Atlantic (Pike *et al.* 2007a).

North Pacific
No trend estimates? Apparent extirpation of Japan/Korea stock.

Antarctic
Estimated trend 1978-2001 7.3% (CI 1.4%-11.6%) from IDCR/SOWER sightings (Branch *et al.* 2004). Very low fraction of pre-whaling abundance (estimated 0.3%-1.3% in 1996).

Other Southern Hemisphere
No trend estimates. Subspecies identification uncertain in most areas.

Fin whales *Balaenoptera physalus*
Antarctic
No trend estimate from IDCR/SOWER has been calculated, but could (should?) be done. JARPA trend estimate 10.2% (SE 2.8%) (Matsuoka *et al.* 2006).

Current abundance probably still a fairly low fraction of pre-whaling level, even if hypothesis is accepted of some increase prior to major exploitation due to reduced competition with blue whales (Sampson 1990; Mori and Butterworth 2006).

Clarke (1982) analysed age structure data to draw inferences on net recruitment rates. Recruitment rate appeared to decline following start of exploitation.

Estimates of sustainable yield rates as a function of biological parameters are discussed by Sampson (1994).

Other Southern Hemsiphere
No recent abundance estimates N. of 60°S.

North Atlantic
The population trend during 1987-2001 for the central and northeastern North Atlantic combined has been estimated at 4% p.a. (95% CI 1-8%) (Víkingsson et al. 2007), but with evidence of substantial relative shifts in density between areas. These authors suggest that the population may now exceed the historical *K*.

From population modelling of a putative East-Greenland Iceland stock, with sub-stock structure, fitted to catch and abundance data, MSYR(1+) estimated at 1.7% (Branch and Butterworth 2006).

North Pacific
Estimate of trend 1987-2003 in Gulf of Alaska reported as 4.8% (95% CI 4.1-5.4%) by Zerbini *et al.* (2006) , but a recalculation of confidence limits gives -1.6% to +11.1% (email correspondence with authors).

Further data potentially useful for trend estimation exist (JSV, JARPN, Japanese dedicated surveys) but have not yet been examined for fin whale trend.

The stock structure of North Pacific fin whales has not been elucidated, and stocks may have experienced different levels of depletion and recovery.

Sei whales *Balaenoptera borealis*
Southern Hemisphere
No recent trend estimates are available. The species is not abundant in the Antarctic south of 60°S, and no trends have been estimated from IDCR/SOWER or JARPA data because of the small number of sightings. There has been very little recent survey effort in the main habitat north of 60°S.

Estimates of sustainable yield rates based on biological parameters are considered by Horwood and Millward (1987).

North Atlantic
No trend estimates exist. Stocks may be close to *K* in some areas, but lack of information on stock structure and apparent short- and long-term shifts in distribution, confounded with possible differential depletion of stocks, could make it difficult to interpret any trends that might be observed.

North Pacific
Data potentially relevant to trend exist for the western North Pacific (JSV, Japanese dedicated surveys, JARPN) but have been subject only to preliminary analysis to date (Hakamada *et al* 2004).

Bryde's whales *Balaenoptera brydei*
Data potentially informative on trend exist for the western North Pacific (JSV, Japanese dedicated surveys, JARPN) but await appropriate analysis.

Antarctic minke whales *Balaenoptera bonaerenesis*
Trend estimates are currently the subject of analysis/debate (IWC 2007b).

Model-based estimates of MSYR from a combination of abundance and age composition data have been obtained (Butterworth and Punt 1999; Mori, Kitikado and Butterworth 2006) using a variable-*K* model. These are currently subject to discussion, in view of their apparent sensitivity to the interpretation of commercial age composition data which has to date proven difficult to reconcile with age compositions from JARPA (IWC 2008). This discussion is currently ongoing.

Common minke whales. *Balaenoptera acutrostrata*
Northeast Atlantic
A model-based estimate of MSYR of 1.7% was obtained by Schweder and Hjort (1997) by combining trend data from CPUE with estimates of absolute abundance. The CPUE series has since been revised and further abundance data are available: a reanalysis by Butterworth et al. (2007) yields an es timate of MSYR(1+) of 1.9% (95% CI 0.1-3.8%)

Central North Atlantic.
Some indication of increasing trend, but not informative on MSYR because past catches were too small to have depleted stocks.

North Pacific

Abundance data and limited trend data (CPUE) exist for the western North Pacific but it is unclear whether they would allow for any inferences on MSY rate. New abundance information on the Asian coastal minke whale (J-Stock) is expected following a survey in 2007, but reliable trend data are lacking.

Humpback whales *Megaptera novaeangliae*

North Atlantic

Estimate of trend 3.1% p.a. (se 0.5% p.a.) for West Indies breeding ground (Stevick *et al.* 2003), but the population size and rate of growth implies that the population is above historical *K* if past catches have not been seriously underestimated, hence determination of MSYR depends on how trends are interpreted.

Higher trend estimates are reported for some feeding grounds: e.g. 6.5% for the Gulf of Maine (Barlow and Clapham 1997), 14.8% (SE 1.2%) during 1969-89 for the area west of Iceland (Sigurjónsson and Gunnlaugsson 1990), and 10.8% (95% CI 6.3-15.5%) during 1986-2001 in Icelandic coastal waters (Pike et al. 2007b).

Attempts to reconcile the various sources of information through sub-stock modelling have not been entirely successful (Punt *et al.* 2006). The modelling exercise involves estimation of parameters that implicitly determine MSYR, but the corresponding MSYR estimates are not presented in the published analysis. Judging from the results presented, they are apparently quite low.

North Pacific

Trend was estimated at 6-7% p.a. (SE ??) for eastern North Pacific stock 1990-2002 (Calambokidis et al. 2004) , and 7% p.a. (SE ??) for the Hawaiian Islands breeding ground (Mobley *et al.* 2001). Trend estimates have not been derived for the western North Pacific, but relevant data exist.

Southern Hemisphere

Trends estimates from breeding ground estimates are available for stocks A, C1, D and E, but are only precise for stock E (Table 1). Feeding ground estimates are available from IDCR/SOWER (Branch 2006) and JARPA (Matsuoka *et al.* 2006).

The trend estimate for eastern South Pacific humpbacks (Noad *et al.* 2006), at 10.5% (95% CI 10.1-11.1) is close to the maximum feasible (Clapham *et al.* 2006) and perhaps merits careful review. Some other estimates are as high but have much wider confidence intervals.

Gray whales *Eschrichtius robustus*

Eastern North Pacific

Model-based MSYR estimated as 3.7% (2.5%-6.6%) (Wade 2002). Recent mortality events and downward fluctuations in population can be interpreted as evidence that population is close to current *K*. Population appears to be above historical *K* if catch history is approximately correct (Punt and Butterworth 2002).

An alternative population dynamics model proposed by Witting (2003) called the “inertial model” has been fitted to the western gray whale data, but to date there is no accepted definition of MSYR in the context of this model.

Western North Pacific
Population trend estimated as 3.0% (90% CI 2.1%-4.2%) 1994-2005 but with evidence of fluctuations in productivity (Cooke *et al.* 2006). Population probably still small compared to pre-whaling level.

North Atlantic Right whales *Eubalaena glacialis*
There appears to be substantial variation in calving rate, and no reliable trend estimate using the full span of data appears to have been derived, although this should be possible with the existing photo-id data.

North Pacific right whales *Eubalaena japonica*
No trend estimates available. Data from Japanese and Japanese/Russian surveys in the Okhotsk Sea potentially contain information on trend but await appropriate analysis. Elsewhere right whales are probably too scarce for trend estimation to be feasible.

Southern Hemisphere right whales *Eubalaena australis*
Populations SW Atlantic, SE Atlantic and SW Pacific. Breeding ground estimates of rate of increase. All are probably still substantially below pre-whaling levels, and have been increasing at around 7% p.a. (Bannister 2001; Best et al. 2001, 2005; Cooke et al. 2001, 2003).

The Southeast Pacific population is still apparently very small, following large catches in 19th centuries and smaller catches in the mid-20th century that may have impeded recovery. No trend estimate is available.

Bowhead whales *Balaena mysticetus*
Trend/MSYR estimates only available for Bering-Chukchi-Beaufort Sea stock.
Raw trend estimate: 3.4% (1.7%-5.0%) (Zeh and Punt 2005).
Model-based MSYR: 3.3% (1.6%-5.1%) (Brandon and Wade 2004; SC/56/BRG20).

Other baleen whales *Balaenoptera edeni, Balaenoptera omurai, Caperea maginata*
No estimates of abundance or trends, and probably no significant past catches, except locally.

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