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Estimation of the lower bound of MSYR for western North Pacific Bryde's whale

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ABSTRACT

At the Workshop on the *pre-implementation assessment* of the western North Pacific Bryde's whale in March 2005, it was recommended that data on calving intervals and their possible implications for the range for values of MSYR(mature) should be summarised and presented to the Scientific Committee no later than the First Annual Meeting (IWC, 2005). Bando *et al*. (2005) estimated annual pregnancy rate (i.e. inverse of calving interval) as 0.55 and 0.59 using JARPN II data obtained during 2002-2005 and 2000-2001, respectively. Instantaneous increasing rate using the annual pregnancy rate estimates was calculated using the method in Brandão *et al*. (2000). We applied inequalities between the estimated instantaneous increasing rate and MSYR, which were derived by Butterworth and Best (1980), to compare MSYR to the estimated increasing rate. Using point estimates of annual pregnancy rate estimates in Bando *et al*. (2005), lower bounds of MSYR are estimated under the assumption that population exceeds MSYL. In conclusion, at least 1% should not be used as a MSYR(mature) in the *IST*.

KEYWORDS: BRYDE'S WHALES, WESTERN NORTH PACIFIC, MSY RATE

INTRODUCTION

At the Workshop on the pre-implementation assessment of the western North Pacific Bryde's whale, it was recommended that data on calving intervals and their possible implications of the range for values of MSYR(mature) that should be used in Implementation Simulation Trials should be summarised and presented to the Scientific Committee no later than the First Annual Meeting. This paper is aimed to answer this recommendation.

To estimate lower bound of MSYR, we used the method described by Butterworth and Best (1990). They estimated lower bound of MSYR using increasing rate assuming 'Strong Convexity' of sustainable yield rate and applied to the case of South African right whale. We also consider the case that population level exceeds MSYL adding to the case without assumption on the population level. From the results of HITTER runs for this stock, it is suggested that population size of this stock is more than MSYL (IWC,1997). In such a condition, lower bound of MSYR would be estimated much lower than real MSYR value.

MATERIAL AND METHODS

Biological parameters

We used four biological parameters as follow;

Age at the first parturition

It was agreed that the estimate is 9 at the CA of this stock in 1996 (IWC, 1997). Bando *et al*. (2005) estimates this parameter as 7. In this analysis, we use both of the estimates. When we assume this parameter as 9, we assume that natural mortality coefficient is 0.07. When 7 is assumed as age at the first parturition, we used 0.08 as natural mortality coefficient.

Natural mortality coefficient

It was agreed that the estimate is 0.07 at CA of this stock in 1996 (IWC, 1997). Bando *et al*. (2005) estimates this parameter as 0.08. We used both of the estimates as explained in the above paragraph.

Annual pregnancy rate

Bando *et al*. (2005) estimated 0.55 and 0.59. We use these two estimates.

Juvenile natural mortality coefficient (at 0 age)

Because we don't have enough information on this parameter, we assume this parameter is more than the natural mortality coefficient. On the analogy of the case for other large whales (Punt, 1999; Wade, 2002; Punt and Butterworth, 2002), we assume this parameter are 0.1, 0.3, and 0.5, respectively.

Estimation of instantaneous increasing rate

From Leslie matrix model applied to mature female component, we can derive equation:

$$e^{t_m \delta} = e^{(t_m - 1)\delta} S + p q_f S_j S^{t_m - 1} \tag{1}$$

where:

t_m = age at first parturition (adding 1 to age at sexual maturity),

δ = instantaneous increasing rate,

S = annual survival rate (=exp(-M), where M is natural mortality coefficient),

P = annual pregnancy rate,

q_f = proportion of births that are female（=0.5）

and S_j = juvenile survival rate at age 0 (=exp(-M_j), where M_j is juvenile natural mortality coefficient).

This equation was applied to the case of humpback whales to estimate the maximum increasing rate of this species (Brandão *et al*., 2000). Given biological parameters except instantaneous increasing rate, by solving equation (1) with respect to δ, the instantaneous increasing rate is estimated.

Relation of MSYR to instantaneous increasing rate

Butterworth and Best (1990) derived the inequality in the constraint of 'Strong Convexity' of increasing rate as a function of population of the stock. The inequality is:

$$MSYR > \frac{r(0)}{2} \tag{2}$$

where, $r(0)$ is the maximum increasing rate. For example, it is easy to see that Pella-Tomlinson model with an assumption that MSYL is more than a half of carrying capacity satisfies 'Strong Convexity'. The instantaneous increasing rate derived from equation (1). Of course, instantaneous increasing rate δ is less than $r(0)$ (Fig. 1a).Therefore,

$$MSYR > \frac{r(0)}{2} > \frac{\delta}{2} \tag{3}$$

As suggested from results of HITTER runs (IWC, 1997), it is possible that population of the stock is more than MSYL. Assuming that population size is more than MSYL, as illustrated in Fig. 1b,it holds that

$$MSYR = r(N_{MSY}) > r(N) = \delta \qquad (MSYL<N\leq K) \tag{4}$$

because $r(N)$ is strictly decreasing function with respect to N. Inequality (4) would provide better estimate of lower bound of MSYR than inequality (3) under this assumption.

RESULTS

Table 1 and Table 2 show lower bound of MSYR given by inequality (4) assuming that population size is above MSYL. From these tables lower bound decreases as M_j increases.

DISCUSSIONS

At the CA of the Bryde's whales, HITTER runs were conducted. The results are shown in Appendix 1. They suggest population is above MSYL in 1996 for most of the cases. For MSYR(mature)=1% in the case for (1b), (2a) and (2b), population size in 1996 is less than MSYL but more than 50% of K. For MSYR(mature)=1%, RY is 131-168. These figures are more than double of JARPNII annual catch. This indicates the population have been increasing since 1996 and therefore population size is now more than MSYL even if MSYR(mature)=1%. From this, it is likely that this stock is more than MSYL. Therefore, the instantaneous increasing rate is better estimate of lower bound of MSYR than a half of it.

Wade (2002) estimates juvenile survival rate for eastern North Pacific grey whales as 0.925. Punt and Butterworth (2002) estimates it as 0.607. Punt (1999) estimates that for Bering-Chukchi-Beaufort Seas stock of bowhead whales 0.905 – 0.929 for several cases, respectively. On the analogy of these cases, estimated juvenile survival rate ranges 0.929 – 0.607 that corresponds to juvenile natural mortality coefficient of 0.074-0.499. Therefore, we used 0.1-0.5 as this parameter.

Kitakado *et al*. (2005) estimates additional variance of abundance estimates for the Bryde's whale. They also estimates instantaneous increasing rate as 0.052 assuming that year effect is exponential. This figure is more similar to estimated lower bound of MSYR assuming M_j is 0.1 or 0.3 than assuming that M_j =0.5. This may suggests that the former estimates are better than the latter.

In conclusion, we recommend 3% as the lower bound of MSYR.

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REFERENCES

Bando, T., and Hakamada, T. and Ohsumi, S. 2005. Estimation of true pregnancy rate of the western North Pacific. Paper SC/O05/BWI5 presented to this meeting (unpublished). xxpp

Bando, T., Kishiro, T., Ohsumi,.S., Zenitani, R. and Kato, H. 2005 Estimation of some biological parameters of western North Pacific Bryde's whales by age distributions. Paper SC/O05/BWI7 presented to this meeting (unpublished). xxpp.

Brandão, A., Butterworth, D. S. and Brown, M. R. 2000. Maximum possible Humpback Whale increasing rates as a function of biological parameter values. *J. Cetacean Res. Manage*. 2 (suppl.):192-3.

Butterworth, D. S. and Best, P. B. 1990. Implications of the recovery rate of the South African Right Whale population for baleen whale population dynamics. *Rep. Int. Whal. Commn.* 40:433-47.

Government of Japan. 2000. Research plan for cetacean studies in the western North Pacific under special permit (JARPN II) (Feasibility study plan for 2000 and 2001). Paper SC/52/O1 presented to the IWC Scientific Committee, June 2000 (unpublished). 68pp.

Government of Japan. 2002. Research Plan for Cetacean Studies in the Western North Pacific under Special Permit (JARPN II). Paper SC/54/O2 presented to IWC Scientific Committee, May 2002 (unpublished). 115pp

International Whaling Commission, 1997. Report of the Sub-committee on the North Pacific Bryde's whales. Rep. Int. Whal. Commn. 47:163-8.

International Whaling Commission, 2005. Report of the Workshop on the pre-implementation assessment of western North Pacific Bryde's Whales. Paper SC/57/Rep3 presented Scientific Committee, May 2005 (unpublished). 30pp.

Kitakado, T., Shimada, H., Okamura, H. and Miyashita, T. 2005. Update of additional variance estimate for the western North Pacific stock of Bryde's whales. Paper SC/O05/BWI6 submitted to this meeting (unpublished). xxpp

Ohsumi, S. 1977. Bryde's whales in the pelagic whaling ground of the North Pacific. *Rep. Int. Whal. Commn* (special issue 1):140-50.

Punt, A. E. 1999 Results for two selected assessments of the Bering-Chukchi-Beaufort seas stock of bowhead whales. *J. Cetacean Res. Manage*. 1 (suppl.):192-4.

Punt, A. E. and Butterworth, D. S. 2002. An examination of certain of the assumptions made in the Bayesian approach used to assess the eastern North Pacific stock of gray whales (*Eschrichtius robustus*). *J. Cetacean Res. Manage*. 4(1): 99-110.

Wade, P. R. 2002. A Bayesian stock assessment of the eastern Pacific gray whale using abundance and harvest data from 1967-1996. *J. Cetacean Res. Manage*. 4(1): 85-98.

Table 1. Estimated lower bound of MSYR using inequality (4) when t_m=9and M=0.07 as agreed at CA of the Bryde's whale in 1996 (IWC, 1997).

	M_j		
p	0.1	0.3	0.5
0.55	0.037	0.026	0.016
0.59	0.041	0.030	0.020

Table 2. Estimated lower bound of MSYR using inequality (4) when t_m=7and M=0.08 as in Bando *et al*. (2005)..

	M_j		
p	0.1	0.3	0.5
0.55	0.042	0.029	0.016
0.59	0.047	0.033	0.021

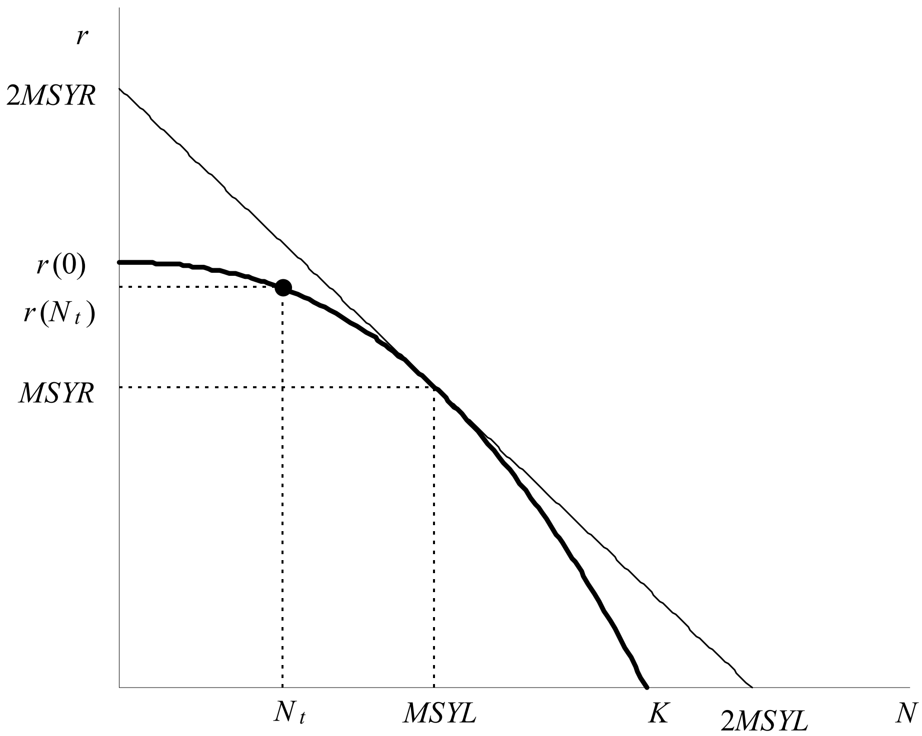

Fig. 1a. Relation between MSYR and instantaneous increasing rate δ without assumption that current population size is more than MSYL. Bold curve indicates a graph of *r*=*r*(*N*), A dot indicates current population size N_t and current instantaneous increasing rate δ and straight line tangent line of the curve at *N*=*MSYL*.

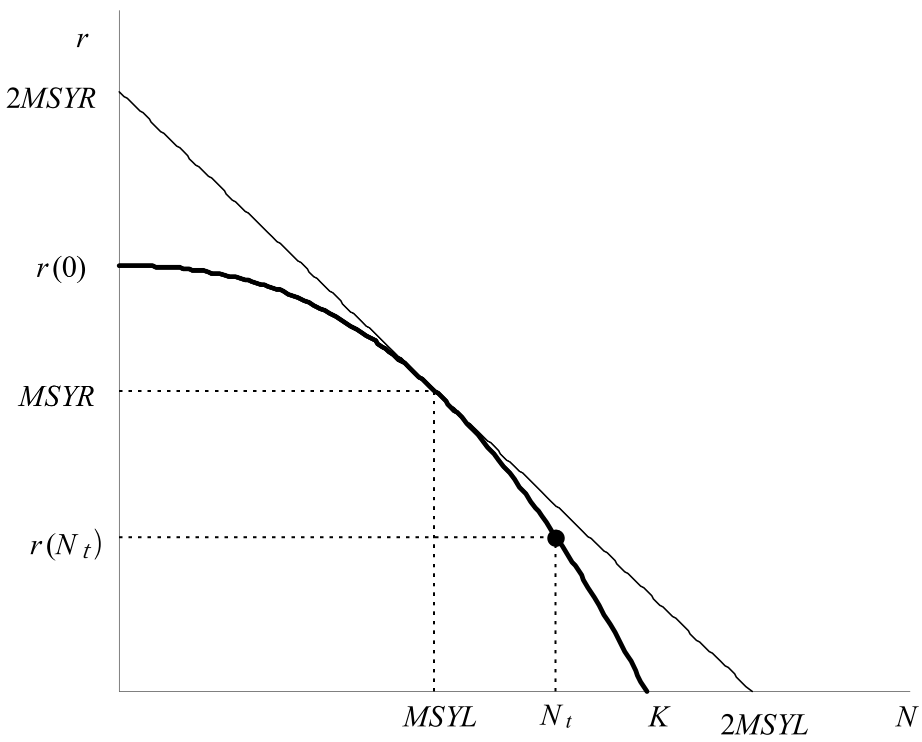

Fig. 1b. Relation between MSYR and instantaneous increasing rate δ under the condition that current population size is more than MSYL. Bold curve indicates a graph of *r*= *r*(*N*), A dot indicates current population size N_t and current instantaneous increasing rate δ and straight line tangent line of the curve at *N*=*MSYL*.

Appendix 1. Results from HITTER run for western north pacific Bryde's whales at the 47th IWC/SC meeting (referred from IWC, 1997).

MSYR (mature)		0%	1%	2%	4%	6%
(a1) Hit total population of 25,640 (best estimate)						
Total	K	46,039	40,328	36,220	30,824	27,354
	N(1996)	25,835	26,563	27,091	27,626	27,504
Mature females	K	13,149	11,518	10,345	8,803	7,812
	N(1996)	7,517	7,391	7,294	7,162	7,092
	N/K(%)	57.2	64.2	70.5	81.4	90.8
RY		33	151	238	336	341
(a2) Hit total population of 25,640, 1.2×catch						
Total	K	50,105	43,626	38,938	32,767	28,803
	N(1996)	25,874	26,666	27,274	28,006	28,150
Mature females	K	14,310	12,460	11,121	9,358	8,226
	N(1996)	7,556	7,421	7,313	7,156	7,055
	N/K(%)	52.8	59.6	65.8	76.5	85.8
RY		39	168	267	395	441
(b1) Hit total population of 18,531 (lower 5th percentile)						
Total	K	38,926	33,758	30,007	25,068	21,913
	N(1996)	18,726	19,334	19,817	20,460	20,722
Mature females	K	11,117	9,641	8,570	7,160	6,258
	N(1996)	5,487	5,384	5,300	5,173	5,084
	N/K(%)	49.4	55.8	61.8	72.2	81.2
RY		33	131	210	319	376
(b2) Hit total population of 18,531, 1.2×catch						
Total	K	42,991	37,140	32,880	27,276	23,727
	N(1996)	18,766	19,415	19,952	20,736	21,195
Mature females	K	12,278	10,607	9,391	7,790	6,777
	N(1996)	5,526	5,417	5,327	5,185	5,077
	N/K(%)	45	51.1	56.7	66.6	74.9
RY		39	144	231	361	446