An examination on the effect on the stocks of JARPAII catches

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ABSTRACT
The possible effects of an annual JARPAII take of 850 Antarctic minke whales (425 males and 425 females) on the Eastern Indian Ocean stock (I-stock) and Western South Pacific stock (P-stock), respectively, are examined by using Hitter methodology and updated information on abundance and stock structure. Results of the simulations suggested that there would be no negative effect on the minke whale stocks of future JARPAII catches.

KEYWORDS: ANTARCTIC; ANTARCTIC MINKE WHALE; SPECIAL PERMIT; MODELLING

INTRODUCTION

This paper examines the possible effects of an annual take of 850 Antarctic minke whales during the Second Phase of the Japanese Whale Research Program under Special Permit in the Antarctic (JARPA II) on the Eastern Indian Ocean stock (I-stock) and Western South Pacific stock (P-stock), respectively. HITTER/FITTER program (de la Mare, 1989; Punt and Butterworth, 1991; de la Mare and Cooke, 1992) was used for this exercise in the same manner as in previous studies (Butterworth and Geromont, 1996; Hakamada, 2005).

Analyses are based on updated information on abundance and stock structure of the Antarctic minke whale.

MATERIALS AND METHODS

Stock structure
Based on the knowledge on stock structure (Pastene *et al*, 2006), a two-stock scenario is assumed as follows:

Base case scenario: one stock (I-stock) distributes west of 130^oE and another stock (P-stock) distributes east of 130^oE.

Sensitivity scenario: same as above but Area VW is considered a mixing area of I and P stock whales. The mixing rate of the I-stock in Area VW is 55% (Pastene and Kanda, 2005).

These scenarios are simpler than recent information of stock structure (Kitakado *et al*., 2014), and these simpler scenarios are used to match the limitations of the HITTER/FITTER program.

Historical catches
The historical catches corresponding to both stock scenarios in the period 1955/56-2012/13 are shown in Table 1.

Future catches
Catches will be conducted in sector 130^oE-145^oW in the first year (2013/14) and in sector $35^{\circ}E-175^{\circ}E$ in the second year (2014/15). Subsequently catches will be conducted in each sector every two years alternately. Animals will be taken in every year in the sector 130º-175ºE, where the two stocks are assumed to mix.

The sex ratio of the Antarctic minke whales to be harvested in the future is assumed as 1:1. Because the ratio of averaged abundance estimate in the western part of Area V (130^oE -165^oE) to that in 130^oE –145^oW is about 1/3 (based on the JARPA and JARPAII data during 1996/97–2008/09) (Hakamada and Matsuoka, 2014), it was assumed that approximately 284 (=850/3) animals are taken in the sector

130°E-175°E every year.

In the base case scenario no I-stock animals would be taken in the first year and 566 would be taken in the second year. A total of 850 animals from the P-stock would be taken in the first year and 284 animals in the second year.

In the sensitivity scenario, future catches is as follows. Under the assumptions that approximately 284 (=850/3) animals are taken in 130°E-175°E every year and that mixing rate of I-stock is 55% in this sector, it can be assumed that 156 animals (78 males and 78 females) are taken from the I-stock in the first year and 722 animals (361 males and 361 females) are taken in the second year. A total of 694 animals (347 males and 347 females) are taken from the P-stock in the first year and 128 animals (64 males and 64 females) are taken in the second year.

Future catches during 2013/14 – 2042/43 from the I and P stocks are shown in Table 2, for both base case and sensitivity scenarios.
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Abundance estimate
Abundance estimates used in this analysis were those from IDCR/SOWER surveys agreed by the International Whaling Commission Scientific Committee (IWC SC) meeting in 2012 (IWC, 2013). For abundance estimate of half Areas (IIIE (40-70°E), VW (130-170°E) and VIW (170-140°W))[1], abundance estimate in Table 1 in Okamura and Kitakado (2012) multiplied by the agreed correction factors (IWC, 2013) was used. Additional CV estimate was not taken into account to calculate 90% lower limit of the abundance estimate. Abundance estimate for I-stock and P-stock are assumed according to the definitions in the base case and sensitivity scenarios:

Base case scenario
I-stock: 100,628 (90%CI lower limit: 71,375) in 1996/97; P-stock: 212,726 (90%CI lower limit: 180,662) in 2000/01

Sensitivity scenario
I-stock: 128,391 (90%CI lower limit: 97,832) in 1998/99; P-stock: 184,963 (90%CI lower limit: 153,141) in 1999/00

RESULTS AND DISCUSSIONS

For each scenario, depletions in 1987/88 (when commercial whaling ceased), in 2005/06 (the start year of JARPA II), in 2013/14[2] (present), and in 2017/18 (after the second 6-year period of JARPAII has been completed) are shown. For reference, depletion after 30 years (2043/44) is also shown.

As shown in Table 3, for I-stock, both for best estimate and for 90% lower limit, even if Maximum Sustainable Yield Rate $MSYR(1+)=1\%$, abundance would show increasing trend when 850 whales are taken every year from 2013/14. For P-stock, abundance keeps nearly carrying capacity, although abundance decreases slowly. Abundance has been approaching to the level where replacement yield (*RY*) and annual catch are balanced in future.

Table 4 shows results of sensitivity scenario. This table shows similar results as in Table 3 and suggests no negative effect of the catches on the I-stock and P-stock.

Therefore, it can be concluded that there would be no negative effect on the Antarctic minke whale stocks of these future JARPAII catches.

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[1] Longitudinal range of Areas IIIE, VW and VIW were slightly different from those used in JARPA and JARPA II survey. In this analysis, the abundance estimates were assumed in Areas IIIE (35-70°E), VW (130-165°E) and VIW (170-145°W) used in JARPA and JARPA II surveys.

[2] Depletion in 2013/14 means depletion before the catch in 2013/14.

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Table 1. Historical catches by sex in I-stock and P-stock for the base case and sensitivity scenarios.

Base case

	I-stock		P-stock	
year	Male	Female	Male	Female
1955/56	13	17	0	0
1956/57	0	0	0	0
1957/58	0	0	208	273
1958/59	28	36	0	0
1959/60	23	17	58	85
1960/61	19	19	39	53
1961/62	0	0	1	0
1962/63	4	5	6	5
1963/64	78	18	3	3
1964/65	0	1	2	2
1965/66	3	0	4	3
1966/67	11	3	1	4
1967/68	393	214	1	2
1968/69	107	38	2	2
1969/70	75	48	12	6
1970/71	123	84	0	0
1971/72	1248	1986	0	0
1972/73	2995	2886	0	0
1973/74	2279	4163	10	3
1974/75	1530	2175	259	475
1975/76	1304	1843	409	381
1976/77	1676	2800	648	968
1977/78	782	1982	682	729
1978/79	1369	2497	221	328
1979/80	2005	2564	544	800
1980/81	1483	2140	547	1130
1981/82	1281	2516	1152	976
1982/83	1203	1877	703	1969
1983/84	1417	2094	570	1350
1984/85	796	2108	743	697
1985/86	552	2064	655	771
1986/87	654	1860	291	1136
1987/88	153	119	0	0
1988/89	0	0	85	151
1989/90	184	142	0	0
1990/91	0	0	164	159
1991/92	165	123	0	0
1992/93	0	0	167	160
1993/94	200	130	0	0
1994/95	0	0	200	130
1995/96	273	167	0	0
1996/97	0	0	206	234
1997/98	279	159	0	0
1998/99	0	0	247	142
1999/00	233	206	0	0
2000/01	0	0	258	182
2001/02	201	239	0	0
2002/03	0	0	235	205
2003/04	200	240	0	0
2004/05	0	0	177	263
2005/06	373	330	89	61
2006/07	0	0	154	351
2007/08	244	220	29	58
2008/09	0	0	375	304
2009/10	142	206	95	63
2010/11	0	0	62	108
2011/12	0	0	49	50
2012/13	49	53	1	0

Sensitivity

	I-stock		P-stock	
year	Male	Female	Male	Female
1955/56	13	17	0	0
1956/57	0	0	0	0
1957/58	208	0	208	273
1958/59	28	36	0	0
1959/60	81	17	58	85
1960/61	31	40	39	53
1961/62	1	1	1	0
1962/63	9	5	6	5
1963/64	80	20	3	3
1964/65	2	1	2	2
1965/66	3	0	4	3
1966/67	11	3	1	4
1967/68	394	214	1	2
1968/69	107	38	2	2
1969/70	82	53	12	6
1970/71	123	84	0	0
1971/72	1248	1986	0	0
1972/73	2995	2886	0	0
1973/74	2279	4163	10	3
1974/75	1789	2175	259	475
1975/76	1621	1843	409	381
1976/77	2273	2800	648	968
1977/78	1112	2009	682	729
1978/79	1511	2497	221	328
1979/80	2548	2565	544	800
1980/81	1689	2229	547	1130
1981/82	1656	2528	1152	976
1982/83	1619	1877	703	1969
1983/84	1840	2115	570	1350
1984/85	1133	2108	743	697
1985/86	895	2064	655	771
1986/87	816	1860	291	1136
1987/88	153	119	0	0
1988/89	0	0	85	151
1989/90	184	142	0	0
1990/91	110	77	54	82
1991/92	165	123	0	0
1992/93	118	87	49	73
1993/94	200	130	0	0
1994/95	113	27	87	103
1995/96	273	167	0	0
1996/97	55	72	151	162
1997/98	279	159	0	0
1998/99	96	88	151	54
1999/00	233	206	0	0
2000/01	95	45	163	137
2001/02	201	239	0	0
2002/03	54	46	181	159
2003/04	200	240	0	0
2004/05	35	47	142	216
2005/06	462	389	0	2
2006/07	0	0	154	351
2007/08	273	278	0	0
2008/09	77	57	298	247
2009/10	232	264	5	5
2010/11	0	0	62	108
2011/12	49	50	50	117
2012/13	49	53	1	0

Table 2. Assumed future catches by sex from I-stock and P-stock for base case and sensitivity scenarios.

Base case					Sensitivity				
	I-stock		P-stock			I-stock		P-stock	
year	Male	Female	Male	Female	year	Male	Female	Male	Female
2013/14	0	0	425	425	2013/14	78	78	347	347
2014/15	283	283	142	142	2014/15	361	361	64	64
2015/16	0	0	425	425	2015/16	78	78	347	347
2016/17	283	283	142	142	2016/17	361	361	64	64
2017/18	0	0	425	425	2017/18	78	78	347	347
2018/19	283	283	142	142	2018/19	361	361	64	64
2019/20	0	0	425	425	2019/20	78	78	347	347
2020/21	283	283	142	142	2020/21	361	361	64	64
2021/22	0	0	425	425	2021/22	78	78	347	347
2022/23	283	283	142	142	2022/23	361	361	64	64
2023/24	0	0	425	425	2023/24	78	78	347	347
2024/25	283	283	142	142	2024/25	361	361	64	64
2025/26	0	0	425	425	2025/26	78	78	347	347
2026/27	283	283	142	142	2026/27	361	361	64	64
2027/28	0	0	425	425	2027/28	78	78	347	347
2028/29	283	283	142	142	2028/29	361	361	64	64
2029/30	0	0	425	425	2029/30	78	78	347	347
2030/31	283	283	142	142	2030/31	361	361	64	64
2031/32	0	0	425	425	2031/32	78	78	347	347
2032/33	283	283	142	142	2032/33	361	361	64	64
2033/34	0	0	425	425	2033/34	78	78	347	347
2034/35	283	283	142	142	2034/35	361	361	64	64
2035/36	0	0	425	425	2035/36	78	78	347	347
2036/37	283	283	142	142	2036/37	361	361	64	64
2037/38	0	0	425	425	2037/38	78	78	347	347
2038/39	283	283	142	142	2038/39	361	361	64	64
2039/40	0	0	425	425	2039/40	78	78	347	347
2040/41	283	283	142	142	2040/41	361	361	64	64
2041/42	0	0	425	425	2041/42	78	78	347	347
2042/43	283	283	142	142	2042/43	361	361	64	64

Table 3. Evaluation of the effects on the Antarctic minke whales stocks of annual catches of 850 animals (425 males and 425 females) every years using Hitter Methodology for the base case scenario.

I-stock

a) Hit the total (1+) population of 100,628 (best estimate) in 1996/97.

Statistic	$MSYR$ (1+) (%)				
	1	2	3	4	5
K (1+)	167,849	152,718	140,771	131,383	124,064
Depletion - 1987/88	45.6%	43.0%	40.6%	38.7%	37.2%
Depletion - 2005/06	57.7%	64.0%	69.8%	74.9%	79.3%
Depletion - 2013/14	61.1%	71.0%	79.1%	85.1%	89.1%
Depletion - 2017/18	62.3%	73.8%	82.5%	88.1%	91.5%
Depletion - 2043/44	71.0%	87.3%	93.4%	95.3%	95.9%
RY - 2013/14	512	830	890	790	644
MSY (+1)	1,007	1,833	2,534	3,153	3,722

b) Hit the total (1+) population of 71,375 (90% lower limit) in 1996/97

Statistic	$MSYR$ (1+) (%)				
	1	2	3	4	5
K (1+)	141,866	129,071	118,662	110,162	103,190
Depletion - 1987/88	35.5%	32.1%	28.9%	25.9%	23.3%
Depletion - 2005/06	47.4%	52.8%	57.9%	62.8%	67.2%
Depletion - 2013/14	50.5%	60.0%	68.8%	76.1%	81.7%
Depletion - 2017/18	51.5%	63.1%	73.2%	80.8%	86.0%
Depletion - 2043/44	59.9%	80.7%	90.4%	93.8%	94.9%
RY - 2013/14	422	781	962	965	861
MSY (+1)	851	1,549	2,136	2,644	3,096

P-stock

a) Hit the total (1+) population of 212,726 (best estimate) in 2000/01

Statistic	$MSYR$ (1+) (%)				
	1	2	3	4	5
K (1+)	230,809	224,017	220,018	217,626	216,154
Depletion - 1987/88	86.3%	86.3%	86.3%	86.4%	86.5%
Depletion - 2005/06	90.5%	93.0%	94.7%	95.8%	96.5%
Depletion - 2013/14	91.3%	94.4%	96.0%	96.9%	97.4%
Depletion - 2017/18	90.7%	93.9%	95.5%	96.3%	96.7%
Depletion - 2043/44	89.1%	92.9%	94.4%	95.1%	95.5%
RY - 2013/14	303	348	326	296	274
MSY (+1)	1,385	2,688	3,960	5,223	6,485

b) Hit the total (1+) population of 180,662 (90% lower limit) in 2000/01

Statistic	$MSYR$ (1+) (%)				
	1	2	3	4	5
K (1+)	198,971	192,183	188,129	185,683	184,172
Depletion - 1987/88	84.1%	84.0%	84.0%	84.1%	84.2%
Depletion - 2005/06	88.8%	91.7%	93.7%	94.9%	95.8%
Depletion - 2013/14	89.8%	93.3%	95.3%	96.4%	97.0%
Depletion - 2017/18	89.1%	92.8%	94.6%	95.6%	96.1%
Depletion - 2043/44	87.2%	91.7%	93.4%	94.2%	94.8%
RY - 2013/14	301	350	329	299	276
MSY (+1)	1,194	2,306	3,386	4,456	5,525

Table 4. Evaluation of the effects on the Antarctic minke whales stocks of annual catches of 850 animals (425 males and 425 females) every years using Hitter Methodology for sensitivity scenario.

I-stock

a) Hit the total (1+) population of 128,391 (best estimate) in 1998/99

Statistic	$MSYR$ (1+) (%)				
	1	2	3	4	5
K (1+)	193,404	175,248	161,747	151,909	144,918
Depletion - 1987/88	52.8%	50.5%	48.7%	47.5%	47.0%
Depletion - 2005/06	64.0%	70.4%	76.1%	81.0%	84.9%
Depletion - 2013/14	67.1%	76.6%	83.8%	88.7%	91.8%
Depletion - 2017/18	67.9%	78.5%	85.9%	90.4%	92.9%
Depletion - 2043/44	74.2%	87.9%	92.6%	94.2%	94.7%
RY - 2013/14	614	890	885	752	607
MSY (+1)	1,160	2,103	2,911	3,646	4,348

b) Hit the total (1+) population of 278,082 (90% lower limit) in 1998/99

Statistic	$MSYR$ (1+) (%)				
	1	2	3	4	5
K (1+)	165,818	149,435	136,718	126,897	119,379
Depletion - 1987/88	44.8%	41.6%	38.7%	36.4%	34.6%
Depletion - 2005/06	56.3%	62.1%	67.7%	72.8%	77.4%
Depletion - 2013/14	59.3%	68.9%	77.1%	83.3%	87.7%
Depletion - 2017/18	59.9%	71.2%	80.0%	86.0%	89.7%
Depletion - 2043/44	66.2%	83.5%	90.2%	92.4%	93.1%
RY - 2013/14	805	1,127	1,146	1,033	892
MSY (+1)	995	1,793	2,461	3,046	3,581

P-stock

a) Hit the total (1+) population of 184,963 (best estimate) in 1999/00

Statistic	$MSYR$ (1+) (%)				
	1	2	3	4	5
K (1+)	202,881	196,362	192,422	190,021	188,526
Depletion - 1987/88	84.4%	84.3%	84.3%	84.4%	84.5%
Depletion - 2005/06	89.6%	92.5%	94.3%	95.6%	96.4%
Depletion - 2013/14	90.6%	94.0%	95.8%	96.8%	97.4%
Depletion - 2017/18	90.4%	93.9%	95.6%	96.5%	96.9%
Depletion - 2043/44	90.0%	93.9%	95.3%	95.9%	96.3%
RY - 2013/14	273	310	282	248	224
MSY (+1)	1,217	2,356	3,464	4,561	5,656

b) Hit the total (1+) population of 153,141 (90% lower limit) in 1999/00

Statistic	$MSYR$ (1+) (%)				
	1	2	3	4	5
K (1+)	171,341	164,839	160,838	158,369	156,822
Depletion - 1987/88	81.5%	81.3%	81.2%	81.3%	81.4%
Depletion - 2005/06	87.6%	90.8%	93.1%	94.6%	95.5%
Depletion - 2013/14	88.7%	92.7%	94.9%	96.1%	96.8%
Depletion - 2017/18	88.4%	92.6%	94.6%	95.7%	96.3%
Depletion - 2043/44	88.0%	92.7%	94.3%	95.1%	95.5%
RY - 2013/14	270	312	286	252	227
MSY (+1)	1,028	1,978	2,895	3,801	4,705