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Biological observations of fin whales sampled by JARPAII in the Indo-Pacific region of the Antarctic

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ABSTRACT

A limited number of fin whales (n=17) was sampled during the JARPAII surveys in the Indo-Pacific region of the Antarctic in the austral summer seasons between 2005/06 and 2010/11. This paper summarizes the biological information obtained from those whales such as body proportion, reproductive status, age/length relationship, body length/body weight relationship and ecological markers (external parasites). Some of the biological information was compared with data from the commercial whaling period. The main results were that body weights of whales in the JARPAII period are heavier than those reported in the 1950′s. Results suggested the possibility that whales are reaching sexual maturity at younger ages, which is consistent with the reported increase in the abundance in recent decades. Given the small sample size, these results should be considered as preliminary.

INTRODUCTION

The fin whale, *Balaenoptera physalus* (Linnaeus, 1758) was one of the main target species of commercial whaling during the 20th century, and populations reached critical levels after overexploitation. The species was protected in 1976 (IWC, 1977).

More than 40 years have passed since the ban of commercial whaling of fin whales in the Antarctic. As an effect of the protection measures, in recent years abundance of this species in the Indo-Pacific region of the Antarctic has been increasing at annual rates of 13–16% based on JARPA sighting data obtained from the austral summer season 1987/1988 (Matsuoka *et al.*, 2005; Matsuoka *et al.*, 2006). Information on biological parameters is important for assessment and management but biological data of this species have not been available since 1976. Changes in biological parameters such as pregnancy rate, sexual maturity rate, and age at sexual maturity changes are density-dependent (Gambell, 1973; Kato, 1986).

A limited number of fin whales (n=17) was sampled during the JARPAII surveys in the Indo-Pacific region of the Antarctic in the austral summer seasons between 2005/06 and 2010/11 (GOJ, 2005). Detailed biological examinations were conducted on these whales. The objective of this paper was to summarize the biological information collected. These are the only available biological data from fin whales in the Antarctic after the commercial whaling operations stopped some 40 years ago. Some of the biological information was compared with data in the commercial whaling period.

MATERIALS AND METHODS

Samples

Catch records and biological data of the 17 whales sampled are shown in Table 1. The geographical distribution of the catches is shown in Figure 1. The body weight of one individual (0506F001) was not obtained because of some technical reasons. Another individual (0607F001) was lost before landing on the deck of the research base vessel and no measurements could be obtained.

Biological data

External measurements

The external measurements were conducted based on previous protocols (Mackintosh and Wheeler, 1929; Laws, 1961), modified by the Institute of Cetacean Research (ICR). Figure 2 shows the external measurements obtained. Figure 3 shows a fin whale being measured onboard the research base vessel. Body length was defined as the body axes length from the tip of snout to notch of flukes in parallel to the plane of the deck.

Ventral grooves

The number of ventral grooves was counted following Williamson (1973).

Table 1
Catch records and biological data of the fin whales sampled in the JARPAII.

Serial No.	Catch date	Catch position		Sex	Sexual maturity	Body length (m)	Body weight (t)	Age (yrs)	Foetus sex	Foetus body length (cm)
		Latitude	Longitude							
0506F001	030206	65°44S	71°38E	M	Immature	19.17	—	9		
0506F002	080206	65°54S	78°06E	F	Mature	20.05	53.48	11	Male	127.5
0506F003	090206	65°48S	78°07E	F	Mature	19.47	52.05	12	Female	280.7
0506F004	100206	65°37S	78°13E	M	Mature	18.73	41.87	22		
0506F005	130206	65°22S	82°00E	M	Mature	19.14	47.28	11		
0506F006	140206	65°10S	81°59E	F	Immature	19.15	47.04	9		
0506F007	070306	64°34S	111°51E	F	Mature	20.22	61.52	7		
0506F008	090306	64°53S	114°06E	F	Immature	18.22	41.06	7		
0506F009	100306	64°48S	114°14E	M	Immature	18.30	42.27	6		
0506F010	130306	65°36S	120°30E	F	Immature	19.35	47.24	8		
0607F001	030107	63°53S	170°44W	F	—	—	—	—	—	—
0607F002	050107	62°35S	174°17W	M	Mature	20.67	51.62	11		
0607F003	020207	68°46S	173°41W	F	Mature	21.15	65.02	10	Male	243.4
0809F001	130309	65°38S	165°08E	F	Immature	14.79	22.26	6		
0910F001	030210	66°08S	62°32E	M	Immature	17.61	34.20	6		
1011F001	070111	63°28S	175°40W	M	Mature	19.05	39.63	12		
1011F002	200111	66°39S	165°32E	M	Mature	18.99	43.78	10		

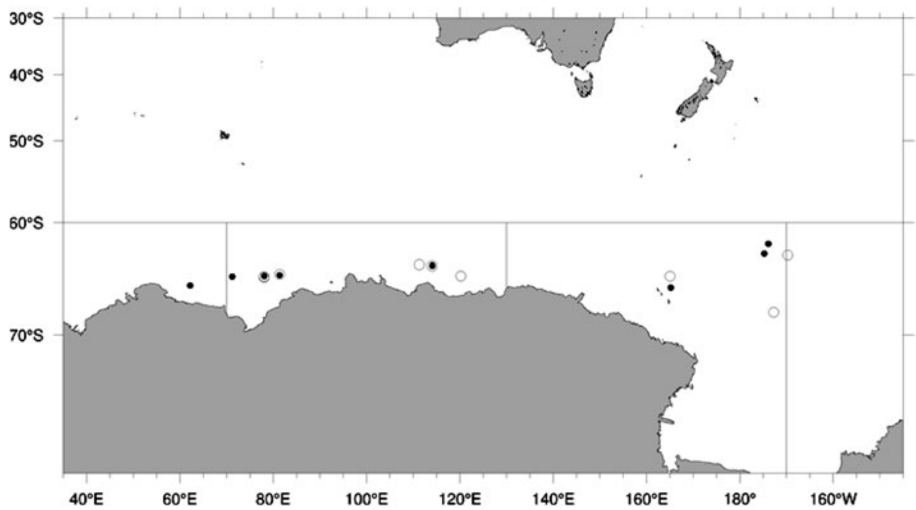

Figure 1. Geographical distribution of fin whales sampled during JARPAII surveys. Closed circle: female; open circle: male.

Body weight
Body weights were measured by summing all body parts using an electronic hanging scale (maximum capacity of 30t) and marine scale (M1100, Marel, Iceland).

Reproductive data
Three individuals (0506F002, 0506F003 and 0607F003) were pregnant. Their foetuses were measured and sampled in the same manner as adult whales.

In females, both ovaries were removed and weighed together. In males, testes were removed from both sides and weighed separately. The gonads weight was measured by using the electronic marine scale (S-182, Marel, Iceland).

The sexual maturity of females was determined by the presence of corpus luteum or corpus albicans in either ovary. In the case where no corpus luteum or corpus albicans was observed in both ovaries, the female was categorized as sexually immature. Conversely, if at least one corpus luteum or corpus albicans was observed in either or both ovaries, the female was categorized as sexually mature. The counting of the corpus luteum and

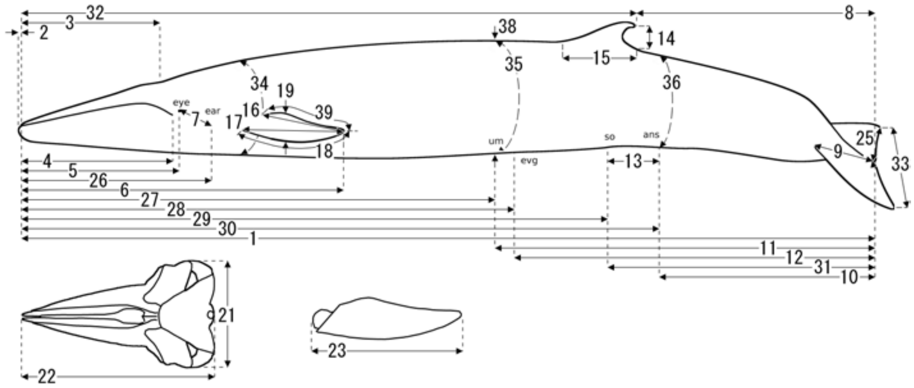

Figure 2. Measurement points of external proportions of fin whale in the JARPAII. 1: total length; 2: lower jaw, projection beyond tip of snout; 3: tip of snout to blowhole; 4: tip of snout to angle of gape; 5: tip of snout to centre of eye; 6: tip of snout to tip of flipper; 7: eye to ear; 8: notch of flukes to posterior emargination of dorsal fin; 9: flukes, width at insertion; 10: notch of flukes to anus; 11: notch of flukes to umbilicus; 12: notch of flukes to end of ventral grooves; 13: anus to reproductive aperture; 14: dorsal fin, vertical height; 15: dorsal fin, length of base; 16: flipper, tip to axilla; 17: flipper, tip to anterior end of lower border; 18: flipper, length along curve of lower border; 19: flipper, greatest width; 20: not available; 21: skull, greatest width; 22: skull length, condyle to tip of premaxilla; 23: flipper, tip to head of humerus; 24: not available; 25: flukes, notch to tip; 26: tip of snout to centre of ear; 27: tip of snout to centre of umbilicus; 28: tip of snout to end of ventral grooves; 29: tip of snout to centre of reproductive aperture; 30: tip of snout to anus; 31: notch of flukes to centre of reproductive aperture; 32: tip of snout to posterior emargination of dorsal fin; 33: width of flukes; 34: girth of chest, half; 35: girth of abdominal, half; 36: girth of buttock, half; 37: not available; 38: body height of navel; 39: border length posterior end to tip of flipper.

Figure 3. Body measurements of fin whale No. 1011F001 on the deck of the research base vessel.

corpus albicans was not carried out because the ovary samples were lost after the earthquake and tsunami on 11 March 2011.

The male sexual maturity was determined by the weight of testis. If one testis was over 2.5 kg, the whale was determined as sexually mature (Ohsumi, 1964).

Figure 4 shows ovaries and testes of Antarctic fin whales examined in this study.

Age determination

The age was determined by counting of growth layers in the earplugs (Purves, 1955; Ohsumi, 1964; Lockyer, 1972; Maeda *et al.*, 2013). The left and right earplugs were collected carefully using scalpel, and immediately fixed in 10% formalin until age determination. After slicing the surface of earplugs by use of whetstone, the layers were counted using a stereoscopic microscope under low magnification (3.15–31.5x, Figure 5). One pair of the light and dark laminae in the core of the earplug corresponds to one year, according to evidence from Ohumi (1964) and optimized histochemical method of Maeda *et al.* (2013).

Marine diatom

Quantitative measurements of attached marine diatoms on the whale body (five categories) were made following Omura (1950).

Parasites

Observation of internal/external parasites was carried out.

Analytical procedures

Fin whale data obtained by JARPAII were compared with published Japanese commercial whaling data obtained in the Antarctic in the late 1940s and early 1950s. Table 2

Figure 4. A pair of ovaries of fin whale individual No. 0506F003 (left) and a pair of testes with epididymis of fin whale individual No. 0607F002 (right).

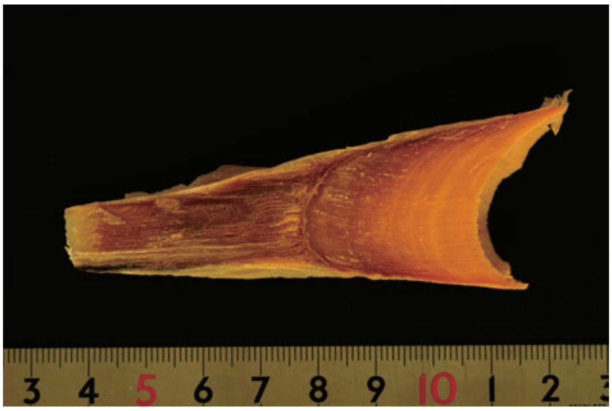

Figure 5. Earplug of fin whale individual No. 0506F001 after slicing the surface.

shows the number of samples used for the comparative analysis. The following biological data were used in the comparison.

Body proportion

The mean values (±SD) of JARPAII were calculated and compared through plotting data on the normalized axis using Japanese commercial whaling data.

Relationship between body length and body weight/organ weight

The relationship between body length and body weight was evaluated by applying single nonlinear regression. The following formula was used (Lockyer, 1976):

$$\text{Body weight (t)} = a \text{ Body length (m)}^{b}$$

The coefficient of *a* and *b* were estimated by the least-squares method.

Comparison between body length and body part weights was carried out using samples from 34 fin whales from Japan's commercial whaling data. These data were calculated on mean (±SD) value in each class of 1 m body length.

In order to check whether there are differences in reproductive condition, we compared the relationship body length/gonad weight using the same data from body parts weight.

Relationship between body length and sexual maturity, and between age and sexual maturity

We estimated the age and length at sexual maturity by fitting a logistic regression to the proportion of mature female and male at age (length) *x*.

For body length and sexual maturity in JARPAII, there was no significant regression coefficient in the logistic model ($p=0.09$). Therefore estimates were based only on commercial whaling data in seasons 1949/1950s, 1950/1951s, and 1951/1952s.

For age and sexual maturity the same approach as described above was used. In this case the logistic model was based on both JARPAII and commercial whaling (1956/1957 season; Nishiwaki *et al.*, 1958). Each formula of logistic regression model was used:

$$p = \frac{e^{\beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_p x_p + \beta_0}}{1 + e^{\beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_p x_p + \beta_0}}$$

p: predicted value, *x*: independent variable, *e*: base of natural logarithm, *β*: parameter.

RESULTS

Biological information from JARPAII

Sex ratio and body weight

Of 17 whales sampled nine were females (male sex ratio: 0.47). Mean body weight was 46.02t (SD: 10.47). The maximum and minimum weights for females were 65.02t

Table 2
Number of samples, period of sampling and source of data used in the comparative analysis of fin whales between JARPAII and past commercial whaling.

Items	JARPAII	Commercial whaling		
	Samples	Samples	Season	Source
Body proportion	16	16	1948/1949	Fujino (1954)
		6	1949/1950	Fujino (1954)
		5	1950/1951	Fujino (1954)
Body length and weight	16	16	1947/1948	Nishiwaki (1950)
		13	1948/1949	Nishiwaki (1950)
		5	1950/1951	Ohno and Fujino (1952)
Organ weight	15	16	1947/1948	Nishiwaki (1950)
		13	1948/1949	Nishiwaki (1950)
		5	1950/1951	Ohno and Fujino (1952)
Body length and gonad weight	16	16	1947/1948	Nishiwaki (1950)
		13	1948/1949	Nishiwaki (1950)
		5	1950/1951	Ohno and Fujino (1952)
Body length and maturity	16	437	1949/1950	Mizue and Murata (1951)
		2,049	1950/1951	Ohno and Fujino (1952)
		2,583	1951/1952	Kakuwa *et al.* (1953)
Age and maturity	16	288	1956/1957	Nishiwaki *et al.* (1958)
Body length	16	535,740	1930/1931–1975/1976	International Whaling Statistics

and 22.26t, respectively. The maximum and minimum weights for males were 51.62t and 34.20t, respectively (Table 1).

Sexual maturity
Sexual maturity rate was 50.0% (4/8) and 62.5% (5/8) for female and males, respectively. The three pregnant whales had a single foetus, and a single corpus luteum existed on one ovary. During the dissection of all female whales, no milk was found in the mammary glands. As shown in Table 1, body lengths of foetuses were 280.7 cm (female), 127.5 cm (male) and 243.4 cm (male). Their body weights were 172.0 kg, 20.00 kg, and 141.0 kg, respectively. No abnormalities were observed in the fetuses.

Ventral grooves
The mean number of ventral grooves was 67 (SD: 10) in males and 69 (SD: 5) in females.

Marine diatom
In most cases diatom film was recognized on the surface of the whale body (14 of 16 whales). Adhesions of diatom films were more densely observed in males than females (category '++' in Table 3).

Table 3
The adhesion level of diatom films of the body of fin whales sampled by JARPAII.

Classification[1]	Female	Male	Total
−	2	0	2
±	0	0	0
+	6	6	12
++	0	2	2
+++	0	0	0
Total	8	8	16

[1] −: not infected; ±: with thin film; +: with patched; ++: with thick film; +++: with thick film on whole body.

Parasites
Table 4 shows the frequency of external parasites. The most observed sessile organisms on the skin were *Cyamus* (44.0%). 75.0% of males and 12.5% of females had *Cyamus* on the ventral grooves. Chi-square test revealed that the percentage of attachments of *Cyamus* significantly differed by sex ($p<0.05$). Neither *Pennella* nor *Conchoderma* were observed. *Coronula sp*. was observed

in males and females with the same percentage.

Internal parasites were not observed in the stomachs of 16 fin whales. Unidentified parasites were observed in the Gastroepiploic.

Comparative analyses

Average body length

Mean body length for female whale sampled in JARPAII was 19.05 m (SD: 1.92) (maximum and minimum lengths were 21.15 m and 14.79 m, respectively). Mean body length for male whales sampled in JARPAII was 18.96 m (SD: 0.87) (maximum and minimum lengths were 20.67 m and 18.61 m, respectively).

Body length (m) of each fin whale sampled in JARPAII is plotted in Figure 6 with annual mean length and ±SD of fin whales captured in Antarctic pelagic whaling during the periods 1930/1931–1975/1976.

It is difficult to compare the data between the commercial and JARPAII, because there was a regulation for size limit of 70ft (21.34 m) for the fin whale in pelagic commercial whaling. On the other hand, for technical reasons it was not possible to take fin whales of more than 20 m in JARPAII. Notwithstanding these difficulties, a decreasing trend in the average body length is observed for the years of commercial whaling (Figure 6).

Table 4

Infection rate of external parasites and diatom films in fin whales collected from JARPAII.

Species	Male[1]	Female[1]	Total[1]
Cyamus	6/8 (75.0)	1/8 (12.5)	7/16 (43.8)
Coronula sp	1/8 (12.5)	1/8 (12.5)	2/16 (12.5)
Conchoderma sp	0/8 (0.0)	0/8 (0.0)	0/16 (0.0)
Pennella sp	0/8 (0.0)	0/8 (0.0)	0/16 (0.0)
Diatom film	8/8 (100.0)	6/8 (75.0)	14/16 (100.0)

[1] infected/investigated (infected rate %)

Body proportion

The mean value and body proportion of the external measurements of JARPAII is summarized in Table 5, by sex. As shown in this table, no difference in proportions was observed between the sexes except for the reproductive aperture (e.g. measurement point 13).

In order to clarify the JARPAII properties of body proportions, a data chart was created using the mean value and the standard deviation for 15 measurement locations of Japanese commercial whaling data (Figure 7). JARPAII data are smaller than Japanese commercial whaling data in many parts in both sexes. In measurements points 7, 14, and 21 in JARPAII, males are larger than commercial whaling data. Females are larger than males in many points. Excepting for sex difference, dorsal fin is higher, and the skull is shorter than commercial whaling data. This trend was particularly pronounced in males.

Relationship between body length and body weight

Figure 8 shows the relationship between body length and body weight for JARPAII and commercially caught fin whales. Calculated coefficients *a* and *b* in the formula are a=0.005394±0.005329 and b=3.068448±0.332619 in JARPAII, and a=0.044530±0.027880 and b=2.315830±0.205040 in commercial data. From the graph, predicted body weights of fin whale captured in JARPAII tend to be

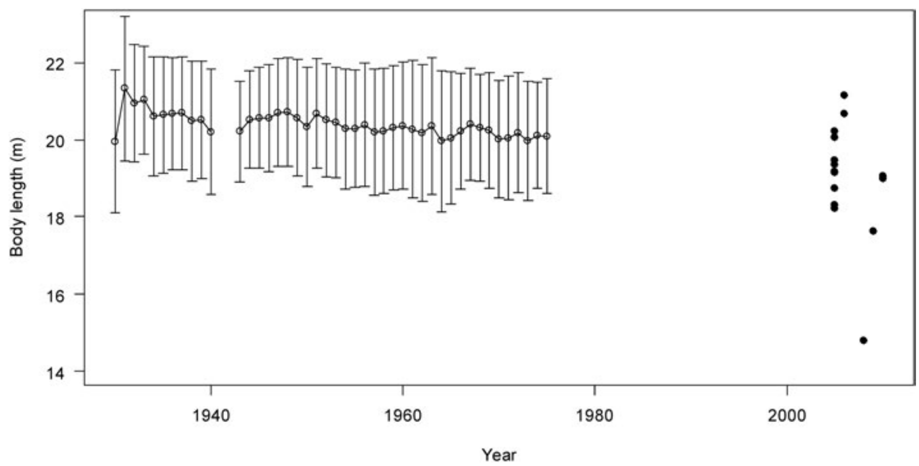

Figure 6. Yearly change in average body length of fin whale captured in Antarctic pelagic commercial whaling (open circle: seasons 1930/1931–1975/1976) and the body lengths of fin whale sampled in JARPAII (closed circle: seasons 2005/2006–2010/2011). Vertical bars indicate plus/minus one standard error. The data used in Antarctic pelagic commercial whaling were summarized from International Whaling Statistics.

Table 5
The external body proportions of the fin whales in the JARPAII (see Figure 2 for details).

	Males			Females		
	n	Mean	%BL	n	Mean	%BL
1. Body length (0.01 m)	8	18.96	100.0	8	19.05	100.0
2. Projection of snout (0.1 cm)	4	9.9	0.5	6	7.2	0.4
3. Snout-blow-hole (1 cm)	8	344	18.2	8	353	18.5
4. Snout-angle of gape (1 cm)	8	365	19.2	8	371	19.5
5. Snout-eye (1 cm)	8	372	19.6	8	382	20.1
6. Snout-tip of flipper (1 cm)	8	777	41.0	8	779	40.9
7. Eye-ear (0.1 cm)	8	91.4	4.8	8	91.1	4.8
8. Notch of flukes-dorsal fin (1 cm)	8	429	22.6	8	435	22.8
9. Notch of flukes-root of flukes (1 cm)	7	98	5.1	9	100	5.2
10. Notch of flukes-anus (1 cm)	8	535	28.2	8	532	27.9
11. Notch of flukes-umbilicus (1 cm)	8	860	45.4	8	860	45.1
12. Notch of flukes-ventral grooves (1 cm)	8	833	44.0	8	835	43.8
13. Anus-reproductive aperture (0.1 cm)	8	131.3	6.9	8	59	3.1
14. Height of dorsal fin (0.1 cm)	8	47.9	2.5	8	45	2.4
15. Length dorsal fin (0.1 cm)	8	108.3	5.7	8	102.1	5.4
16. Axilla-tip of flipper (1 cm)	8	149	7.9	8	151	7.9
17. Flipper length (1 cm)	8	230	12.1	8	230	12.1
18. Border length flipper (1 cm)	8	237	12.5	8	236	12.4
19. Width of flipper (0.1 cm)	8	52.8	2.8	8	52.3	2.7
21. Skull width (0.1 cm)	8	220.6	11.6	6	205.4	10.8
22. Skull length (0.1 cm)	8	464.5	24.5	8	475.6	25.0
23. Flipper length (from humerus) (1 cm)	8	239	12.6	5	245	12.9
25. Notch of flukes-flukes (1 cm)	4	215	11.3	3	226	11.9
26. Snout-ear (1 cm)	8	461	24.3	8	470	24.6
27. Snout-umbilicus (1 cm)	8	1032	54.5	8	1056	55.4
28. Snout-ventral grooves (1 cm)	8	1061	56.0	8	1055	55.4
29. Snout-reproductive aperture (1 cm)	8	1227	64.7	8	1311	68.8
30. Snout-anus (1 cm)	8	1358	71.6	8	1370	71.9
31. Notch of flukes-rep. aperture (1 cm)	8	664	35.0	8	589	30.9
32. Snout-dorsal fin (1 cm)	8	1460	77.0	8	1467	77.0
33. Width of flukes (1 cm)	8	407	21.5	8	426	22.4
34. Chest circumference, half (1 cm)	8	436	23.0	8	452	23.7
35. Abdominal circumference, half (1 cm)	8	345	18.2	8	366	19.2
36. Buttock circumference, half (1 cm)	8	260	13.7	8	277	14.5
37. Body height (0.1 cm)	7	182.6	9.6	8	195.4	10.3
38. Body height (0.1 cm)	8	246.6	13.0	8	254.8	13.4
39. Border leng. flipper (posteroior) (1 cm)	8	154	8.1	8	156	8.2

Remarks. n: number of samples; %BL: percentage to body length; Mean: mean length.

heavier than that of the commercial whaling for the same body length.

Relationship between body length and organ weights

Figure 9 shows the relationship between body length and gonad weight. The relationship is very similar between JARPAII and commercially caught fin whale samples.

Tables 6a–b and 7a–b, and Figure 10 show the mean weights of each body part, by body length. Figure 10 shows that the body parts weight increase with body length. This increase is more pronounced in the case of the JARPAII whales for blubber (Figure 10b) and meat (Figure 10c). For bones and viscera the increasing pattern is similar between JARPAII and commercially caught whales.

Relationship between body length and sexual maturity

Figure 11 shows the relationship between body length and maturity rate of fin whales sampled by commercial whaling during the seasons 1949/1950, 1950/1951, and 1951/1952, for female and males. JARPAII samples are plotted for both immature (0 rate) and mature (1.0 rate) individuals. Immature individuals of JARPAII ranged from 14.79 m to 19.35 m (17.61–19.17 m in males, 14.79–19.35 m in females). Mature individuals ranged from 18.73 m to 21.15 m (18.73–20.67 m in male, 19.47–21.15 m in female respectively).

It is estimated that the body length at 50% sexual maturity is 18.99 m (18.69 m in male and 19.90 m in female) in commercial whaling samples. Regression coefficient

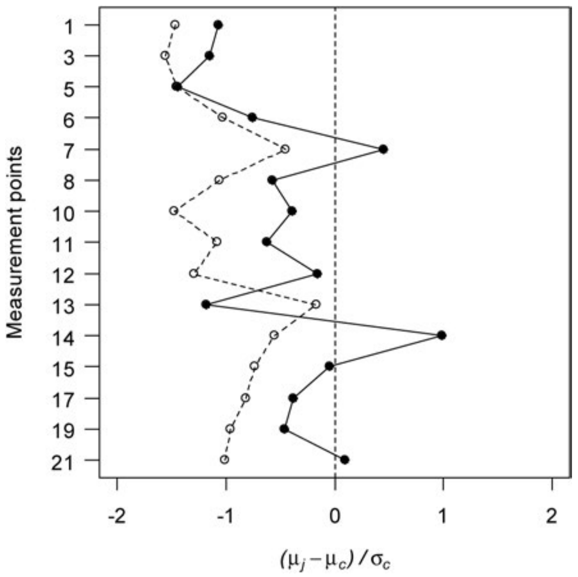

Figure 7. Body proportions of the JARPAII sample (closed circles and solid line: male; open circle and broken line: female). The data are plotted on the normalized axis using the data of Japanese commercial whaling (seasons 1948/1949–1950/1951). Measurement point key are shown in Figure 2. μ_j: mean value of JARPAII data; μ_c: mean value of the commercial whaling data; σ_c: standard deviation of the commercial whaling data.

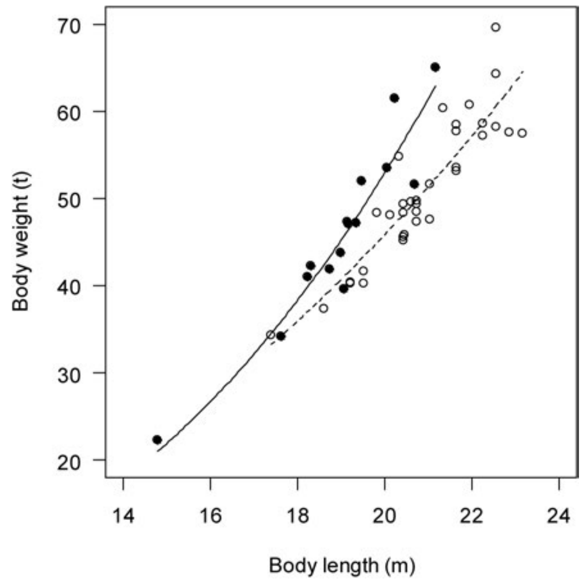

Figure 8. Relationships between body length and body weight in fin whales. Closed circles and solid line: JARPAII; open circles and broken line: Japanese commercial whaling (Nishiwaki, 1950; Ohno and Fujino, 1952: seasons 1947/1948–1950/1951).

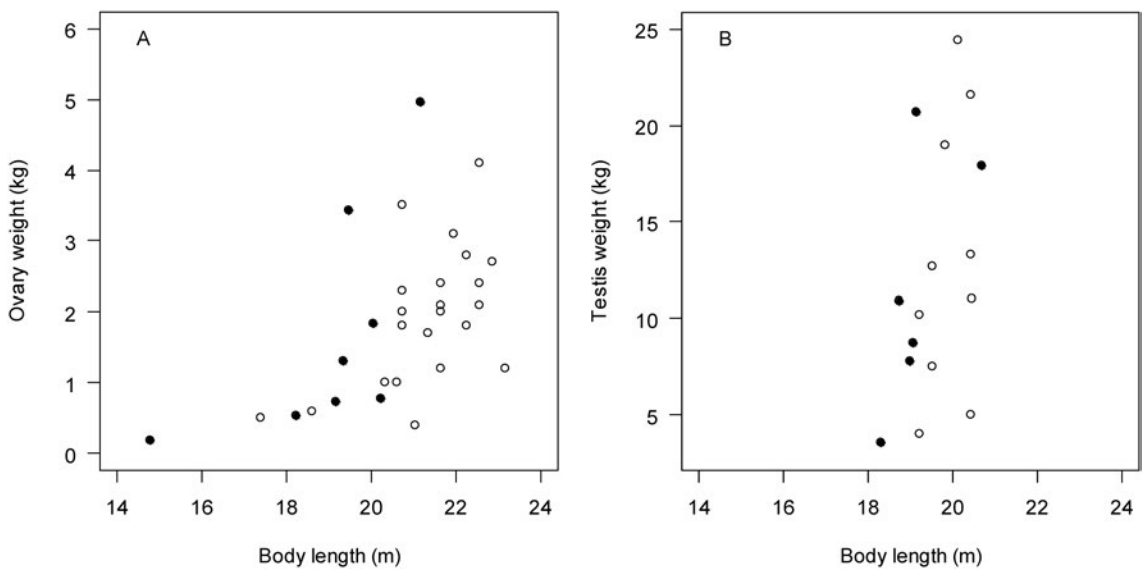

Figure 9. Relationship between body length and gonad weight. A: ovary weight; B: testis weight; closed circle: JARPAII; open circle: Japanese commercial whaling (Nishiwaki, 1950; Ohno and Fujino, 1952: seasons 1947/1948–1950/1951).

Table 6a
Average body parts weight (kg) of the fin whales in the JARPAII.

Class of body length (m)	Samples (female/male)	Total parts weight	Blubber	Meat	Bone	Viscera and others
14.0–	1 (1/0)	21,982.0	5,505.8	10,700.8	2,783.2	2,992.2
17.0–	1 (0/1)	33,996.0	7,779.1	17,080.4	4,879.5	4,257.1
18.0–	4 (1/3)	41,837.1	10,317.3	20,463.3	5,370.9	5,685.6
19.0–	5 (3/2)	46,090.3	11,678.0	22,318.7	5,918.1	6,175.5
20.0–	3 (2/1)	54,992.7	13,587.8	27,499.9	7,195.1	6,709.9
21.0–	1 (1/0)	63,999.3	16,745.8	31,439.0	7,287.7	8,526.8
Total	15 (8/7)	45,517.0	11,363.5	22,344.4	5,840.7	5,968.4

Table 6b
Percentage of body parts weight of the fin whales in the JARPAII.

Class of body length (m)	Samples (female/male)	Total parts weight	Blubber	Meat	Bone	Viscera and others
14.0–	1 (1/0)	100.0	25.0	48.7	12.7	13.6
17.0–	1 (0/1)	100.0	22.9	50.2	14.4	12.5
18.0–	4 (1/3)	100.0	24.7	48.9	12.8	13.6
19.0–	5 (3/2)	100.0	25.3	48.5	12.8	13.4
20.0–	3 (2/1)	100.0	24.7	50.0	13.1	12.2
21.0–	1 (1/0)	100.0	26.2	49.1	11.4	13.3
Total	15 (8/7)	100.0	25.0	49.1	12.8	13.1

Table 7a
Average body parts weight (kg) of the fin whales in commercial whaling data during the seasons 1947/1948–1950/1951.

Class of body length (m)	Samples (female/male)	Total parts weight	Blubber	Meat	Bone	Viscera and others
17.0–	1 (1/0)	33,817.0	6,953.0	16,875.0	4,899.0	5,123.0
18.0–	1 (1/0)	37,367.0	8,270.0	18,391.0	5,906.0	4,800.0
19.0–	5 (0/5)	43,712.0	10,263.8	19,473.6	7,760.2	6,214.4
20.0–	12 (6/6)	48,652.7	11,289.8	21,971.2	8,264.3	7,127.5
21.0–	8 (8/0)	55,629.7	12,761.0	25,914.0	8,856.8	8,098.0
22.0–	6 (6/0)	60,966.0	15,897.7	27,398.5	10,284.7	7,385.1
23.0–	1 (1/0)	57,487.6	13,319.0	24,093.0	9,132.0	10,943.6
Total	34 (23/11)	51,232.3	12,141.5	23,296.6	8,543.3	7,251.9

Table 7b
Percentage of body parts weight of the fin whales in commercial whaling data during the seasons 1947/1948–1950/1951.

Class of body length (m)	Samples (female/male)	Total parts weight	Blubber	Meat	Bone	Viscera and others
17.0–	1 (1/0)	100.0	20.5	49.9	14.5	15.1
18.0–	1 (1/0)	100.0	22.1	49.3	15.8	12.8
19.0–	5 (0/5)	100.0	23.5	44.5	17.8	14.2
20.0–	12 (6/6)	100.0	23.2	45.2	17.0	14.6
21.0–	8 (8/0)	100.0	22.9	46.6	15.9	14.6
22.0–	6 (6/0)	100.0	26.1	44.9	16.9	12.1
23.0–	1 (1/0)	100.0	23.2	41.9	15.9	19.0
Total	34 (23/11)	100.0	23.7	45.4	16.7	14.2

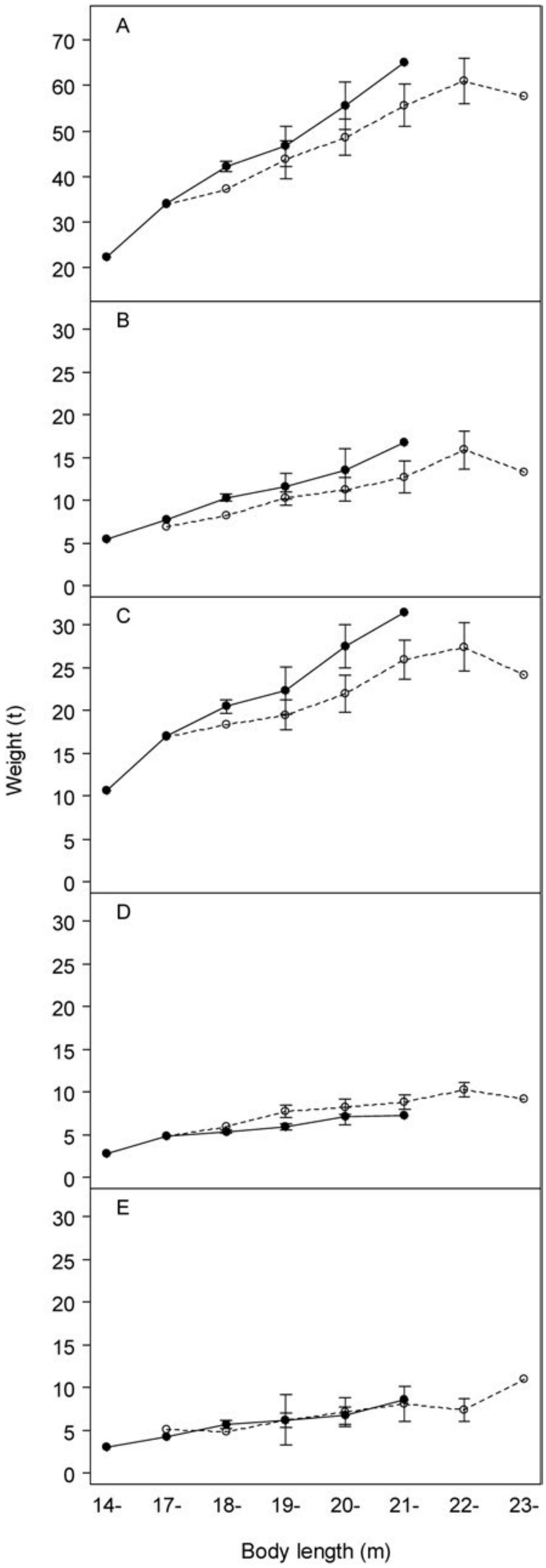

Figure 10. Comparison of the relationship body parts weight/body length between JARPAII (closed circle and solid line) and commercial whaling (open circle and broken line: seasons 1947/1948–1950/1951). A: body weight; B: blubber; C: meat; D: bones; E: viscera and others.

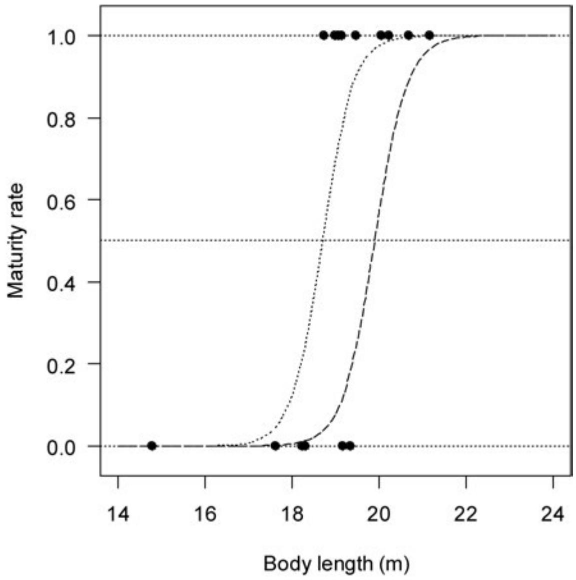

Figure 11. Relationship between body length and sexual maturity rate of the fin whales sampled by JARPAII (closed circle), and comparison of that with that from commercial whaling (broken line: female; dot line: male; seasons 1949/1950–1951/1952).

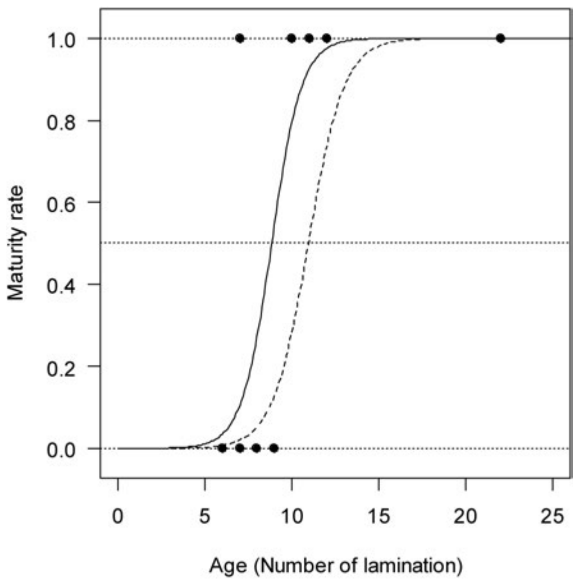

Figure 12. Relationship between age and sexual maturity rate of the fin whales sampled by JARPAII (closed circle and solid line), and comparison with that by commercial whaling (broken line: season 1956/1957).

between sexual maturity and body length of JARPAII did not reach statistical significance, possibly due to the small sample size. From the plotting, JARPAII data were equally distributed besides the rise of predicted probability of maturity rate in commercial whaling data except for immature one (body length = 14.79 m).

Relationship between age and sexual maturity
Figure 12 shows the relationship between age and sexual maturity rate of fin whales sampled by JARPAII and commercial whaling during the season 1956/1957, for both sexes combined. Immature individuals of JARPAII ranged from 6 to 9 years old, and mature individuals ranged from 7 to 22 years old. It is estimated that the 50% sexual maturity age are 8.8 years old in JARPAII and 11.0 years old in commercial whaling, respectively. The minimum age of a pregnant whale obtained in JARPAII was 10 years old. Age at 50% sexual maturity of JARPAII is 2.2 years younger than Japanese commercial whaling data.

DISCUSSION

This study provided new biological information of fin whales in the Antarctic after 36 years of protection from commercial whaling. Although the number of whales examined was small some new and interesting results such as body proportion and parasites were obtained. During the commercial whaling period only large whales were taken. During the JARPAII survey there was the opportunity of sampling small animals for the first time. In fact the smallest whale was a 14.79 m whale and several biological data were obtained from this whale. The limitation of JARPAII, however, was for animals larger than 20.0 m which usually were not sampled because technical difficulties.

Body length/ body weight
It was found that Antarctic fin whales collected by JARPAII were heavier than those taken by commercial whaling in the 1950s. This might suggest that the feeding condition for the Antarctic fin whale has improved in recent years. It was also found that the relative weights of the blubber and the meat are heavier for fin whales sampled by JARPAII (Figure 10). The increase in body weight of fin whales, particularly in weight of meat and blubber, might indicate faster growth which was derived from better nutritional condition in recent years.

Body length and age at sexual maturity
There is the possibility that the age at sexual maturity of the fin whale has decreased in the 2000s. Decline in the age at sexual maturity in whales in response to substantial decrease in the abundance (for example due to overexploitation) has been reported for sei and fin whales in part of the Indian Ocean and the Antarctic Ocean, and for fin whales in the northwest Pacific Ocean (Gambell, 1973; Lockyer, 1979; Ohsumi, 1986). Our study provided evidence that the age at sexual maturity of fin whales sampled by JARPAII has decreased about 2.2 years from the 1950s.

The number of pregnant whales among the fin whales sampled by JARPAII was three out of four matured whales (75.0%). This high pregnancy rate was similar to the 1970s (Gambell, 1973).

All this evidence suggests improved nutritional conditions for fin whales in recent years. The biological studies based on JARPAII data were based on a small sample size. Further biological samples and data from this species will be needed to confirm the results found in this study.

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