# Evaluation of 2005/06 and 2006/07 Feasibility Study of the Second Phase of the Japanese Whale Research Program under Special Permit in the Antarctic (JARPA II)

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## ABSTRACT

The Second Phase of the Japanese Whale Research Program under Special Permit in the Antarctic (JARPA II) started with two feasibility surveys in the austral summer seasons 2005/06 and 2006/07. The objectives of the feasibility surveys were 1) to examine the practicability and appropriateness of sighting methods and sampling procedures in the enlarged research area, and 2) to examine the practicability of methods of hunting, hauling, flensing and taking biological measurements of large body-sized whales such as fin and humpback whales. Based on the results obtained in the two feasibility surveys this paper evaluates whether or not these objectives were fulfilled. It is concluded that the practicability and appropriateness of the planned sighting methods and design were adequate and could be used to cover the entire research area under normal conditions. Results also showed that sampling procedure were appropriate for the increased sample size of Antarctic minke and fin whales. Although it took more time to catch, transport, measure and dissect fin whales than is the case of Antarctic minke whales, the process from catching to biological sampling of this species was successfully conducted at least for animals less than 21m in body length or 65tons in body weight. As the full-scale JARPA II survey will incorporate sample sizes for fin and humpback whales as specified in the original research plan (Government of Japan, 2005), further improvement to deal with such larger animals will be continued during the full-scale program.

## INTRODUCTION

Following the completion of the Japanese Whale Research Program under Special Permit in the Antarctic (JARPA), conducted between 1987/88 and 2004/05 austral summer seasons (season), the Government of Japan launched a new research program called Second Phase of the Japanese Whale Research Program under Special Permit in the Antarctic (JARPA II), under Article VIII of the International Convention for the Regulation of Whaling (Government of Japan, 2005). This is a long-term research program, which combines lethal and non-lethal methods, JARPA II has the following objectives: 1) monitoring of the Antarctic ecosystem, 2) modeling competition among whale species and developing future management objectives, 3) elucidation of temporal and spatial changes in stock structure and 4) improving the management procedure for the Antarctic minke whale stocks.

The full-scale JARPA II will start from the 2007/08 season. JARPA II will focus on Antarctic minke, humpback and fin whales and possibly other species in the Antarctic ecosystem that are major predators of Antarctic krill (*Euphausia superba*). Annual sample sizes for the full-scale research (lethal sampling) are 850 (with 10% of allowance) for Antarctic minke whales (Eastern Indian Ocean and Western South Pacific Stocks), 50 for humpback whales (D and E-Stocks) and 50 for fin whales (Indian Ocean and the Western South Pacific Stocks).

Before the start of the full-scale survey of JARPA II, two feasibility surveys were conducted in the 2005/06 and 2006/07 seasons. In the feasibility surveys, a maximum annual sample size of 850+-10% Antarctic minke and ten fin whales were planned for each season. Humpback whales were not sampled during the feasibility surveys. Cruise reports of the feasibility surveys were reported by Nishiwaki *et al*. (2006; 2007).

The objective of this paper is to examine the main results of the two feasibility surveys (Nishiwaki *et al*., 2006; 2007) and to evaluate whether or not the objectives of those surveys were fulfilled, and suggest changes for the full JARPA II research program, if necessary.

## OBJECTIVES OF THE FEASIBILITY STUDY

The objectives of the feasibility surveys were: 1) to examine the practicability and appropriateness of sighting methods and sampling procedures in the enlarged research area, 2) to examine the practicability of methods of hunting, hauling, flensing and taking biological measurements of large body-sized whales such as fin and humpback whales (Government of Japan, 2005).

## OUTLINE OF JARPA II FEASIBILITY SURVEYS

### 1. First feasibility survey (2005/06, Nishiwaki *et al.*, 2006)

*1. 1. Research area*

As mentioned in the original research plan (Government of Japan, 2005), the research area of JARPA II is basically the same as in JARPA: south of 60°S, 35°E - 145°W. The area was divided into six sectors (eastern Area III, western Area IV, eastern Area IV, western Area V, eastern Area V and western Area VI) as shown in Fig. 1. The four sectors on the west side (eastern Area III, western Area IV, eastern Area IV, and western Area V) were covered in the first feasibility survey between 3 December 2005 and 20 March 2006 (Fig. 2).

Latitudinal ranges of the survey were different according the research type. Dedicated sighting vessel (SV) surveyed areas south of 60ºS while the sighting and sampling vessel (SSV) areas south of 62ºS.

*1. 2. Sighting method*

*1.2.1. Sighting vessels (SV)*

Two research vessels *Kyoshin Maru No.2* (KS2) and *Kaikoh Maru* (KK1) were engaged in sighting activities and experiments only (SV). Design of the survey track line was improved with regard to previous JARPA surveys by conducting survey in north and south strata simultaneously.

The survey track line was designed by each 10 degree longitudinal width interval in principle. The survey starting point was randomly selected from the arrangement of the survey track line and longitude standard lines in the survey.

As mentioned in Nishiwaki *et al*. (2006) the survey track line with the even numbers to the longitudinal width (10 degrees) was set based on the planed research days. Track line design was constructed from unit of two or more track lines (zigzag shape) in the north stratum and four or more in the south stratum (Fig. 3).

Sighting procedures were the same as in the previous JARPA surveys (Nishiwaki *et al*. 1999, Ishikawa *et al*. 2000). The survey was operated under optimal research conditions (when the wind speed was below 25 knots in the south strata and below 20 knot in the north strata, and when visibility was more than 2n.miles). The standard searching speed of 11.5 knots was used. The sighting survey by SV was conducted under limited closing mode (only sightings of Antarctic minke whales or likely Antarctic minke whales were approached to confirm species and school size) and passing mode (the vessel did not approach the sighted whales and searching from the barrel was uninterrupted). In the case of fin whale sightings, some experiments were conducted in the same manner as the other whale species listed below.

The survey of SV was conducted independently from the SSVs. In addition to the sighting of Antarctic minke whales or like Antarctic minke whales and fin whales, the SV approached blue (*B. musculus*), humpback (*Megaptera novaeangliae*), southern right (*Eubalaena australis*), pigmy right (*Caperea marginata*), sei (*B. borealis*), sperm (*Physeter macrocehpalus*) and southern bottlenose *(Hyperoodon planifrons*) whales for conducting some experiments.

The research period was 108 days between 3 December 2005 and 20 March 2006. By adding a second dedicated sighting vessel, distance of searching was increased remarkably in comparison to former JARPA. Searching distances was 8836.2n.miles by the SVs. The sighting survey covered most of the research area as originally planned, despite external disturbances.

*1.2.2. Sighting and sampling vessel (SSV)*

Three sighting and sampling vessels *Yushin Maru No.2* (YS2), *Yushin Maru* (YS1) and *Kyo Maru No.1* (K01) were engaged in sighting and sampling surveys (sighting / sampling vessels; SSVs).

Design of track line of the SSV is fundamentally the same as those of the SV (Fig. 4). According to the original JARPA II plan (Government of Japan, 2005) the survey of SSVs was focused south of 62°S.

Three SSVs advanced along parallel track lines 7n.miles apart from each other at a standard speed of 11.5 knots. The sighting survey was conducted under limited closing mode as defined above, and individuals were targeted for sampling as explained below. In addition, the SSVs also approached other whale species for conducting some experiments. The total searching distance by the SSVs was 7536.5 n.miles covered in 108 days.

Sightings made by SVs and SSVs are summarized in Table 1.

**1.3. Sampling method**

The sampling activity was focused to the area south of 62°S as mentioned in the original plan (Government of Japan, 2005). Density index of Antarctic minke whales based on sighting data from JARPA is low in the latitudinal band between 60°S and 62°S (less than 10% of the whole latitudinal range). This indicates that sampling of Antarctic minke whales in this latitudinal band has a low importance.

During the first feasibility study, external disturbances occurred from 21 December 2005 to19 January 2006.

*1.3.1. Antarctic minke whale*

A maximum of two Antarctic minke whales was sampled randomly from each primarily sighted school. A total of 821 schools (1,959 individuals) were made by SSVs as primary sightings. A total of 779 schools (1,879 individuals) were targeted for sampling and a total of 853 individuals were sampled. Those samples were transported to the research base *Nisshin Maru* (NM) for biological research and flensing. Therefore the planned sample size was achieved. Only three animals were struck and lost.

*1.3.2. Fin whale*

The sampling of fin whales was restricted to animals with an estimated body length less than 20m due to technical limitations of NM, and to avoid any handling accident.

Out of 37 schools (245 individuals) primarily sighted by SSVs, 11 schools (112 individuals) were targeted for sampling. A total of 10 individuals were sampled as originally planned. Sampling efficiency was 90.16%. No struck and lost occurred.

**1.4. Biological survey**

Biological research was conducted on the NM for all whales sampled.

*1.4.1. Antarctic minke whale*

To cover for the larger number of Antarctic minke whales to be sampled in a similar research period as in the previous JARPA, two research teams conducted biological research for 24 hours. As a result of this modification the total 853 minke whales were investigated biologically in the same research period. Some biological information of the animals sampled is given in Nishiwaki *et al*. (2006).

*1.4.2. Fin whale*

All the ten fin whales sampled were examined biologically on board the NM. Because of the instrument scale limitation (up to 25ton), body weight of the fin whales was estimated by summing up the weight data in each part of the body. A summary of biological samples and data collected from fin whales is given in Table 2.

The maximum body length and weight of the collected fin whales was 20.22m and 61.52t, respectively (female). The minimum body length and weight was 19.14m and 47.28t, respectively (male) (Table 3). Two individuals were pregnant. Therefore even with the limitation of body size (weight) in sampling, this sampling scheme can partially cover for the mature component.

**1.5. Non-lethal component**

Apart from the sighting component of the program, the following experiments were part of the non-lethal components of the JARPA II in 2005/06: sighting distance and angle experiment, photo-identification experiment, biopsy sampling, satellite tagging and oceanographic and acoustic survey. Details can be found in Nishiwaki *et al*. (2006).

**2. Second feasibility survey (Nishiwaki *et al.*, 2007)**

**2. 1. Research area**
In the second year feasibility study the three sectors on the east side of the research area (western Area V, eastern Area V and western Area VI) were surveyed between 15 December 2006 and 28 February 2007 (Figs. 1 and 5).

Same as in the first feasibility survey latitudinal ranges of the survey were different according the research type. Dedicated sighting vessel (SV) surveyed areas south of 60ºS while the sighting and sampling vessel (SSV) areas south of 62ºS.

**2. 2. Sighting method**
*2.2.1. Sighting vessels (SV)*
Two research vessels (KS2 and KK1) were engaged in sighting activities only. Track design was similar as in the first feasibility survey. In the Eastern part of Area V (including the Ross Sea), two strata were defined as East-North and East-South. Zigzag-shaped track lines were adopted independently in each stratum. Details were described in the cruise report (Nishiwaki *et al.*, 2007).

In 2006/07 survey the research period was 76 days between 15 December 2006 and 28 February 2007. Searching distances was 6,091.73n.miles by the SVs. The sighting survey covered the most of research area planned except for western part of Area V (130E-165E), which could not be surveyed due to a fire accident at NM.

*2.2.2. Sighting and sampling vessel (SSVs)*
Three sighting and sampling vessels (YS2, YS1 and K01) were engaged in sighting and sampling surveys.

Design of track line, survey manner and experiments by the SSV were basically the same as in the first feasibility study, except for the eastern part of Area V (including the Ross Sea) where two strata were defined as East-North and East-South. Zigzag-shaped track lines were adopted independently in each stratum. Details were described in the cruise report (Nishiwaki *et al.*, 2007).

The searching distance by the SSVs was 5,877.14n.miles covered in 76 days. The sighting survey covered most of the planned research area except for the western part of Area V (130ºE-165ºE), which could not be surveyed completely due to a fire accident at NM.

A summary of the sightings made during the second feasibility survey is shown in Table 4.

**2.3. Sampling method**
Sampling method was also the same as in the first feasibility survey. However in the case of the fin whale the limit of body size was changed from 20m to 19m. The reason is that fin whales in Area V were heavier than expected for our predicted body size.

*2.3.1. Antarctic minke whale*
In the second feasibility study out of 443 schools (1,043 individuals) of the primary sightings of Antarctic minke whales by the SSVs, 438 schools (1,027 individuals) were targeted for sampling. A total of 505 individuals were sampled. Sampling efficiency was 93.8 %. Struck and lost occurred in only three cases.

*2.3.2. Fin whale*
In the second feasibility study in 2006/07, sampling of fin whales was restricted to an estimated body length less than 19m (change from 20m to 19m decided at the field) due to technical limitations of NM.

Out of 19 schools (156 individuals) of primarily sighted fin whales in Area VNE by SSVs, 3 schools (9 individuals) were targeted for sampling. A total of 3 individuals were sampled. Sampling efficiency was 100 %.

In retrieving the first fin whale onboard NM most of the body was dropped into the sea because it was cutted off by the band used to pull it. The animal was larger (heavier) than estimated and the NM was not technically experienced to onboard an animal of such weight.

Fin whales migrating to the Area V could be larger than fin whales distributed in other parts of the research area. After careful considerations after the first sampled fin whale, no problems were observed with the other two fin whales sampled, including an animal of 65.02tons.

**2.4. Biological survey**
Biological research was conducted on the NM for all whales sampled.

*2.4.1. Antarctic minke whale*
Biological data and samples collected from the Antarctic minke whales in 2006/07 are summarized in Nishiwaki *et al*. (2007).

*2.4.2. Fin whale*
Biological data and samples collected from the fin whales in 2006/07 are summarized in Table 5. The largest fin whale sampled in the second feasibility survey was 21.15m and 65.02 tons in body length and body weight, respectively (Table 6).

**2.5. Non-lethal components**
As in the first feasibility survey apart from the sighting component the following non-lethal researches were conducted: sighting distance and angle experiment, photo-identification experiment, biopsy sampling, satellite tagging, prey species survey and oceanographic and acoustic surveys (see details in Nishiwaki *et al*., 2007).

**3. Progress in the biological analysis of Antarctic minke and fin whales**
One of the main objectives of the JARPA II is to monitor the biological parameters such as apparent pregnancy rate (PPF) and age at sexual maturity. Below is a brief progress report of the analyses related to some biological parameters.

**3.1. Antarctic minke whales**
*3.1.1. Apparent pregnancy rate (PPF)*
Temporal variations of PPF for I-stock and P-stock of Antarctic minke whales are shown in Fig. 6. The PPF was constant both I- and P-stocks during 16 years of the JARPA period at around 92.9% and 85.4% for I and P-stocks, respectively. PPF was estimated based on data collected during the JARPA II feasibility surveys and results were added to the time series of JARPA. Those data will be monitored al least for the next 4 years.

*3.1.2. Age at sexual maturity*
It is known that the age at sexual maturity deduced from the transition phase of Antarctic minke whales shows temporal changes possibly in response to change in environmental conditions (see Fig. 7 for temporal trend of this parameters based on JARPA data). The age of whales sampled during the feasibility surveys is being estimated and values will be added to study the trend shown in Fig. 7.

**3.2. Fin whales**
*3.2.1. Stomach contents*
It was reported that fin whales mainly fed on the Antarctic krill *Euphausia superba* in the 1950s (Mackintosh and Wheeler, 1929; Nemoto, 1959). In late 1960s and early 1970s whaling grounds for fin whales shifted to north. In the northern grounds fin whale mainly consumed *E. vallentini* (Kawamura, 1974, 1980). Therefore prey species of fin whales had been expected to differ from those of Antarctic minke whales.

However during the recent JARPA surveys, it was observed that distribution of fin whales expanded southward to near pack ice of the Antarctic since 1990 (Matsuoka *et al.*, 2005).

Table 7 shows the summary of the stomach contents of fin whales sampled during the two JARPA II feasibility surveys. Prey species in the stomach contents of the fin whales was the Antarctic krill. This is direct evidence that Antarctic minke whales and fin whales consume the same prey species, at least in some regions of the Antarctic.

*3.2.2. Body weight*
Biomass estimations are important for the construction of ecosystem models. In this context, precise estimations of body weight are essential. However it is difficult to estimate the body weight of fin whale because of their large body size.

Lockyer (1976) estimated the relationship between body weight and length of fin whale using data from Japanese whaling fleet in Nishiwaki (1950) and Ohno and Fujino (1952).

Fig. 8 shows the relationship between body weight and length of eleven fin whales sampled during the JARPA II feasibility surveys. This figure also shows the data for fin whales reported previously (Nishiwaki, 1950; Ohno and Fujino, 1952).

The body weight of the fin whale from recent JARPA II surveys is heavier than those previously reported in 1950s, and this suggests that new data obtained from JARPA II is valuable for ecosystem modeling exercises.

**4. A review of the biological information available for southern humpback whale of Groups IV and V**

The humpback whale is one of the target species of the JARPA II. From the start of the full JARPA II an annual catch of 50 animals is planned. Catches will be made in each austral summer season alternatively in Areas IV (Stock D) and V (Stock E).

As indicated above the main objectives of the JARPA II feasibility surveys were a) to examine the practicability and appropriateness of sighting methods and sampling procedures, and improve them as necessary, and b) to examine the practicability of methods of hunting, hauling, flensing and biological sampling in large-sized baleen whales. Unlike the Antarctic minke and fin whales, no humpback whales were sampled during the feasibility surveys in 2005/06 and 2006/07 austral summer seasons. Regarding to the second feasibility objective results were satisfactory for fin whale; animals were sampled and no critical problem with hunting, hauling, flensing and biological sampling was observed. On this particular issue no problems are expected for humpback whales as this species is smaller than the fin whale.

Biological information in Antarctic Areas III-VI related to stock structure, biological parameters, feeding ecology and level of contaminants in cetacean, are relevant for the JARPA II research objective of 'Monitoring of the Antarctic Ecosystem'. Samples and biological data related to these research items were obtained for Antarctic minke and fin whales during the JARPA II feasibility surveys but not for the humpback whale. In this section the biological information available for humpback whales in Areas IV and V is reviewed.

*Stock structure*
Mackintosh (1965) showed that humpback whales tend to gather into five or six distinct feeding concentrations in the Antarctic during the austral summer season. These feeding concentrations were denominated as Groups I-V (with a Group IIa and IIb) corresponding roughly to IWC Management Areas I-VI. The Groups most documented are Groups IV and V. Omura (1953) examined the distribution of humpback whale in the feeding grounds of Areas IV and V based on catch data. Based on catch information he suggested that two populations occur in these Areas with a boundary around 130°-142°E. He did not discard the possibility of intermingling between these two populations in the feeding ground. He also examined the pattern of distribution by month and suggested that for the month where more data were available (November-March) the boundary between these two populations changed from 120°-130°E in November to eastside of 140°E in December and to 120°-140°E in January.

More recently the IWC Scientific Committee (SC) proposed the breeding grounds, migratory routes and feeding grounds of seven humpback whale stocks (identified by the alphabet letters A-G, respectively), and suggested the possibility of sub-stocks in some of them (IWC, 2005). Of interest for the research under JARPA II are Stock D (Western Australian Stock related to Antarctic Area IV) and Stock E, which is composed of three putative sub-stocks: E1=eastern Australian sub-stock; E2=New Caledonia sub-stock and E3= Tonga sub-stock. Stock E is related to Antarctic Area V.

During the Hobart Workshop on the comprehensive assessment of Southern Hemisphere humpback whales, Stock D was recognized as a single stock, with animals migrating northward during winter from Antarctic Area IV along the west coast of Australia towards a current breeding destination as far north as 15ºS, beyond North West Cape, Western Australia (IWC, 2006a). On the other hand six possible models for stock structure were proposed for the South Pacific (Stocks E and F) and the Workshop strongly recommended several genetic analyses to discern among these models (IWC, 2006a).

The most recent genetic analysis conducted in the feeding grounds of Areas IIIE, IV, V and VIW involved several hundreds of samples obtained during the JARPA and IDCR/SOWER cruises. Mitochondrial DNA control region sequencing and microsatellite analyses showed significant genetic heterogeneity in humpback whales among the four Areas examined, and the authors concluded that these Areas are occupied by different populations (Pastene *et al*., 2006).

The SC endorsed the Hobart workshop recommendation that every effort be made for scientists to share data from low and high latitude and carry out mtDNA analyses under the IWC Data Availability Access protocol (IWC, 2006b). Such co-operative analyses would allow for a more comprehensive study of stock structure of humpback whales of Stocks D, E and F. Additional genetic sampling in the feeding grounds, particularly in Area V, will be valuable for such study.

*Biological parameters*
Lockyer (1984) summarized information on biological parameters for baleen whale species from several geographic regions. With regard southern humpback whale, the peak months of conception for Australia/Antarctic populations are July/August, and the gestation period is of 11 and half months. The peak month of birth is July/August and the length of neonate is 4.3m. The sucking period is from 10 and half to 11 months and the length at weaning is 8.8m. The mean length at sexual maturity is 11.5 and 12.0m for males and females, respectively. The average age at sexual maturity is 4 or 5 years for both sexes. The maximum recorded length in physically mature females is >15.0m.

Of interest for the research under JARPA II is the information available for Western Australia-Area IV (Group IV) and Eastern Australia-Area V (Group V), particularly on the following biological parameters: pregnancy rate, age/length at sexual maturity and age/length at physical maturity, which could change according to changes in the conditions of the whales. The available information is derived from samples obtained during the past commercial whaling for this species. Therefore the information can be considered as old. The oldest publication based on such samples source is dated Mattews (1937) and the latest one is Chittleborough (1965).

Below the main results of some relevant studies are summarized.

Pregnancy rate
Chittleborough (1958) examined pregnancy of humpback whales based on samples obtained during whaling operations in Western Australia (1949-1956, n=2,450), Eastern Australia (1952-1956, n=821), Antarctic Area IV (1949/50-1955/56, n=1,767) and Antarctic Area V (1949/50-1955-56, n=1,250). He defined pregnancy rate as the percentage of females in advanced pregnancy amongst the sexually mature females taken in the catches. Pregnancy rates were lower for Western Australia (11.7%) than Area IV (48.2%) and for eastern Australia (9.3%) than Area V (47.8%). The authors also provided information on pregnancy rate by year or by austral summer season (season). In the case of Western and Eastern Australia the percentage fluctuate each year, but about different levels at each station.

Omura (1953) examined sexual matured females taken in Area V in the seasons 1950-52 (n=63) and estimated the pregnancy rate at 85.7%.

Length at sexual maturity
Omura (1953) examined humpback whales sampled in Area V in the seasons 1950/51-1951-52. Sexual maturity in males was determined according to the weight of testes. For a sample of n=42 males he suggested a length at sexual maturity of 12m (39 feet 4 inches). For females sexual maturity was determined by the presence of one or more corpora lutea in the ovaries. For a sample of n=70 he estimated the sexual maturity is reached in average at a body length of 39-40 feet (11.9-12.2m).

Chittleborough (1955a) examined male humpback whales taken in Western Australia from 1951 to 1953. He used the mean testis weight of 2000g as indicator of puberty. Based on 609 males whose testes were weighted he estimated that at a length of 36 feet 9 inch (11.2m), 50% of male humpback whales would be sexually immature and 50% would have reached or passed puberty.

Chittleborough (1955b) examined female humpback whales taken in Western Australia from 1949 to 1954. A total of 821 animals were examined of which 154 were immature, 77 at puberty and 590 mature. At puberty the mean body length of the female humpback whales was 38.50 feet (11.7m). According to this author sexual maturity (based on the first pregnancy) may either follow immediately upon puberty or be delayed for a further year. He estimated the length at sexual maturity at 39.66 feet (12.1m).

Chittleborough (1960) examined the mean lengths of the samples of puberal females taken on the west coast each year from 1956 to 1959 and compared each year estimate with the previous estimate for the period 1949-1954. In 1956 (40.15feet, n=17) (12.2m), the mean length was considerably greater than of the sample accumulated from 1949 to 1954 (38.50 feet, n=77) (11.7m). Since 1956 the mean length of the puberal females decreased each year

until 1959 (37.96 feet, n=43) (11.6m). These differences were statistically significant. The same author examined the mean lengths of the samples of puberal females taken on the east coast for two periods: 1952-54 (n=60) and 1956-59 (n=15). The mean length varied insignificantly from the first period (38.51feet, n=60) (11.7m) to the second period (39.38 feet, n=15) (12.0m).

Age at sexual maturity

Chittleborough (1959) examined age at puberty for humpback whales from Western and eastern Australia combined (1957). For females the author examined the ages (as determined from baleen plates) and ovaries condition of 391 animals. The majority of females reach puberty at 4 or 5 years old and the upper limit of the age at puberty is close to seven years. The author also examined the relationship between ages (as determined by baleen plates) and sexual condition in 238 males. He classified a male as sexually mature with total testes weight exceeding 4kg. In males the mean age at puberty lies between 4 and 5 years old. Furthermore, the author examined the relationships between number of earplug laminations and ovarian conditions in 290 females. He concluded that since most humpback whales reach puberty at 4 and 5 years old, the mean number of laminations in the earplug at puberty is between eight and ten laminations.

Chittleborough (1965) examined a larger number of samples for Western and Eastern Australia combined (1949-52). Based on data from 1,067 males and the criterion of testes weight of 4kg, puberty is reached at 3-6years old. For a total of 1,603 females examined the majority of individuals (70%) attain puberty at 4 and 5 years old.

Length at physical maturity

Chittleborough (1955a) studied the physical maturity based on 567 male humpback whales taken in Western Australia (1951-53), where epiphyses were examined. Only eight animals had attained physical maturity. The mean body length at physical maturity for these animals was 42.97 feet (13.1m). Chittleborough (1955b) studied the physical maturity based on 457 female humpback whales taken in Western Australia (1951-54), where epiphyses were examined. Only eight animals had attained physical maturity. The mean body length at physical maturity for these animals was 44.34 feet (13.5m).

No information on age at physical maturity was available for the relevant region.

More recently some information on biological parameters e.g. age at first calving, has been obtained from long-term sighting histories of individually identified female humpback whales in the Gulf of Maine (Clapham, 1992) and southeastern Alaska (Gabriele *et al*. 2007). Information from such source is not available for whales of group IV and V.

*Feeding ecology*

Mizue and Murata (1951) examined the stomach content and blubber thickness of whales caught by the Japanese whaling fleet in the season 1949/50 in Antarctic waters comprised between 61º-69ºS and between 116ºE-162ºW. A total of 56 humpback whales were examined, which fed exclusively on Antarctic krill (*Euphausia superba*). Of a total of 56 animals examined in the second half of December, 12.5% had the first stomach empty, 16.1% it contained less than 25% filled; 28.6 % had the stomach 25-50% filled; 21.4 % had the stomach 60-75% filled and 21.4% had the stomach full (75-100%). They also examined the size of the Antarctic krill contained in the stomach. A 5.3% had krill of size over 5cm; 66.1% had krill of sizes between 4 and 5cm; 26.8% had krill of size under 4cm and 1.8% had krill of different sizes mixed. They also collected some data on blubber thickness but sample size was too small to reach any conclusion.

Kakuwa *et al*. (1953) examined the stomach content of 37 humpback whales caught by Japanese whaling fleet in the 1951-52 season in the area comprised between 66º-72ºS and between 160ºW and 180º. Whales fed exclusively on krill. Whales with empty first stomach accounted for 35% of the catch while small krills predominated in the stomach contents. Neither the coefficient nor the variance of the regression of the blubber thickness upon the length of the whales differed significantly between sexes. Difference was significant in the adjusted mean of the blubber thickness suggesting that females had thicker blubber than males of similar sizes.

Klumov (1961) cited in Chittleborough (1965) estimated that humpback whales feeding in polar waters consume 1-1.5tons of euphausiids per day. The latter author informed of the examination of the stomach contents from 197 humpback whales sampled at the west coast of Australia, which showed food remains in just five. In each of these whales the quantity of food ingested was small (probably less than 2kg before decomposition began).

*Level of contaminants*
No information is available for the relevant region.

It can be concluded that apart from the information on stock structure, which has been updated recently using molecular techniques, other biological information of southern humpback whales are old dated, only available from animals taken from the past commercial whaling about 40 years ago. Furthermore there is limited information on time series for key biological parameters and other biological indicators of whale conditions. In addition it should be noted that the interpretations of several biological parameters in the past was complicated by the nature of whaling operations, which, among other aspects, concentrated operations in some particular areas.

## EVALUATION OF THE FEASIBILITY STUDIES

### 1. The practicability and appropriateness of research methods

#### 1.1. Sighting methods in the enlarged area

The feasibility study was planned to cover a wide longitudinal span: 140° (from 35°E to 175°E) in the 2005/06 survey, and 85° (from 130°E to 145°W) in the 2006/07 survey. These surveys were planned to be conducted through early December to late March. It was planned that the search effort would be distributed mainly in Area IV in the first survey and in Area V in the second survey, in the peak feeding season of baleen whales.

Due to external disturbances the sectors comprised from 35°E to 55°E and from 135°E to 139°E could not be covered in the first feasibility survey. Despite these disturbances sighting surveys was conducted in the peak feeding season from early January to early March in the main research area from 55°E to 130°E, which included Area IV. Without such disturbances the survey could have covered the entire research area.

Due to a fire accident at NM the western part of Area V could not be covered in the second feasibility survey. However the survey had been conducted normally in the other sectors previous to the accident and clearly Area V west could have been surveyed, if the fire accident not occurred.

Therefore it can be concluded that the practicability and appropriateness of the planned sighting methods and design were adequate and could be used to cover the entire research area under normal conditions. In particular the use of two dedicated sighting vessels allowed the surveys to be conducted in the north and south of the research area simultaneously.

#### 1.2. Sampling procedures given the increased sample size and additional species

In the first feasibility study, a total of 779 schools (1,879 individuals) of Antarctic minke whales were targeted for sampling. A total of 853 individuals were sampled from 4 December to 20 March. Sampling efficiency of this species was 95.6%. A total of 11 schools (112 individuals) of the fin whales were targeted for sampling. A total of 10 individuals were sampled from 3 February to 13 March. Sampling efficiency was 90.16%.

In the second feasibility study, a total of 438 schools (1,027 individuals) of Antarctic minke whales were targeted for sampling. A total of 505 individuals were sampled from 15 December to 14 February. The survey stopped on 27 February. Sampling efficiency of this species was 93.8%. Out of 20 schools (157 individuals) in the primary sightings of fin whales by SSVs, 3 schools and 9 individuals were targeted for sampling. A total of 3 individuals were sampled. Sampling efficiency was 100.0 %.

One of the modifications that allowed the biological examination of larger sample sizes was the design of two research teams that alternated the work in the period of 24 hours.

These results showed that sampling procedures were appropriate for the increased sample size of Antarctic minke whale and for additional species. However it should be noted that in the full JARPA II survey the targeted sample sizes for fin whales will be 50 (instead of 10 in the feasibility surveys) and humpback whales will be also sampled with n=50 (no humpback whale was sampled in the feasibility surveys) (Government of Japan, 2005). The efficiency will be improved to deal with such larger sample sizes during the full-scale program.

### 2. Methods for catching, flensing and taking biological measurements of large body-sized whales

Although it took more time to catch, transport, measure and dissect the fin whales than is the case for the Antarctic minke whales, the process from catching to biological sampling of fin whales was successfully conducted at least for animals less than 21m in body length or 65tons in body weight. Some facilities such as the strength of winches

and hauling methods, are being planned. Technical improvements will be continued during the full-scale JARPA II program.

## CONCLUSIONS

Based on the evaluation above it can be concluded that the feasibility surveys of JARPA II was conducted satisfactorily and that the objectives of the feasibility survey were covered adequately. However, the full JARPA II survey will involve sample sizes for fin and humpback whales as specified in the original research plan (Government of Japan, 2005) and therefore techniques and devices for handling these large animals will be improved continuously through the full-scale JARPA II program.

## ACKNOWLEGEMENTS

Our acknowledgements to scientists and crew member that participated in the JARPA II feasibility surveys of 2005/06 and 2006/07 seasons for their dedication, hard work and efficiency despite external disturbances.

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Table 1: Summary of whale sightings conducted by SV and SSVs in the whole research area in the 2005/06 JARPA II feasibility survey.

| Vessls | Sighting vessls | | | | Sighting and sampling vessels | | | | Total | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Type of the sightings | Primary | | Secondly | | Primary | | Secondly | | Primary | | Secondly | |
| Species | Sch. | Ind. | Sch. | Ind. | Sch. | Ind. | Sch. | Ind. | Sch. | Ind. | Sch. | Ind. |
| Antarctic minke whales | 837 | 2,424 | 170 | 470 | 821 | 1,959 | 20 | 64 | 1,658 | 4,383 | 190 | 534 |
| Liked minkewhales | 85 | 138 | 8 | 14 | 12 | 13 | 0 | 0 | 97 | 151 | 8 | 14 |
| Blue whales | 18 | 29 | 2 | 3 | 6 | 9 | 5 | 7 | 24 | 38 | 7 | 10 |
| Fin whales | 151 | 503 | 12 | 40 | 37 | 245 | 24 | 148 | 188 | 748 | 36 | 188 |
| Sei whales | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 3 | 0 | 0 |
| Humpback whales | 1,085 | 2,024 | 99 | 161 | 617 | 1,176 | 47 | 93 | 1,702 | 3,200 | 146 | 254 |
| Southern right whales | 33 | 44 | 4 | 4 | 20 | 29 | 4 | 5 | 53 | 73 | 8 | 9 |
| Baleen whales | 226 | 456 | 25 | 71 | 8 | 8 | 11 | 72 | 234 | 464 | 36 | 143 |
| Sperm whales | 138 | 139 | 12 | 12 | 43 | 43 | 6 | 6 | 181 | 182 | 18 | 18 |
| Southern bottlenose whales | 71 | 150 | 3 | 6 | 17 | 29 | 0 | 0 | 88 | 179 | 3 | 6 |

Table 2: Summary of biological data and samples collected from fin whales in the 2005/06 JARPA II feasibility survey.

| Samples and data | Number of whales | | |
|---|---|---|---|
| | Male | Female | Total |
| Photographic record of external character | 4 | 6 | 10 |
| Body length and sex identification | 4 | 6 | 10 |
| Measurement of external body proportion | 4 | 6 | 10 |
| Body weight by total weight of parts | 3 | 6 | 9 |
| Skull measurement (length and breadth) | 4 | 4 | 8 |
| Detailed measurement of blubber thickness (fourteen points) | 4 | 6 | 10 |
| Lactation status | - | 6 | 6 |
| Measurement of mammary gland | - | 6 | 6 |
| Breadth measurement of uterine horn | - | 6 | 6 |
| Testis weight | 4 | - | 4 |
| Epididymis weight | 4 | - | 4 |
| Weight of stomach content | 4 | 6 | 10 |
| Number of ribs | 4 | 6 | 10 |
| Diatom film observation | 4 | 6 | 10 |
| Diatom film sample | 4 | 6 | 10 |
| Blood plasma for physiological study | 4 | 6 | 10 |
| Earplug for age determination | 4 | 6 | 10 |
| Ocular lens for age determination | 4 | 6 | 10 |
| Tympanic bone for chemical analysis | 4 | 6 | 10 |
| Largest baleen plate for chemical analysis | 3 | 6 | 9 |
| Vertebral epiphyses sample | 4 | 6 | 10 |
| Ovary | - | 6 | 6 |
| Histological sample of endometrium | - | 6 | 6 |
| Histological sample of mammary gland | - | 6 | 6 |
| Milk sample for chemical analysis | - | 0 | 0 |
| Histological sample of testis | 4 | - | 4 |
| Histological sample of epididymis | 3 | - | 3 |
| Skin and liver tissues for genetic study | 4 | 6 | 10 |
| Blubber, muscle and liver tissues for environmental monitoring | 4 | 6 | 10 |
| Lung tissue for air monitoring | 4 | 6 | 10 |
| Macro pathological observation (thyroid, lung, stomach, liver and gonad) | 4 | 6 | 10 |
| Tissues for histopathological study | 4 | 3 | 7 |
| Muscle, liver, kidney, lumbar and blubber tissues for lipid analysis | 4 | 6 | 10 |
| Muscle, liver and blubber tissues for chemical analysis | 4 | 6 | 10 |
| Muscle and blubber tissues for nutritional analysis | 4 | 6 | 10 |
| Stomach contents for food and feeding study | 4 | 5 | 9 |
| Stomach contents for environmental monitoring | 2 | 3 | 5 |
| Stomach contents for lipid analysis | 2 | 4 | 6 |
| External parasites | 3 | 2 | 5 |
| Internal parasites | 1 | 0 | 1 |
| Photographic record of fetus | 1 | 1 | 2 |
| Fetal length and weight | 1 | 1 | 2 |
| External measurements of fetus | 1 | 1 | 2 |
| Collection of whole fetus | 0 | 0 | 0 |
| Fetal ocular lens for age determination | 1 | 1 | 2 |
| Fetal skin for genetic study | 1 | 1 | 2 |
| Baleen plates for educational exhibition | 1 | 0 | 1 |

Table 3: Some biological information obtained from fin whales in the 2005/2006 JARPA II feasibility survey.

| No. | Date of capture | Body length | Body weight* | Sex | Weight of testis (L/R) | Reproductive information | Remarks |
|---|---|---|---|---|---|---|---|
| F-001 | 060203 | 19.17m | − | M | 1.84/2.19kg | | |
| F-002 | 060208 | 20.05m | 53.48t | F | − | Pregnant | Fetal length 127.5cm |
| F-003 | 060209 | 19.47m | 52.05t | F | − | Pregnant | Fetal length 280.7cm |
| F-004 | 060210 | 18.73m | 41.87t | M | 5.36/5.54kg | | |
| F-005 | 060213 | 19.14m | 47.28t | M | 10.10/10.60kg | | Spondylosis deformans |
| F-006 | 060214 | 19.15m | 47.04t | F | − | Immature | |
| F-007 | 060307 | 20.22m | 61.52t | F | − | Mature/Resting | |
| F-008 | 060309 | 18.22m | 41.06t | F | − | Immature | |
| F-009 | 060310 | 18.30m | 42.27t | M | 1.65/1.91kg | | |
| F-010 | 060313 | 19.35m | 47.24t | F | − | Immature | |

* Body weight was estimated by summing the weight of body parts.

Table 4: Summary of whale sightings conducted by SVs and SSVs in whole research areas in 2006/07 JARPA II feasibility survey.

| Type of the vessls | SVs | | | | | | SSVs | | | | | | Grand total | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Type of the sightings | Primary | | Secondly | | Sub total | | Primary | | Secondly | | Sub total | | Primary | | Secondly | | Combined | |
| Whale species | Sch. | Ind. | Sch. | Ind. | Sch. | Ind. | Sch. | Ind. | Sch. | Ind. | Sch. | Ind. | Sch. | Ind. | Sch. | Ind. | Sch. | Ind. |
| Antarctic minke whale | 526 | 1,126 | 41 | 105 | 567 | 1,231 | 443 | 1,043 | 13 | 66 | 456 | 1,109 | 969 | 2,169 | 54 | 171 | 1,023 | 2,340 |
| Dwarf-formed minke whale | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| Like minke whale | 20 | 32 | 2 | 4 | 22 | 36 | 8 | 8 | 2 | 4 | 10 | 12 | 28 | 40 | 4 | 8 | 32 | 48 |
| Blue whale | 5 | 8 | 0 | 0 | 5 | 8 | 2 | 4 | 1 | 3 | 3 | 7 | 7 | 12 | 1 | 3 | 8 | 15 |
| Fin whale | 18 | 97 | 0 | 0 | 18 | 97 | 19 | 156 | 4 | 14 | 23 | 170 | 37 | 253 | 4 | 14 | 41 | 267 |
| Humpback whale | 91 | 171 | 8 | 16 | 99 | 187 | 69 | 112 | 3 | 9 | 72 | 121 | 160 | 283 | 11 | 25 | 171 | 308 |
| Baleen whales | 33 | 50 | 2 | 4 | 35 | 54 | 0 | 0 | 3 | 7 | 3 | 7 | 33 | 50 | 5 | 11 | 38 | 61 |
| Sperm whale | 33 | 33 | 0 | 0 | 33 | 33 | 30 | 30 | 0 | 0 | 30 | 30 | 63 | 63 | 0 | 0 | 63 | 63 |
| Southen bottlenose whale | 25 | 41 | 0 | 0 | 25 | 41 | 26 | 39 | 1 | 1 | 27 | 40 | 51 | 80 | 1 | 1 | 52 | 81 |

Table 5: Summary of biological data and samples collected from fin whales in the 2006/07 JARPA II feasibility survey.

| Samples and data | Number of whales(fin whale) | | |
|---|---|---|---|
| | Male | Female | Total* |
| Photographic record of external character | 1 | 1 | 2 |
| Body length and sex identification | 1 | 1 | 2 |
| Measurement of external body proportion | 1 | 2 | 3 |
| Body weight by total weight of parts | 1 | 1 | 2 |
| Skull measurement (length and breadth) | 1 | 1 | 2 |
| Detailed measurement of blubber thickness (fourteen points) | 1 | 1 | 2 |
| Lactation status | - | 1 | 1 |
| Measurement of mammary gland | - | 1 | 1 |
| Breadth measurement of uterine horn | - | 1 | 1 |
| Testis weight | 1 | - | 1 |
| Epididymis weight | 1 | - | 1 |
| Weight of stomach content | 1 | 1 | 2 |
| Photographic record of fetus | 1 | - | 1 |
| Fetal length and weight | 1 | - | 1 |
| External measurements of fetus | 1 | - | 1 |
| Number of ribs | 1 | 1 | 2 |
| Number of vertebrae | 1 | 1 | 2 |
| Diatom film observation | 1 | 1 | 2 |
| Diatom film sample | 1 | 1 | 2 |
| Blood plasma for physiological study | 1 | 1 | 2 |
| Earplug for age determination | 1 | 1 | 2 |
| Ocular lens for age determination | 1 | 1 | 2 |
| Tympanic bone for chemical analysis | 1 | 1 | 2 |
| Largest baleen plate for chemical analysis | 1 | 1 | 2 |
| Number and length of baleen plates | 1 | 1 | 2 |
| Palate length | 1 | 1 | 2 |
| Vertebral epiphyses sample | 1 | 2 | 3 |
| Ovary | - | 1 | 1 |
| Histological sample of endometrium | - | 1 | 1 |
| Histological sample of mammary gland | - | 1 | 1 |
| Milk sample for chemical analysis | - | 0 | 0 |
| Histological sample of testis | 1 | - | 1 |
| Histological sample of epididymis | 1 | - | 1 |
| Skin and liver tissues for genetic study | 1 | 2 | 3 |
| Blubber, muscle and liver tissues for environmental monitoring | 1 | 2 | 3 |
| Lung and liver tissues for air monitoring | 1 | 1 | 2 |
| Macro pathological observation (thyroid, lung, stomach, gonad and liver) | 1 | 1 | 2 |
| Tissues for histopathological study | 1 | 1 | 2 |
| Tissues for lipid analysis (muscle, liver, kidney, lumbar, blubber) | 1 | 2 | 3 |
| Tissues for chemical study (muscle, liver, kidney) | 1 | 2 | 3 |
| Tissues for various studies (muscle, blubber) | 0 | 1 | 1 |
| Tissues for food study (muscle, blubber, ventral groove) | 0 | 0 | 0 |
| Tissues for nutritional study (muscle, blubber) | 1 | 2 | 3 |
| Stomach contents for food and feeding study | 1 | 1 | 2 |
| Stomach contents for environmental monitoring | 1 | 0 | 1 |
| Stomach contents for lipid analysis | 1 | 0 | 1 |
| External parasites | 0 | 0 | 0 |
| Internal parasites | 0 | 0 | 0 |
| Fetus | 0 | 0 | 0 |
| Fetus ocular lens for age determination | 1 | 0 | 1 |
| Fetal skin for genetic study | 1 | 0 | 1 |
| Blood samples for genetic study | 1 | - | 1 |
| Baleen plates for educational exhibition | 0 | 0 | 0 |
| Tympanic bone for educational exhibition | 0 | 0 | 0 |
| Pelvis bone for educational exhibition | 0 | 1 | 1 |

Table 6: Some biological information on fin whales sampled in the 2006/2007 JARPAII feasibility survey.

| No. | Date of capture | Body length (m) | Body weight (ton)* | Sex | Testis weight (L/R, kg) | Reproductive information | Remarks |
|---|---|---|---|---|---|---|---|
| F001 | Jan. 3, 2007 | - | - | F | - | - | |
| F002 | Jan. 5, 2007 | 20.67 | 51.62 | M | 8.10 / 9.80 | | |
| F003 | Feb. 2, 2007 | 21.15 | 65.02 | F | - | Pregnant | Fetal length 243.4cm |

* Body weight was represented by total weight of body parts.

Table 7: Summary of prey species found in the stomach contents of fin whales sampled during two JARPA II feasibility surveys.

| | | **Stomach contents** | | | |
|---|---|---|---|---|---|
| | **Number** | ***Euphausia superba*** | **(%)** | **None** | **Unknown** |
| **Male** | **5** | **5** | **100%** | **0** | |
| **Female** | **7** | **6** | **100%** | **1** | |
| **Unknown** | **1** | | | | **1** |
| **Combined** | **13** | **11** | **100%** | **1** | **1** |

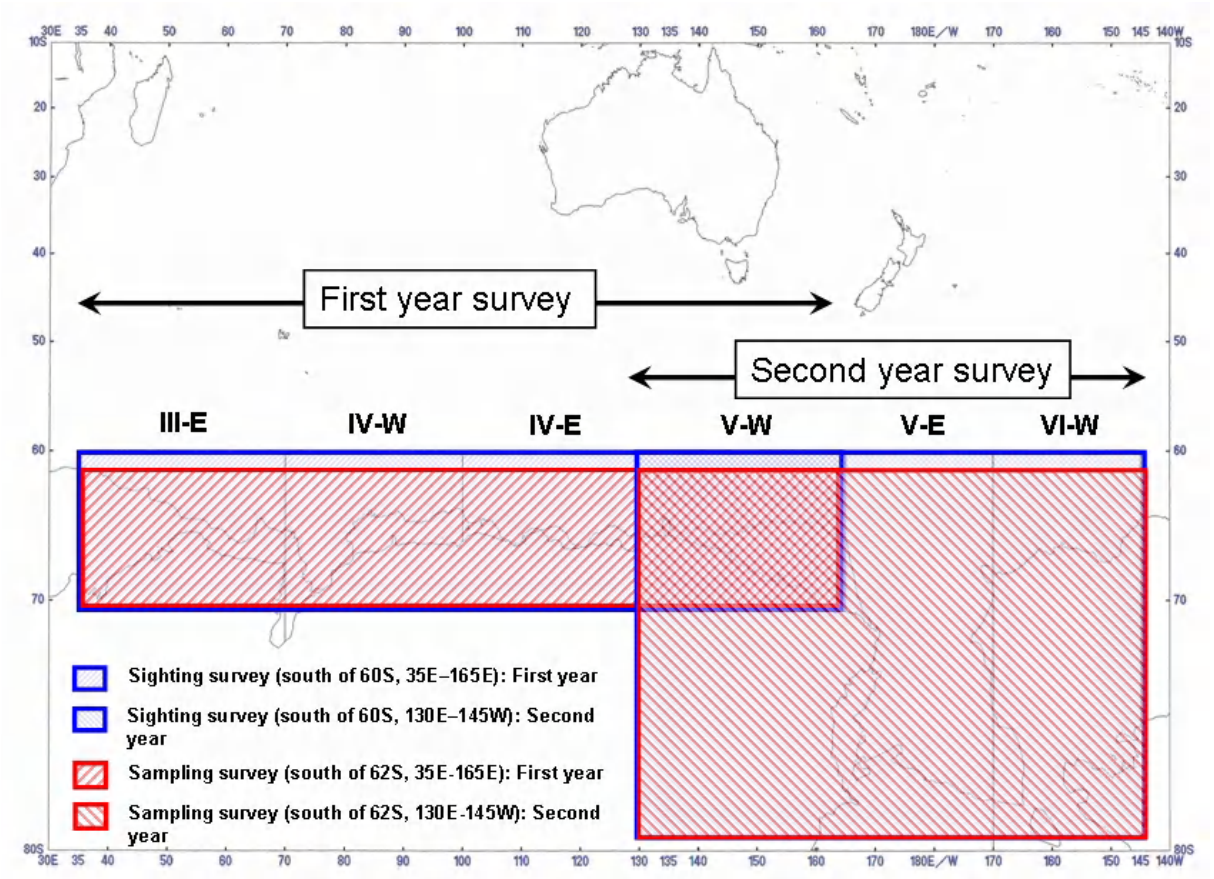



Figure 1: Geographic strata of the two-year JARPA II feasibility surveys.

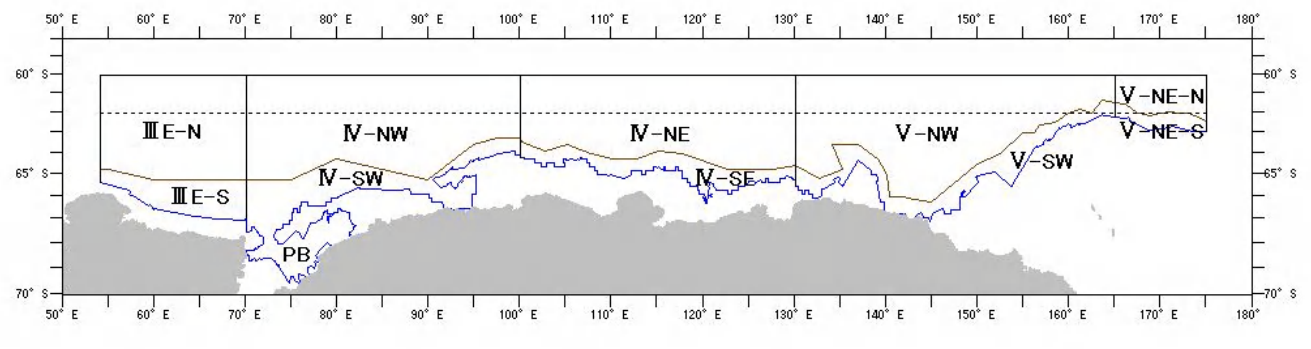



Figure 2: Geographic strata used in the JARPA II feasibility survey in 2005/06. After Nishiwaki *et al.* (2006)

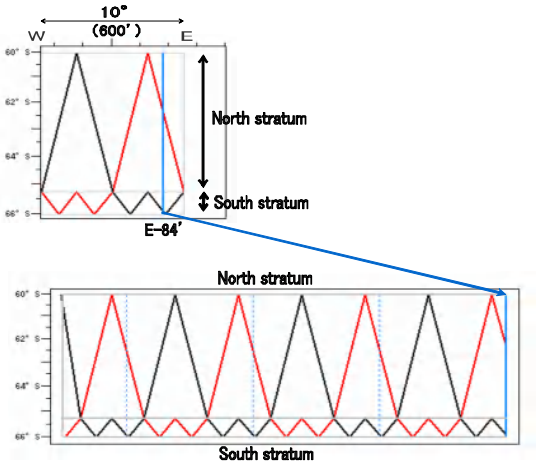



Figure 3: The design of survey track line of SVs from the minimum unit. After Nishiwaki *et al.* (2006).

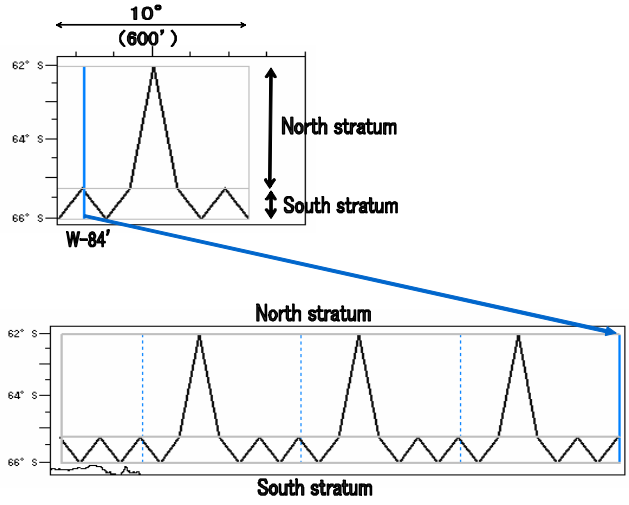



Figure 4: The design of survey track line of SSVs from the minimum unit. After Nishiwaki *et al.* (2006)

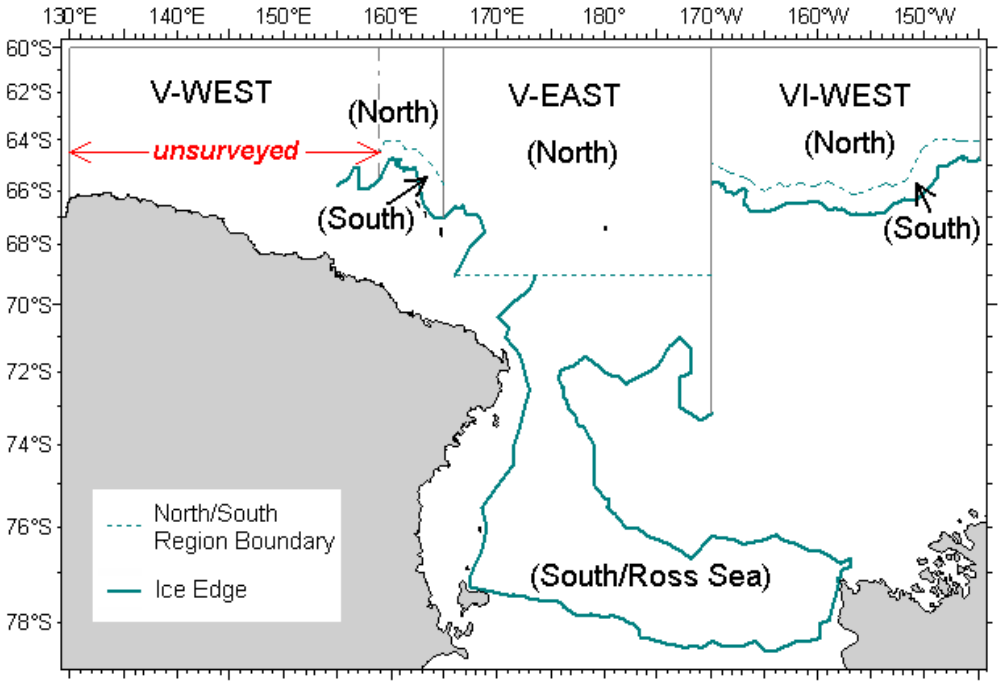



Figure 5: Geographic strata of the JARPA II feasibility survey in 2006/2007 JARPAII survey. Green line show the position of the is ice edge estimated by observation of research vessels and the information from DMSP SSM / I daily polar griddled sea ice concentration data set available from the National Snow and Ice Data Center (NSIDC, Cavalieri *et al*. 1999). After Nishiwaki *et al.* (2007).

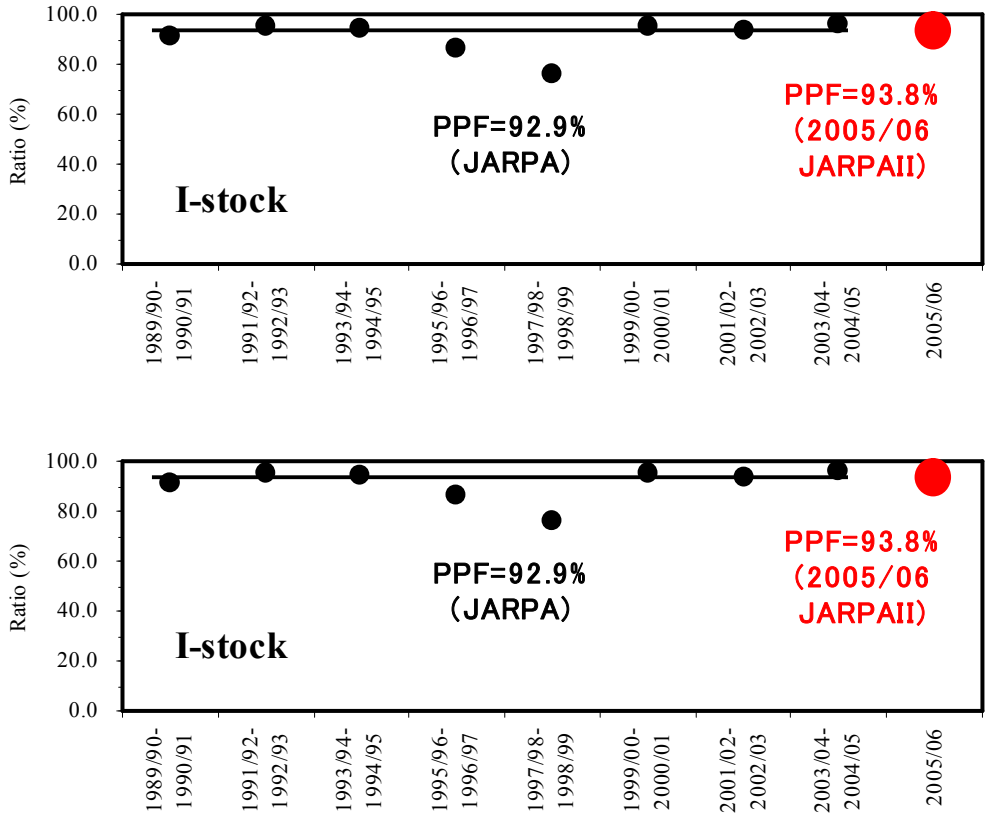
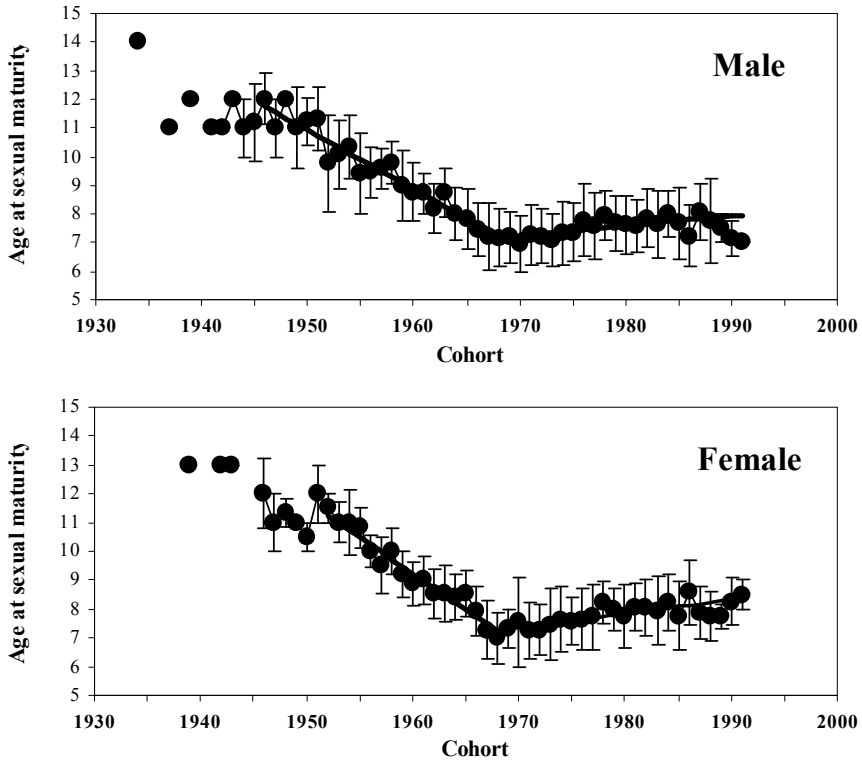



Figure 6: Temporal variation of PPF for I-stock (upper figure) and P-stock (lower figure) of Antarctic minke whales. Close black circles and solid line indicate the PPF trend of I-stock during the JARPA period, and open circles and broken line the PPF trend of P-stock during the JARPA period. Larger close and open circles indicate the PPF estimations based on new data from JARPA II surveys.

## I-stock




## P-stock

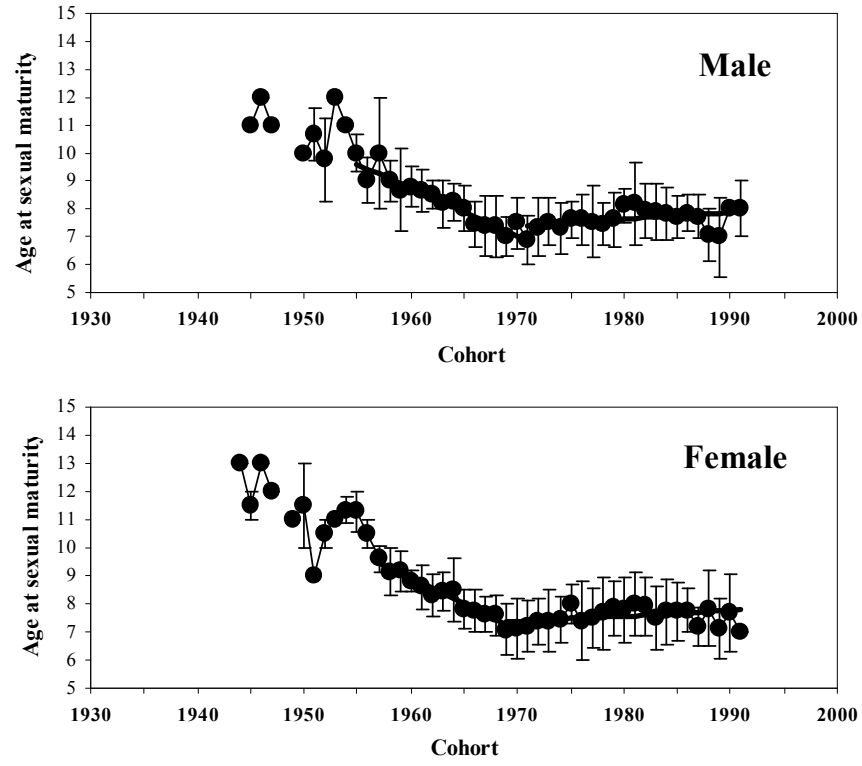



Figure 7: Temporal trend of mean age at sexual maturity derived from transition phase in earplug by cohort for each sex and stock based on JARPA samples. Open circle is mean age and solid line is range of standard deviation.

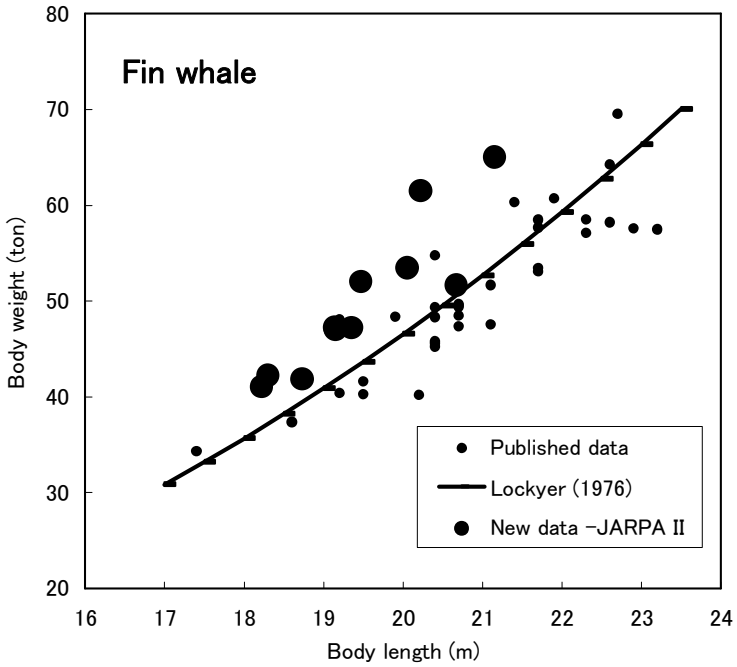



**Fig. 8. Relationship between body length (m) and body weight (ton) for fin whales.**
**Small dot: published data from Nishiwaki (1950) and Ohno & Fujino (1952). Calculated curve is drawn from a regression equation by Lockyer (1976)**