The Japanese Whale Research Program under Special Permit in the Antarctic-Phase II (JARPAII): origin, objectives, research progress made in the period 2005/06-2010/2011 and relevance for management and conservation of whales and the ecosystem

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ABSTRACT

The International Whaling Commission's Scientific Committee (IWC SC) will carry out a Workshop to review the progress made in the research conducted under the Japanese Whale Research Program under Special Permit in the Antarctic – Phase II (JARPAII) in its first six years (2005/06-2010/11). This review will follow the guidelines agreed by the IWC SC as detailed in 'Annex P'. A number of scientific papers are now available, which present JARPAII results for this period. Several analyses on temporal trends in biological parameters have been conducted by combining JARPA and JARPAII data. The present paper was prepared to facilitate the understanding of this large research program in a comprehensive way, which would not be possible by reading only the individual papers. We believe that this paper will be useful for the external reviewers, particularly for those that are not familiar with JARPA and JARPAII. JARPA was carried out between the 1987/88 and 2004/05 austral summer seasons, and this research program produced a considerable amount of data for an improved understanding of the Antarctic minke whale and its environment. This document summarizes a) the origin and objectives of JARPA, b) the development of the research objectives of JARPAII based on the findings of JARPA, c) the progress in research under each JARPAII objective, d) the key results, e) interpretation of results and relevance for the conservation and management of whales and the ecosystem, f) some ideas about the future direction of JARPAII given the results obtained in the first period, and g) the response to the Terms of Reference (TOR) of the specialist workshop for the periodic review of JARPAII as detailed in Annex P. It is necessary to point out some difficulties experienced during the first period of JARPAII. These difficulties and their implications for the research are explained in this document.

CONTENTS **PAGE**

Annexes

1. GENERAL INTRODUCTION

Science as the basis for managing natural resources is a long-standing paradigm and fisheries science is recognized as crucial input to fisheries management world-wide. More than 60 years ago drafters of the 1946 International Convention for the Regulation of Whaling (ICRW) recognized this in the preamble and several Articles of the Convention: Article IV encourages studies and investigations and the collection of statistical information, Article V requires that regulations related to conservation and utilization of whales be based on scientific findings and, Article VIII provides for special permits authorizing the killing of whales for scientific research and recognizes that continuous collection and analysis of biological data in conjunction with whaling operations are "indispensable to sound and constructive management of the whale fisheries." This "science-based management" is the context within which Japan's Whale Research Program under Special Permit in the Antarctic-Phase II (JARPAII), was developed.

Reasons for conducting research in the Antarctic

There are two main general reasons to conduct research on whales and the ecosystem in the Antarctic. First the Antarctic Ocean supports the existence of a vast amount of marine living resources including krill, oceanic squids and fishes, seabirds, Antarctic seals and whales. Although there are fewer species of marine mammals in the Antarctic than in the Arctic, the stocks are substantially larger in the Antarctic and the body sizes of individual species are larger, probably owing to a more abundant food supply (Laws, 1977). Before the commercial whaling started in the Antarctic in 1904 the biomass of large whales was estimated to be about 45 million tons, which was reduced by commercial whaling to about 9 millions tons by the decade of the 70's (Laws, 1985). Following conservation measures the estimated abundances of several whale species and stocks have been increasing in recent decades, with some of them perhaps now close to reaching pre-exploitation levels. Therefore the current biomass of large whales in the Antarctic should be considered substantially larger than the 9 million tons estimated in the decade of the 70's.

Then the Antarctic Ocean represents a very important reserve of proteins for the increasing human population. Rational utilization of the Antarctic marine living resources requires scientific information, which should be collected in a systematic way.

Second, and as noted earlier, the ICRW gives particular importance to science as the basis for managing whale resources and consequently it encourages research activities through several of its Articles. As indicated above there is a huge amount of large whales (in terms of biomass) in the Antarctic and it is a responsibility for International Whaling Commission (IWC) member countries to carry out research on those resources and on the changes in their ecosystem. The IWC adopted a moratorium on commercial whaling in 1982, which promoted scientific research on whale stocks, including those in the Antarctic. Paragraph 10 (e) of the ICRW Schedule provides as follows: '…This provision will be kept under review, based upon the best scientific advice, and by 1990 at the latest the Commission will undertake a comprehensive assessment of the effects of this decision on whale stocks and consider modification of this provision and the establishment of other catch limits'. It is clear from this paragraph that the intention of the moratorium was not a permanent ban of commercial whaling. The necessity of scientific data and thus scientific research is clearly reflected in the terms of Paragraph 10 (e) of the Schedule, which envisages 'review' and 'comprehensive assessment'. The term 'Comprehensive Assessment (CA)' was defined by the IWC SC as 'an in-depth evaluation of the status of all whale stocks in the light of management objectives and procedures' and that 'this would include the examination of current stock size, recent population trends, carrying capacity and productivity' (IWC, 1989).

Research on living resources in the Antarctic is a responsibility of States under international laws including the United Nation Convention of the Law of the Seas (UNCLOS).

Brief background of the JARPAII research

The rational and research needs of JARPAII were explained in the original research plan, which was presented and discussed at the IWC Scientific Committee (IWC SC) in 2005 (Government of Japan, 2005).

Ecological research under JARPAII

Within the Antarctic ecosystem the Antarctic krill is a key prey species, supporting different species of baleen whales, pinnipeds, birds and fish. The large whale populations in the Antarctic have historically undergone extensive changes, for example those derived from their over-exploitation in the first half of the past century, which affected krill availability. JARPA research showed that another major transition has been taking place in recent years, with the recovery of some whale species from past over-exploitation, which again affect the krill availability in the ecosystem and the biology of krill predators (Fujise *et al*., 2006).

The JARPAII research plan therefore emphasized the need to systematically monitor changes of environmental conditions in the Antarctic over the long-term, as well as changes of biological parameters in krill predators, and changes in the abundance of cetaceans inhabiting the Antarctic Ocean. It is also emphasized the need to monitor how cetaceans adapt to global warming and the shifts in the ecosystem structure caused by human activities so as to provide a scientific basis for the comprehensive management of whale stocks (Government of Japan, 2005).

It should be noted here that continuous monitoring programmes form the backbone of all scientific research programmes which have the aim of providing advice on sustainable levels of catch for marine or terrestrial living resources. The reason is that population dynamics, and hence the size of the sustainable yield, can change in a manner that may not be predictable. Factors indexing these dynamics must therefore be monitored so that changes can be detected and important scientific information can be provided to the IWC as the basis for their management decisions.

The JARPA research showed the utility of some biological and ecological parameters as indicators of changes or shift in the ecosystem, and JARPAII monitors these parameters systematically in the long term. Table 1 shows the parameters monitored during the JARPAII, and their relevance in the context of the JARPAII research.

Table 1. Biological and ecological parameters monitored in JARPAII and their relevance.

Research parameter	**How the information is obtained**	**Relevance of monitoring**
Krill biomass	Echo-sounder and net surveys	Krill is a key species in the Antarctic ecosystem. Changes in its abundance have effects on predators and the whole ecosystem.
Whale abundance	Systematic sighting surveys	Fluctuation of abundance of whales through time is important for their management. Different levels of whale abundance have different impacts on krill.
Whale distribution	Systematic sighting surveys	Distribution of whale species can change with time in response to changes in abundance and/or changes in oceanographic conditions/krill availability.
Whale recruitment	Population dynamic models that use age and abundance information from whales	Same as above. Index of young whale abundance.
Blubber thickness	Direct measurements from sampled whales	Index of body condition. Better nutritional condition (e.g. better availability of krill) will be reflected in thicker blubber.
Stomach content weight	Direct measurements from sampled whales	Index of body condition. Better nutritional condition will be reflected in heavier stomach contents.
Age at sexual maturity (ASM)	Examination of transition phase in earplugs; examination of ovaries and testis.	Better nutritional conditions will be reflected in a shift of the ASM to younger ages e.g. whales will be able to reproduce at younger ages.
Pregnancy rate	Examination of ovaries and uterus	Better nutritional conditions will be reflected in higher pregnancy rates.
Oceanographic conditions	Systematic oceanographic surveys based on CTD and XCTD	Changes in oceanographic conditions will affect distribution and krill biomass and in turn the abundance and distribution of whales. Changes in oceanographic conditions might indicate an effect of climate changes.

As explained through this document there are scientific evidences of whale abundance fluctuations with time as well as temporal changes in some of the ecological and biological parameters in the Antarctic minke whale. The temporal pattern of changes in abundance and parameters can be interpreted with the development of ecosystem models. The output of the models will assist in the elucidation of whether these changes are due to competition among krill predators, due to climate changes affecting the krill abundance, or due to both.

Management research under JARPAII
JARPAII also focuses on the collection of data for the implementation and improvement of the Revised Management Procedure (RMP). The IWC adopted the RMP, the procedure for the management of commercial whaling for baleen whales, but it has yet to be applied, with the exception of operations carried out by Norway that has lodged an objection to the commercial whaling moratorium. There is a need for better estimation of Maximum Sustainable Yield Rate (MSYR) in order to respond to any concerns over the implementation of the RMP and to improve its likely deficiencies concerning utilization of whale resources. In the past the RMP *Small Areas* for Antarctic minke whale in the Antarctic were established as longitudinal sectors of 10°, but at the very least, there is a need to redefine appropriate *Small Areas* according to information on stock structure. Also another of the deficiencies of the current RMP is the zero catch quotas that it turns out when carrying capacity declines due to competition among whale species. The decrease in abundance caused by the competition is misinterpreted by the current RMP as an over-exploitation so that catches are set unnecessarily low. That part needs also to be improved by the use of more realistic multi-species models as stated in the JARPAII original research plan (Government of Japan, 2005).

A detailed explanation of the background of the JARPAII research and development of the objectives of this program is given in Section 3.

Objective and contents of this document
The JARPAII research proposal submitted to the IWC SC in 2005 stated that 'a comprehensive review will be conducted following the completion of the first six years of the research' (Government of Japan, 2005). The first six-year period of the JARPA II research was completed between the austral summer seasons (=seasons) 2005/06 and 2010/11. The IWC SC is planning a workshop to review the data and results of the JARPAII obtained in this period, following the review guidelines in Annex P (IWC, 2009a; 2013a). Under these guidelines a Review Panel is tasked to review and evaluate the data and results obtained by JARPAII.

The present paper explains the origin, objectives and progress in research made during the first six years of JARPAII in a comprehensive and easy-to-understand manner. The aim of this paper is to assist members of the Review Panel that may not be familiar with the origin, scientific purposes, and technical details of JARPA and JARPAII. Also this paper aims to assist as a 'frame' for Japanese scientists conducting specific analyses based on data collected by JARPA and JARPAII so that all those analyses are coordinated in the context of the objectives and direction of JARPAII.

When we talk about the origin of JARPAII we can not avoid talking about its predecessor, the JARPA. The JARPA was conducted between the 1987/88 and 2004/05 seasons and produced a considerable amount of data for an improved understanding of the Antarctic minke whale and its environment (IWC, 2008b). Section 2 of this document shows the origin and objectives of JARPA. JARPAII was elaborated on the basis of the scientific information and findings obtained during the JARPA. Section 3 summarizes the key results of JARPA and how these results were taken into consideration in developing the research objectives of JARPAII.

Progress in research under each JARPAII objective is presented in Section 4 while Section 5 presents a summary of the key results. Section 6 summarizes the contribution of JARPA/JARPAII results for the conservation and management of whales and the ecosystem, and Section 7 presents some ideas about the future direction of JARPAII given the results obtained in the first period. Finally Section 8 presents a summary response to the Terms of Reference (TOR) of the specialist workshop for the periodic review of JARPAII as detailed in Annex P (see Annex P, IWC, 2009a; 2013a),

Details of the analyses and results summarized in Section 4 can be found in the individual papers (Annex 1). This annex also includes a list of relevant background documents. The analyses are based on samples and data collected by JARPAII in the first period (Annex 2), although some of the analyses on temporal trends were conducted using both JARPA and JARPAII samples. The data were available to IWC SC members through its data access protocol (Procedure B). Annex 3 shows the protocol for sample/data access from the Institute of Cetacean Research under this Procedure. The different analyses conducted took into consideration previous suggestions and recommendations from the IWC SC. The list of previous recommendations and the responses from Japanese scientists are summarized in Annex 4. Annex 5 presents a brief outline of the research area, target species, sample size and general methodology of JARPAII.

At this introduction it is necessary to point out that some difficulties were experienced during the first period of JARPAII, which meant that this research program could not be implemented as originally planned. These difficulties and their implications for the research are explained in Annex 6.

2. WHY JARPA WAS STARTED?

As explained above the moratorium on commercial whaling was not intended as a permanent ban on whaling. Rather, it was intended as a temporary measure adopted on the basis that knowledge concerning the status of whale stocks was insufficient for management using the New Management Procedure (NMP) which was the IWC's system for classifying whale stocks and calculating catch quotas at the time.

The NMP adopted in 1974 is a set of rules to classify and set catch limits for stocks, based largely on estimates of initial and current population levels, those realizing the Maximum Sustainable Yield (MSY). The theory behind MSY is that through the interplay of the natural responses for a stock to increase when its numbers are reduced, at each particular size of stock there is a certain surplus of recruitment over natural mortality. This is low when the stock is at or close to its initial unexploited level and also at very low stock levels, and increases to a maximum (MSY) at some intermediate point somewhere around 50-60% of the original abundance. This yield represents a harvest which can be taken for an indefinite time without depleting the stock.

Under the NMP, whale stocks were classified in one of three categories: Initial Management Stocks, Sustained Management Stocks and Protection Stocks, for the most part based on where the population existed on a theoretical population curve. Stocks which were judged to be below 90% of the level providing the MSY were to be protected, while catches from other stocks were not to exceed the 90% of MSY so that in theory at least, these stocks would not become depleted to below their MSY levels.

However, implementation of the NMP was problematic primarily because of difficulties in estimating MSY. These difficulties related to the absence of accurate population abundance estimates and estimates of life history parameters such as natural mortality rates, age at sexual maturity and recruitment required to calculate MSY. The difficulties in estimating MSY were then used by members of the Commission (not the IWC SC) as the major "scientific" argument in support of adoption of the moratorium and, to address this matter, the collection of data on life history parameters and abundance estimates became the main objectives of JARPA.

It should however be noted that the moratorium was adopted in the absence of any agreed advice from the IWC SC that such measure was required for conservation purposes and contrary to the stated view of the IWC SC that a stock by stock approach to management was more appropriate than a blanket moratorium (IWC, 1974). In addition, the moratorium rendered impossible the continuous collection and analysis of biological data previously realized in connection with commercial whaling operations, the necessity of which is recognized in paragraph 4 of Article VIII of the ICRW.

In order to resolve the scientific uncertainties described above and to pave the way for the resumption of commercial whaling in a sustainable manner, Japan developed and implemented the plan for the JARPA, under Article VIII of the ICRW in 1987. That is to say, the JARPA was commenced to contribute to the "comprehensive assessment" of the effects of the moratorium on whale stocks prescribed by paragraph 10 (e) of the Schedule.

Sustainable management of resources requires certain basic information with a general understanding that additional information can reduce uncertainty and improve management. In light of this and the specific scientific uncertainties related to the implementation of the NMP described above, the JARPA was initiated with the following two objectives (Government of Japan, 1987; 1989):

Objective 1: Estimation of biological parameters to improve the stock management of the Southern Hemisphere minke whale (this included age-specific natural mortality coefficient and reproductive parameters such as age at sexual maturity and their changes). The original wording of this objective had been "estimation of biological parameters *required for* [emphasis added] the stock management of Southern Hemisphere minke whale". However this wording was changed as a result of the IWC SC's refocusing from the NMP towards the RMP as the basis for management (see in Section 3 a explanation on how biological data can improve the performance of the RMP).

Objective 2: Elucidation of the role of whales in the Antarctic marine ecosystem. To this end, surveys were included to estimate the abundance of each whale species and the diet of the Antarctic minke whale, which was the most abundant species.

A third objective was added in 1995/96 (Government of Japan, 1995).

Objective 3: Elucidation of the effect of environmental change on cetaceans. This objective was added in response to the increasing interest in IWC about the effects of environmental changes such as global warming on cetaceans specifically noted in its resolution on research on environment and whale stocks and the resolution on promotion of research related to conservation of large whale stocks in the Southern Ocean, both of which were adopted in 1994.

A fourth objective was added in 1996/97 (Government of Japan, 1996):

Objective 4: Elucidation of the stock structure of Southern Hemisphere minke whales to improve stock management. This objective was already implicit in Objective 1, and officially acknowledged in 1996/97. Research under the JARPA was carried out on the basis of IWC's management Areas IV and V. However, biological evidences for the particular stock boundaries were weak, especially for Antarctic minke whale, whose data were not considered when the original management Areas were established. There was therefore a need to investigate geographical and temporal boundaries of stocks based on biological evidence. Such information is important for a) the estimation of biological parameters, which should be ideally estimated on the basis of biological stocks, b) the interpretation of abundance estimates, and c) the definition of management areas for the application of the RMP.

As is clear from the primary objective, the main subject species of the JARPA was the Antarctic minke whale, the exploitable population size of which was estimated to be at least about 260,000 by the IWC SC when the research plan was developed (IWC, 1988). During the 1990 comprehensive assessment the IWC SC estimated the abundance of this species (total population) as 760,000 animals (IWC, 1991).

The main reason for the failure of the IWC SC at that time to recommend an agreed catch limit under the NMP for the Antarctic minke whale was that they had not been able to reach agreement on the value of the natural mortality coefficient and its age-specific patterns. A good summary of the estimates of mortality rates before the moratorium and the difficulties experienced was presented by Horwood (1990 pp. 109-117). The primary objective of JARPA was therefore to provide this information.

The secondary objective was based on the recognition that there was an important need for data on the prey-predator relationships among the krill, fish and squid, and whales, considering that global scientific interest in the Antarctic ecosystem had been growing as reflected in the coming into force of the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) in 1982, and because of the possible contribution of such data to multi-species management approaches recommended by almost all fisheries management organizations as well as the Food and Agriculture Organization (FAO) of the United Nations. This was relevant to the IWC SC "comprehensive assessment". For example at the 1990 CA of Antarctic minke whale, information on feeding ecology of this species was presented and discussed in the context of developing an ecosystem approach to the management of whales (IWC, 1991).

The JARPA was started in the 1987/88 and 1988/89 austral summer seasons as a two-year feasibility study. The full program started in 1989/90 and was completed in 2004/05. It was a long-term program over 18 years (including the two years of feasibility studies). The surveys were conducted each year in alternating Areas IV (70°-130°E) and V (130°E-170°W). From the 1995/96 season, the JARPA research area was expanded to include Area III East (35°-70°E, south of 60°S) and Area VI West (170°-145°W, south of 60°S), and then Areas III East + IV and Areas V + VI West were surveyed alternately each season. This expansion of the research area was done in order to improve the study on stock structure of Antarctic minke whales. Studies on stock structure based on samples collected in early JARPA surveys suggested the occurrence of more than one stock in Areas IV and V. The longitudinal expansion of the research area was necessary to investigate distribution and boundaries of stocks occurring in Areas IV and V. Then the JARPA covered almost half of the Antarctic Ocean. The same area was surveyed by the JARPAII (Figure 1).

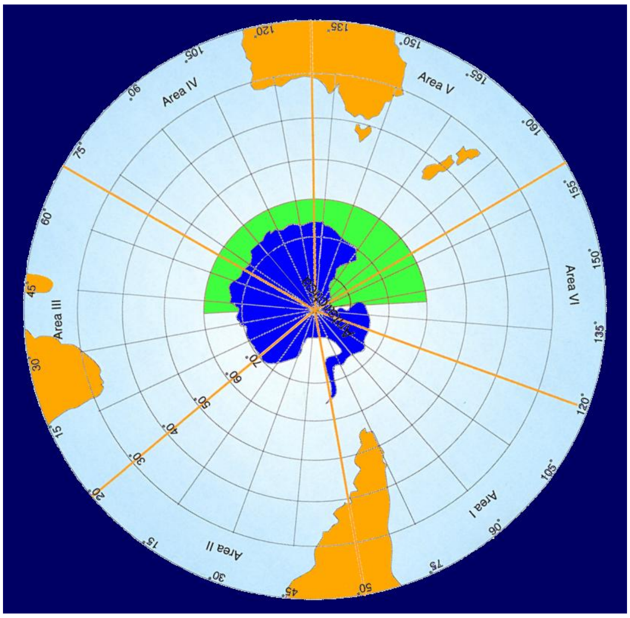

Figure 1. Research area of the JARPA and the JARPAII (in green). Surveys covered approximately the half of Antarctic waters.

Data and results from the JARPA were reviewed in three specialist workshops: an IWC intersessional working group meetings held in May 1997 (IWC JARPA mid-term review) (IWC, 1998a); a non-IWC JARPA review workshop called by the Government of Japan in January 2005 (Japan JARPA review) (Anon, 2005); and the final IWC intersessional workshop held in December 2006 (IWC JARPA final review) (IWC, 2008b).

Results on the main objective of the JARPA (estimation of biological parameters) were summarized and discussed at the IWC JARPA Final Review (IWC, 2008b). The annual natural mortality rate, *M*, was estimated to be 0.038 with a SE of 0.036 for I-Stock, and 0.040 with a SE of 0.035 for P-Stock based on Tanaka's method. During the review it was noted by some that 'these estimates spanned such a wide range that the parameter remains effectively unknown at present' but this was countered by the response by others that 'prior to JARPA, the commercial whaling age data were suggesting an apparent mortality rate of around 0.14, but this was confounded with a suspected trend in stock size. At that time, a finding that the true mortality rate was less than 0.11 would have been regarded as very valuable information' (IWC, 2008b). Estimates based on ADAPT-VPA analysis presented a better precision, 0.056 with a CV of 0.16 for I-Stock, and 0.069 with a CV of 0.15 for P-Stock. The ADAP-VPA analysis was based on age data from both commercial whaling and JARPA. To accept the latter estimates the Final JARPA Review agreed that 'every effort should be made to try to resolve the issue of commercial age data as this has important implications as to how well the objectives of the programme can be met' (IWC, 2008b). The issue was resolved satisfactorily by the IWC SC in subsequent years (IWC, 2011; 2012a), so that the ADAPT-VPA analyses provided accepted estimates of M with reasonably high precision in line with a primary objective of JARPA.

Estimates of other biological parameters of the Antarctic minke whale are summarized in Table 2.

Table 2. Summary of biological parameters of Antarctic minke whale estimated according to one stock structure hypothesis (after IWC, 2008b).

		I-stock (Area IIIE+IV+VW)		P-stock (Area VE+VIW)	
		Male	Female	Male	Female
Length at sexual maturity (m)	*Lmov*		8.40m		8.30m
	Lm50%	7.29m	8.16m	7.17m	7.97m
Age at sexual maturity	*tmov*		7.9		8.4
	tm50%	5.3	7.6	5.4	8.0
Length at physical maturity (m)	50%mature	8.32m	9.12m	8.22m	8.73m
Age at physical maturity	50%mature	16.0	21.2	17.0	20.6
Growth curve		$y = 8.61(1-e^{-(0.27x+0.54)})$	$y = 9.16(1-e^{-(0.23x+0.49)})$	$y = 8.45(1-e^{-(0.29x+0.51)})$	$y = 8.93(1-e^{-(0.21x+0.59)})$
Percentage of matured females pregnant			92.9%		85.4%
Foetal sex ratio (male %)			51.8%		46.8%
Mean litter size			1.007		1.013

Other stock structure and ‘ecological’ results of JARPA are summarized in the next section in the context of the the JARPAII’s objectives and goals.

Since all commercial whaling had been suspended in the Antarctic, the JARPA has in effect been the only comprehensive research program that has provided a continuing time series of biological and ecological information for the assessment and management of whales stocks in the Antarctic, the world’s largest source of whale resources. In fact, the IWC JARPA final review workshop agreed that ‘the data set provides a valuable resource to allow investigations of some aspects of the role of the whales within the marine ecosystem and that this has the potential to make an important contribution to the IWC SC work in this regard as well as the work of other relevant bodies such as the CCAMLR’ (IWC, 2008b).

3. FROM JARPA TO JARPAII

Table 3 summarizes the transition from the JARPA to the JARPAII including changes in objectives, target species, sample sizes and some aspects of the methodology. One of the relevant points in this table is that the development of research objectives of the JARPAII took into consideration the findings of the JARPA. The main results of the JARPA on biological parameters were presented in the previous section. During the 18-year period, the JARPA also demonstrated changes in whale species composition and in some biological parameters of the Antarctic minke whale. As a whole these changes suggested a recent shift in the ecosystem. This particular point is further developed in the first part of this section.

The JARPA also provided information on the stock structure of the Antarctic minke whale as well as on the abundance and other biological parameters useful for the implementation and improvement of the RMP. This particular point is further developed in the second part of this section.

Table 3. Summary of the objectives, sample sizes and research items of the JARPA and the JARPAII.

Pre-JARPA	JARPA (87/88-94/95)	JARPA (95/96-04/05)	JARPA findings and movement to ecosystem-based management	JARPA II Feasibility Study (05/06-06/07)	JARPA II (07/08-)
Large scientific uncertainty in Minke whale’s biological parameters	Main objectives were the estimation of biological parameters and the elucidation of the stock structure of Antarctic Minke whales		(1) Changes in whale species composition (2) New information on stock structure (3) Climate change (4) Need for ecosystem approach (5) Natural mortality	Objectives: (1)Monitoring of the Antarctic ecosystem (2) Modelling competition among whale species and future management objectives (3) Elucidation of temporal and spatial changes in stock structure (4) Improving the management procedure for Antarctic Minke whale stocks	
Sample size	300 (Minke)	400 (Minke)		850/10/0 (Minke/Fin/Humpback)	850/50/50 (Minke/Fin/Humpback)
Reasons of Enlarging Sample Size: Changes in Research Items, Expected Outcomes, and Research Periods					
1. Research items	• Natural mortality	• Natural mortality • Stock structure		• Trends in age at sexual maturity • Trends in pregnancy rate • Trends in body condition indices • Genetic mark-recapture • Monitoring of pathology	
2. Expected outcomes	Estimate of a single biological parameter. “Taking a still picture”			Detection of changes in multiple biological parameters “Taking a movie”	
3. Research periods	18 years			6 years periods	

The JARPAII started in the 2005/06 season. The objectives and goals of the JARPAII were established considering basically a) the findings of the previous JARPA on the ecological research that indicated changes in the Antarctic ecosystem; and b) the finding of the JARPA that emphasized the need of new data for the implementation and improvement of the IWC’s current single-species management procedure (RMP). Consideration a) above was the basis for developing research objectives 1 and 2 of the JARPA II while consideration b) was the basis for developing research objectives 3 and 4 of the JARPA II. The general aim of the JARPAII was to contribute information useful for the sustainable use of Antarctic marine resources including whales.

Development of the 'ecological' objectives of the JARPA II (Objectives 1 and 2) based on the results of the the JARPA research

Fujise *et al*. (2006) and Appendix 2 of the JARPAII research plan (Government of Japan, 2005) summarized the biological changes in the Antarctic minke whale as evidenced by the JARPA research, and provided some ecological interpretation for those changes. In this section updated information of the key JARPA results/changes observed in the Antarctic minke whale and its environment, are provided.

Biological changes in the Antarctic minke whale

Results of the transition phase analyses suggested that Antarctic minke whales became sexually mature at younger ages (Figure 2). Male and female whales born in 1945 were sexually mature at around 12 years old while those born in 1970 were sexually mature at 7 years old (Thomson *et al*., 1999; Zenitani and Kato, 2006). From 1970 there was a halt in the decreasing trend and a slight increase is observed through the 70's and 80's cohorts.

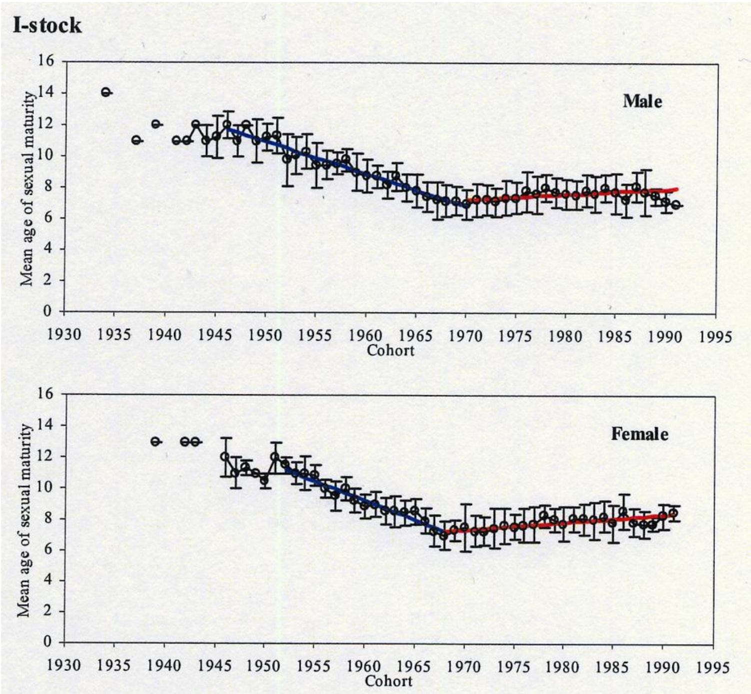

Figure 2. Changes in age at sexual maturity in Antarctic minke whale as determined by transition phase analysis. These analyses were conducted using biological data (age and sexual maturity information) collected by the JARPA and during past commercial whaling operations (Zenitani and Kato, 2006). The trend shown in this figure is for the Indian Ocean Antarctic minke whale stock, 'I' Stock (Pastene, 2006).

Recruitment trend of the Antarctic minke whale in the exploited component of the stock was estimated through ADAPT Virtual Population Analysis (ADAPT VPA) (Figure 3). There was an increase in the number of recruitments for the cohorts 1940-1967, which is followed by a sharp decrease in the 1970-1980 cohorts, and stabilization from the 1980 cohort (Mori *et al*., 2006a).

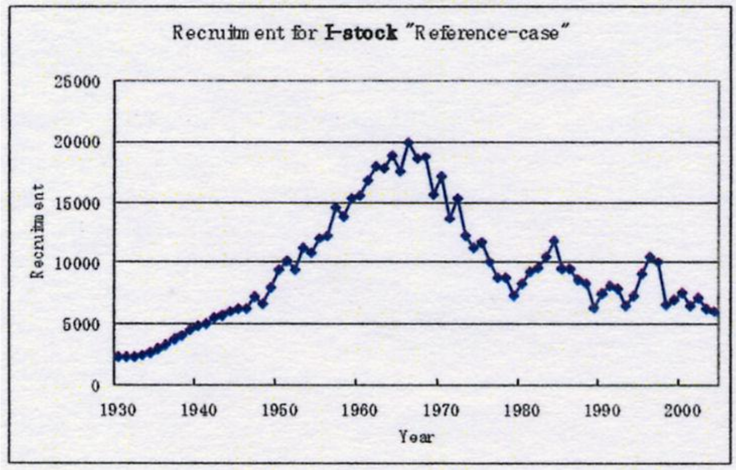

Figure 3. Temporal changes in recruitment in the Antarctic minke whale as estimated by ADAPT VPA analysis. These analyses were conducted using age (from the JARPA and past commercial whaling) and abundance (from the JARPA and IDCR/SOWER) data (Mori *et al*., 2006a). The trend shown in this figure is for the Indian Ocean Antarctic minke whale stock, 'I' Stock (Pastene, 2006).

The JARPA research showed that the blubber thickness (an index of energy storage) decreased at a rate of 0.02 cm/year over the JARPA period (1987/88-2004/05) (Konishi *et al*., 2008) (Figure 4), and the stomach content weight has decreased during the JARPA research period as well (Konishi *et al*., 2012).

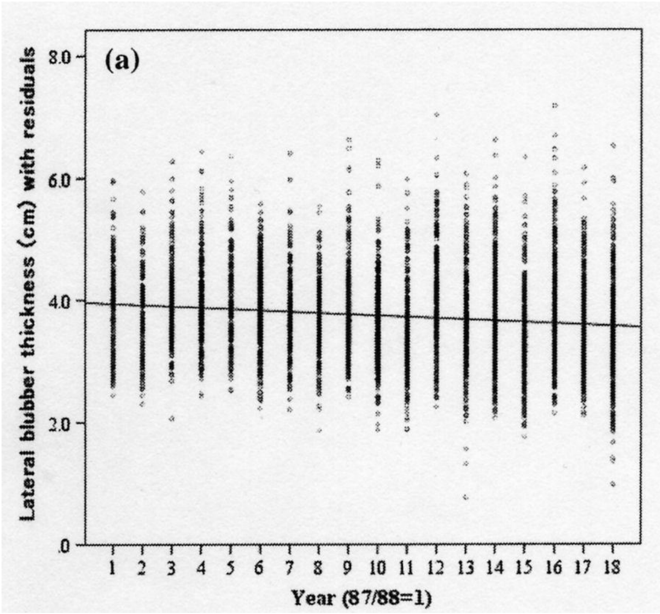

Figure 4. Decrease in energy storage in the Antarctic minke whale during the JARPA period. The blubber thickness showed a decrease of 0.02 cm/year over a period of 18 years (after Konishi *et al*., 2008).

Abundance and abundance trend of large whales

The JARPA sighting surveys showed that the abundance of large whales has been increasing in the last decades, and the scientific evidences are the following. Abundance and growth rates of humpback whale Breeding Stock D in Area IV and Breeding Stock E in Area V were 31,000 (16.4% increase by year with 95% CI: 9.5-23.3%) and 9,000 (12.1% increase by year with 95% CI: 1.7-22.6%), respectively (Matsuoka *et al*., 2011). The current abundance of Breeding Stock D is close to that at its pre-exploitation level. Figure 5 shows the abundance trend of this stock in Area IV for the period 1989/90- 2003/04, and compares it with the trend estimated using IDCR/SOWER sighting data (Matsuoka *et al*., 2011). There is a clear increasing trend that is consistent between both the JARPA and the IDCR/SOWER surveys.

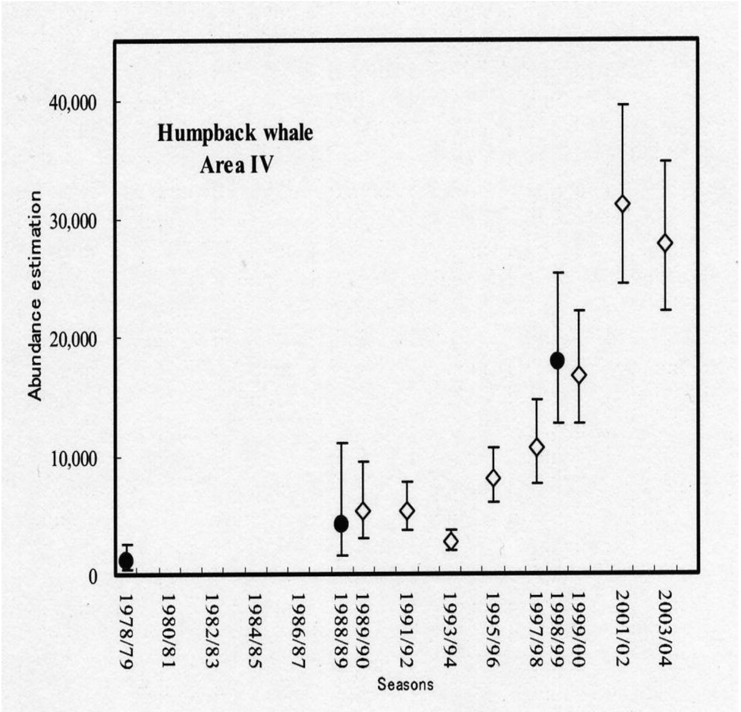

Figure 5. Abundance trend of humpback whale in Antarctic Area IV based on the JARPA sighting data. Black dots are abundance estimates based on the IDCR/SOWER cruises, which are consistent with those from the JARPA (after Matsuoka *et al*, 2011).

The abundance and annual growth rates of fin whales in Areas IIIE+IV and Areas V+VIW were estimated at 6,514 (16.0% CV: 0.78 increase rate) and 5,241 (12.8% CV: 0.60 increase rate) for the period 1989/90-2004/05, respectively (Matsuoka *et al*., 2006). It should be noted that abundance estimates for fin whales were made based on data obtained south of 60°S and therefore the JARPA surveys did not cover the main distribution area of fin whales in the austral summer.

The abundance of the Antarctic blue whales was estimated at 1,700 (95% Bayesian interval 860–2,900) in 1996. Although this figure corresponds to less than 1% of the original levels, blue whales are increasing at 7.3% per annum (95% Bayesian interval 1.4–11.6%) (Branch *et al.*, 2007).

Hakamada *et al.* (*in press*) estimated abundance and abundance trends of Antarctic minke whale in Antarctic Areas IV and V based on the JARPA sighting data, under the assumption of g(0)=1. Abundance estimates for Area IV range from 16,562 (CV=0.542) in 1997/98 to 44,945 (CV=0.338) in 1999/00, while those for Area V range from 74,144 (CV=0.329) in 2004/05 to 151,828 (CV=0.322) in 2002/03. Estimates of the annual rates of increase in abundance are 1.8% with a 95% CI of [-2.5%, 6.0%] for Area IV and 1.9% with a 95% CI of [-3.0%, 6.9%] for Area V. Adjustments to allow for the g(0) being less than 1 were made by the application of a regression model, developed from the results of the Okamura-Kitakado (OK) method estimate of minke whale abundance from the IDCR-SOWER surveys, which provides estimates of g(0) from the statistics of the minke whale school size distribution in a stratum. With this adjustment, abundance estimates increased by an average of 32,333 (106%) for Area IV and 89,245 (86%) for Area V, while the estimates of annual rates of increase and their 95% CIs changed slightly to 2.6% [-1.5%, 6.9%] for Area IV and 1.6 % [-3.4%, 6.7%] for Area V.

In 2012 the IWC SC agreed to a new best abundance estimate for Antarctic minke whale in Antarctic open waters south of 60°S, based on IDCR/SOWER sighting data. The estimates were 720,000 based on the sighting data collected during the CPII (1985/86-1990/91) with 95% CI (512,000, 1,012,000), and 515,000 based on the sighting data collected during the CPIII (1992/93-2003/04) with 95% CI (361,000, 733,000). No significant statistical differences were found between the CPII and CPIII estimates (IWC, 2013b).

By considering the 95% CIs of the estimates it can be suggested that the stocks of Antarctic minke whales are broadly stable with at most a slight decline.

Another way of reflecting the increase in larger whale species is provided by the plots in Figures 6 and 7, which show the temporal changes in whale composition in Areas IV and V, respectively, based on the JARPA and the

JARPA II sighting data. In Area IV, humpback whales are more frequently observed than Antarctic minke whales in recent years (Figure 6). In Area V humpback whales are increasing but Antarctic minke whale is still the predominant species (Figure 7).

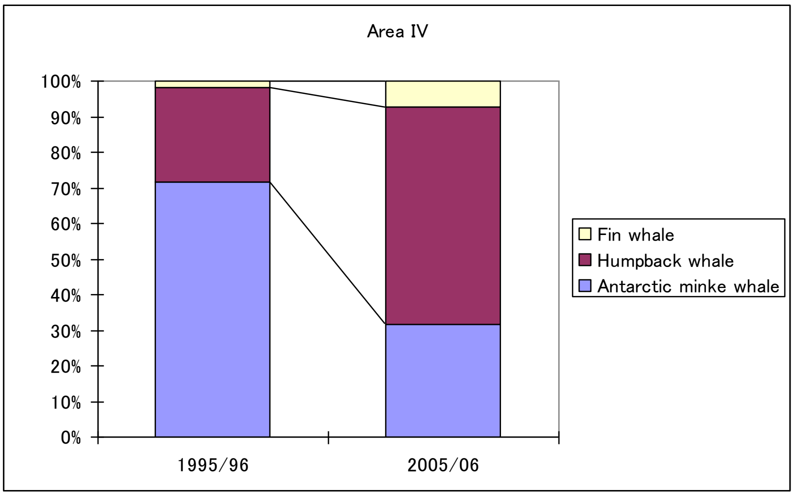

Figure 6. Sighting composition of Antarctic minke, humpback and fin whales in Area IV for two different austral summer seasons, 1995/96 (sighting data from the JARPA) (Nishiwaki *et al*., 1996), and 2005/06 (sighting data from the JARPA II) (Nishiwaki *et al*., 2006). Note that humpback whales are more frequently observed than Antarctic minke whales in recent years.

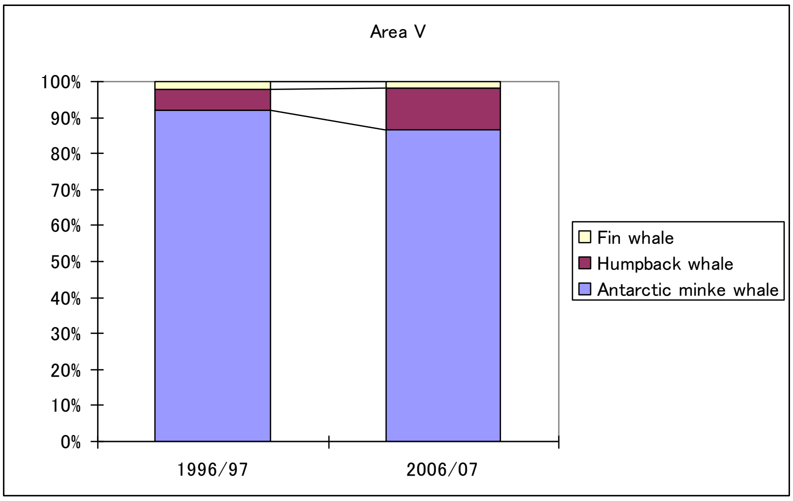

Figure 7. Sighting composition of Antarctic minke, humpback and fin whales in Area V for two different austral summer seasons, 1996/97 (sighting data from the JARPA) (Nishiwaki *et al*., 1997), and 2006/07 (sighting data from the JARPA II) (Nishiwaki *et al*., 2007). Note that Antarctic minke whale is still the predominant species. The composition of humpback whales in the total sighting have increased but at a slower pace compared to Area IV.

Ecological interpretation of the JARPA results

The Antarctic ecosystem is a very dynamic one with changes in species compositions and habitat occurring through the time. The ecological effect of the large-scale exploitation of whales in the first half of the 20^{th} Century has been discussed by several authors, notably by Law (1977; 1985). Exploitation of large whales in the Antarctic Ocean started in 1904. Several species of large whales such as blue and humpback whales were heavily depleted by the first half of the past century (Figure 8). Other species such as the fin and sei whales were depleted during the second half of the 20^{th} Century. Commercial exploitation of the Antarctic minke whale started in the early 70's when all other baleen whale species were already depleted.

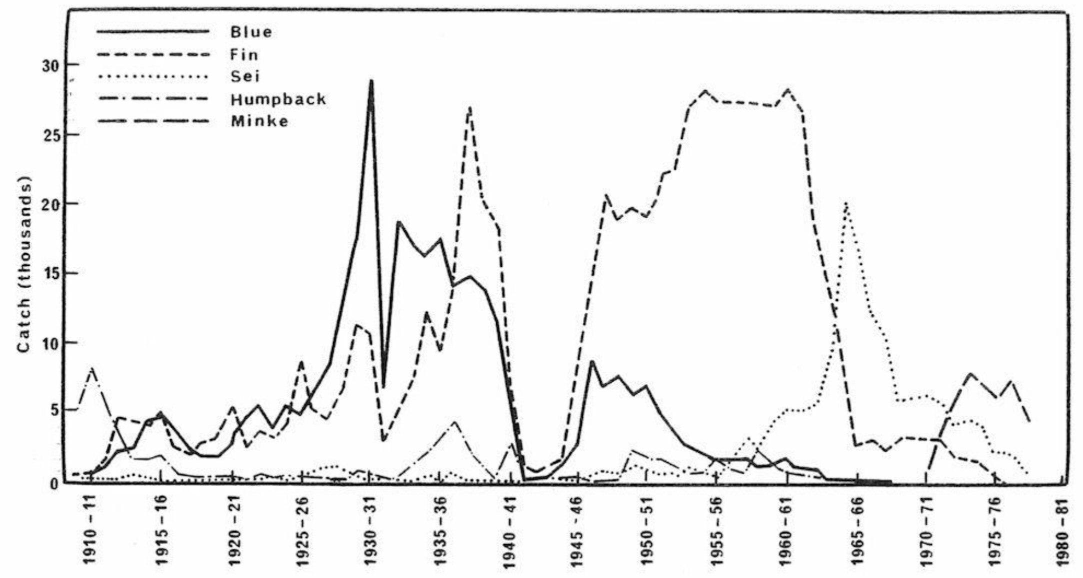

Figure 8. Catches of baleen whales in the southern Hemisphere, 1910-1977 (after Allen, 1980)

The Antarctic krill is a key prey species in the Antarctic ecosystem supporting different species of baleen whales, pinnipeds, birds and fish. Some researchers suggested that following the main exploitation period of large baleen whales in the Antarctic (approximately at the middle of the past century) some 150 million tons of 'surplus' annual production of Antarctic krill became available for other krill predators, such as Antarctic minke whales, crabeater seals, fur seals, penguins and some albatrosses which took advantage of this food surplus to increase their abundance (Figure 9). This is the so-called 'krill surplus hypothesis' (Law, 1977; 1985).

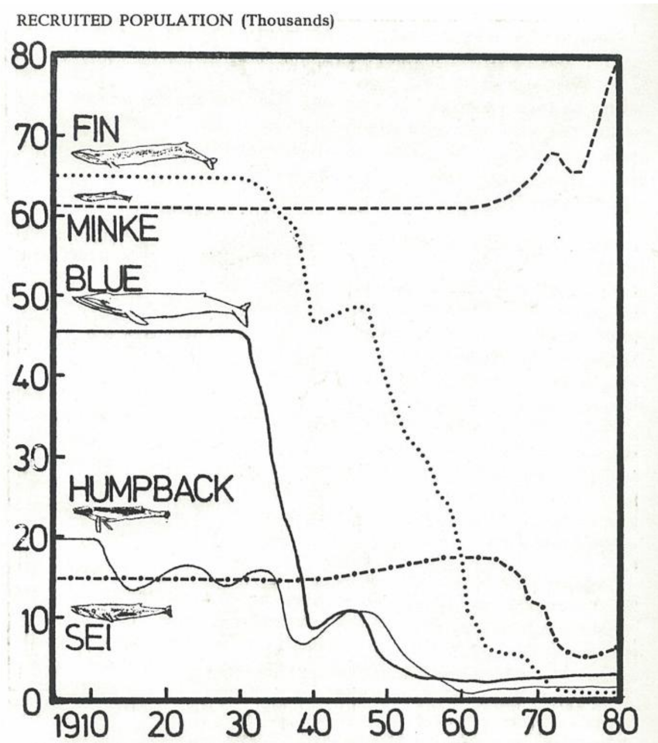

Figure 9. As an effect of commercial exploitation during the first half of the 20th Century most of the large whales in the Antarctic were reduced to a small percentage of their initial abundance. Other non-exploited species in that period, such as the Antarctic minke whale, increased its abundance. This figure shows the yearly trend in the number of recruited whales by baleen whale species (after Beddington and May, 1982).

According to this hypothesis the increased krill availability was translated into better nutritional conditions for some krill predators like the Antarctic minke whale. In the case of this species this resulted in some biological changes such as the observed decreasing trend in the age at sexual maturity between approximately 1940 and 1970 (Figure 2), which coincide with the period of depletion of some key krill-eater large whale species. A low age at sexual maturity favored an increase in the recruitment rate in a similar period (Figures 3 and 9).

The Antarctic minke whale perhaps reached an increased maximum carrying capacity by the late 1960s, and then the stock responded by stabilizing the age at sexual maturity at 7-8 years old (Figure 2). This biological process should have resulted in a continuous high rate of newborns after 1970. However, the recruitment was rather stable after 1970 (Figure 3). The trend in recruitment is consistent with the total abundance of Antarctic minke whale estimated by sighting data which has been broadly stable since the 80's.

Evidence available since the 80's however show that the nutritional conditions for Antarctic minke whales have not been optimal as revealed by the decrease in energy storage and stomach content weight since the 80's. This suggests less availability of krill for Antarctic minke whales. Less availability of krill for this species could result from a) intra-specific competition, b) competition with other recovering krill-eater large whale species, e.g. the reversal of Law's 'krill surplus hypothesis', and/or c) climate changes. The implication of these 'deteriorated' nutritional conditions is the possibility of a decrease of Antarctic minke whale abundance in the near future.

Regarding to a), the so-called 'overshooting' of abundance in the late 1960s might indicate intra-specific competition as other large whale species were still heavily depleted at that time. Regarding to b), commercial whaling of humpback, blue and fin whales in the Antarctic was banned in 1963, 1964 and 1976, respectively. As an effect of these conservation measures, the abundance of these species increased in recent decades as shown above, which points toward a recovery from past commercial exploitation. The speed of recovery varies among these species and among stocks within these species. The increase in the abundance of large whale species that feed on krill in the Antarctic means less food available for species like the Antarctic minke whale that once benefited from the 'surplus' of krill. Regarding to c) krill abundance could be affected by environmental changes. Starting with global warming, large-scale climate changes are appearing in the Antarctic Ocean. For example recent research has indicated that the amount of Antarctic krill in the Southwest Atlantic decreased by 80% compared to their numbers in the 1970's, and the authors attributed this decrease to global warming (Trivelpiece *et al*., 2011). If this association is confirmed, the situation could spread to other regions in the Antarctic in the future.

Section 6 provides an update of the ecological hypothesis, which takes into account the most recent results from the JARPAII research, including an explanation of the apparent inconsistency between age at sexual maturity and recruitment trend after 1970 as noted in the IWC JARPA final review in 2006 (IWC, 2008b).

Strength of the analyses

The individual analyses on temporal changes in the age at sexual maturity based on transition phase data (Zenitani and Kato, 2006; Mori *et al*., 2006b); temporal changes in recruitment based on ADAPT VPA analyses (Mori *et al*., 2006a), food habit and consumption (Tamura and Konishi, 2006), temporal changes in energy storage based on analyses of blubber thickness (Konishi *et al*., 2006), abundance and abundance trend of Antarctic minke whales (Hakamada *et al*., 2006), and abundance and abundance trend of humpback, fin and blue whales (Matsuoka *et al*., 2006), were originally presented to the IWC JARPA Final Review (IWC, 2008b). As mentioned earlier an ecological interpretation of the changes observed in the Antarctic minke whale and its environment was presented to that review meeting by Fujise *et al*. (2006) (updated in the previous section). The validity of such interpretation depends on the strength and robustness of the analyses of each biological and ecological parameter examined.

The IWC JARPA Final Review provided several useful recommendations on how to improve each of the analyses, and a list of those recommendations was published in IWC (2008a). That list and the status of the work in response to the recommendations are shown in Annex 4. Those recommendations are also valid for some of the analyses conducted under the JARPA II (see Section 4).

The catch-at-age analyses such as ADAPT VPA and Statistical Catch at Age Analysis (SCAA) have been carried out not only by Japanese scientists but also by the IWC SC which has supported and funded these analyses for Antarctic minke whales through a specific group of scientists for at least the last ten years. Many recommendations to improve the model have been provided by the IWC SC through the years.

Key information for the VPA and SCAA analyses is age (provided by the JARPA/JARPAII and past commercial whaling) and abundance (provided by the JARPA/JARPAII and the IDCR/SOWER) data. One of the important recommendations from the IWC JARPA Final Review was the investigation of the comparability of commercial and the JARPA age data by re-reading a sub-set of the commercial samples in an appropriately designed blind test (IWC, 2008b; Annex 4). This task was carried out by Zenitani *et al*. (2007) and Lockyer (2010). Based on the latter study the IWC SC agreed in 2010 'that no further experiments or analyses on age reading are needed to resolve ageing related problems raised in e.g. the JARPA review' (IWC, 2011). Furthermore based on new analyses presented in 2011 the IWC SC 'agreed that the SCAA development phase is now complete (it has resolved the issues related to: (a) apparent differences between growth rates estimated from the JARPA and commercial data sets; and (b) the consistency of age readings amongst readers….' (IWC, 2012b). The newest SCAA analyses based on age and abundance data from the JARPA/JARPAII was presented to the IWC SC in 2013 (Punt *et al*., 2013- ForInfo1) (see Section 4). Given the detailed analyses conducted the estimates of recruitment trends based on the SCAA are considered reliable.

There has been some discussion at the IWC SC on the validity of the transition phase as indicator of the age at sexual maturity. This was addressed in detail in a published paper by Thomson *et al*. (1999) who concluded that the declining trend in this biological index between approximately 1940 and 1970 had been real. The 1997 IWC Mid-Term JARPA Review had reached a similar conclusion (IWC, 1998a).

Regarding the blubber thickness and stomach content weight trend analyses based on the JARPA data, the IWC JARPA Final Review provided several technical suggestions to improve those analyses (IWC, 2008b; Annex 4). Regarding the blubber thickness trend analyses the IWC JARPA Final Review suggested the inclusion of other factors in the analysis such as age, latitude, distance from the ice-edge and non-linearity in trends (IWC, 2008b; Annex 4). Most of these factors were incorporated into the analyses and the declining trend in blubber thickness was confirmed and published (Konishi *et al*., 2008). Subsequently additional analyses were conducted e.g. Skaug (2012) and the same results of a declining trend were obtained. Despite this the IWC SC has not reached a conclusion, and recommended more analyses (IWC, 2012c; 2013c). The latest results, which include implementation of those recommendations, are presented in SC/F14/J13 (see Section 4).

Regarding the stomach content weight analyses the JARPA Final Review suggested the use of GLM or similar methods to examine trend, incorporating covariates such as age, size and reproductive status of whales as well as the date and time of day. In response, a document was prepared and presented to the 2007 IWC SC meeting (Tamura and Konishi, 2007) and by Konishi *et al*. (2012). These additional analyses confirmed the declining trend in stomach content weight. Despite this, the IWC SC has not reached a conclusion on this, and recommended additional analyses (IWC, 2013c). Results of these analyses, which include implementation of those recommendations, are presented in Konishi *et al*. (in press- SC/F14/J14) (see Section 4).

Given the extensive data set and detailed statistical analyses conducted in response to IWC SC recommendations, the declining yearly trend in stomach content weight and blubber thickness are considered real.

Regarding the abundance estimates of humpback and Antarctic minke whales, the IWC JARPA Final Review (as well as other IWC SC meetings) provided a long list of suggestions to improve the analyses (IWC, 2008b; Annex 4). Most of those suggestions were incorporated into new analyses and the results were published by Matsuoka *et al*. (2011) for humpback whale and Hakamada *et al*. (in press) for Antarctic minke whale. Therefore estimates of abundance and abundance trend are considered reliable. Abundance estimates for fin whales have not been published yet. As noted earlier, the JARPA/JARPAII sighting surveys do not cover the main distribution area of this species in summer, which is located north of 60°S.

The results and interpretation summarized above are the background for the Objectives 1 and 2 of the JARPA II.

Ecological objectives of the JARPA II
Objective 1: Monitoring the Antarctic ecosystem

The pattern of changes in the Antarctic minke whale and its environment found by the JARPA research, including the changes observed in the abundance of other large whale species, is consistent with the hypothesis of a recent major shift in the Antarctic ecosystem (Fujise *et al*., 2006). These changes are monitored under Objective 1 of the JARPA II.

Aim:
The aim of the JARPAII under the first objective is the monitoring of temporal trend of several parameters examined during the JARPA research, which are considered as 'indicators' of changes in the ecosystem:

- Whale abundance based on sighting data;

- Is the abundance of blue, humpback and fin whales increasing in the JARPA+JARPAII period?
- Is the abundance of Antarctic minke whale still maintaining a stable trend at high levels in the JARPA+JARPAII period?

• Whale distribution based on sighting data;

- How the increase in abundance of humpback whale, particularly in Area IV, is affecting the distribution of other whale species, particularly the Antarctic minke whales?

• Age at sexual maturity and pregnancy rate based on age and reproductive data;

- Is the age at sexual maturity of Antarctic minke whale maintaining a stable trend or has it increased in the more recent cohorts in response to deteriorated nutritional conditions?
- Is the pregnancy rate of Antarctic minke whale maintaining a stable trend at high level or has it decreased in the JARPA+JARPAII period in response to deteriorated nutritional conditions?

• Recruitment rate based on age and abundance data;

- Is the recruitment rate still maintinaing a stable trend at lower level (in comparison with those in the 60's-70's cohorts)?

• Body condition based on blubber thickness data;

- Is the blubber thickness declining in the JARPA+JARPAII period?

• Stomach content weight;

- Is the stomach content weight declining in the JARPA+JARPAII period?

• Contaminant load based on mercury and PCB data;

- What is the pattern of temporal trend of pollutant levels in Antarctic whale samples?
- What is the accumulation mechanism of pollutants in the Antarctic ecosystem?

• Oceanography based on temperature and salinity profiles;

- How have the oceanographic conditions changed through the JARPA/JARPAII period?

Responses to the questions above will assist in the interpretation or refinement of the ecological hypothesis derived from the JARPA research.

For the reason given in Annex 6, no humpback whales were sampled in the first period of the JARPAII, and the number of fin whales sampled in this period was too low to allow for temporal trend analyses in biological and ecological parameters in this species. Furthermore the target sample size of 850 whales for the Antarctic minke whale was reached only in the 2005/06 season for the reasons given in Annex 6. For this reason the analyses of yearly changes in biological and ecological parameters under this objective was possible only for the Antarctic minke whale, and these analyses combined both the JARPA and the JARPAII data.

Although the number of samples of fin whales sampled was not large enough for estimating yearly trend in biological parameters, information in several fields (biological parameters, feeding ecology, pollutants level and genetics) was obtained from 16 fin whales sampled in the JARPAII (see Annex 1 and Section 4). Such information is considered useful because of the scarcity of new biological information from this species in the Antarctic. The only previous information is from the time of the commercial whaling, which was banned in 1976. Furthermore the documented information can be used in future analyses of larger data sets.

Yearly trend analysis under this objective was not possible for krill biomass because comprehensive data were possible only for two seasons, and surveys were not conducted since 2009/10 (see Annex 6). Comparability with the information obtained during the JARPA was problematic because of the differences in analytical procedure between the two surveys.

Yearly trend analysis under this objective was not possible for pollutant load (see reasons in Annex 6) although the levels found for some pollutants in the JARPAII period were compared with those found in the JARPA period (see Section 4).

Objective 2: Modelling competition among whale species

As explained above in recent years large whale species have shown signs of recovery and are increasing their abundance. As a consequence krill became less available for species like the Antarctic minke whale that once benefitted from the krill surplus in mid of the 20th Century. As shown above there are evidences of deteriorated nutritional conditions for the Antarctic minke whale possibly as an effect of interspecific competition for krill. Alternatively less availability of krill in the Antarctic minke whale could be an effect of environmental changes.

Aim:
The aim of the JARPAII under the second objective is to develop models for the competition among whale species. The key question for the modeling exercise is whether the predators-prey interaction alone can explain the observed population trends of whale species (and the biological effects observed in the Antarctic minke whale) in recent decades without the need for recourse to environmental change hypotheses.

It should be noted that the development of the model is just a first step. The establishment of new management objectives or goals will be considered when the model of competition among whale species has been developed to a certain extent. Then the final, long-term goal of the modeling exercise is to assist in the development of management policy based on ecosystem considerations.

Some input data for the ecosystem model development were from the JARPA/JARPAII research e.g. stomach content of Antarctic minke whale, biomass of krill and abundance of large whale species. Other information was obtained from the literature.

As explained above no humpback and only a limited number of fin whales were sampled during the first period of the JARPAII (see Annex 6). At this stage data that the JARPAII collected from these two species by non-lethal methods, e.g. abundance and abundance trends from sighting data were used for the development of ecosystem models (see discussion on the relevance of biological data from humpback and fin whales for the ecosystem model in Section 6).

Development of the 'management' objectives of JARPA II (Objectives 3 and 4) based on the results of the JARPA research

When we are referring to current management of whales we are referring to the RMP, a single-species management procedure adopted by the IWC in 1994 to calculate a catch limit of baleen whales for commercial whaling. The full RMP process is composed of three steps – (i) *Pre-Implementation Assessment*, (ii) RMP *Implementation* process (including the *Implementation Simulation Trials- ISTs*), and (iii) Application of the Catch Limit Algorithm (CLA) based on the recommendations derived from step ii) (IWC, 2012d). The CLA can be used only after steps (i) and (ii) are successfully completed.

At the *pre-implementation assessment*, the IWC SC reviews all the available scientific data for (i) the establishment of plausible stock structure hypotheses consistent with the data, (ii) examination of available abundance estimates, and (iii) information on the geographical and temporal nature of 'likely' whaling operations. On the basis of this assessment, the IWC SC will make a recommendation as to whether or not to formally begin the RMP *Implementation*.

At the RMP *Implementation* step, the *ISTs* are conducted to guarantee the performance of the RMP prior to the actual application of the CLA to calculate a commercial catch limit. The main purpose of the *ISTs*, which are specific to species/areas, is to assure a sustainable exploitation of whale resources by avoiding unintended depletion of individual stocks. A large number of computer simulations are conducted checking different variants of the RMP against various hypotheses and assumptions. For instance, if there are three stock structure hypotheses, three estimated past catch scenarios, and two estimates of MSYR (e.g. 1% and 4%), then different RMP variants will be tested against18 simulation scenarios (three times three times two). The results of the *ISTs* will be assessed in detail and only RMP variants which show successful performance will survive the process and be considered for implementation..

On the basis of the results of the *ISTs* the IWC SC can make a recommendation to the IWC for applying certain RMP variants provided additional research is undertaken.

The 'Requirements and Guidelines for Implementations under the Revised Management Procedure' (IWC, 2012d) specify the kind of data required in each of the steps of the current RMP process. Key information used in one or more of the RMP process steps are stock structure, MSYR and abundance estimates, and the JARPA has already provided such information.

The analyses of genetic and morphometric data obtained under the JARPA suggested the occurrence of at least two stocks in the JARPA research area, which for practical reasons are called 'Eastern Indian Ocean Stock' (I-Stock) and 'Western South Pacific Stock' (P-Stock). The data do not support the current IWC Management Areas. The data also suggested an area of transition in the region around 150-165°E across which there is an as yet undetermined level and range of mixing (Figure 10) (IWC, 2008b).

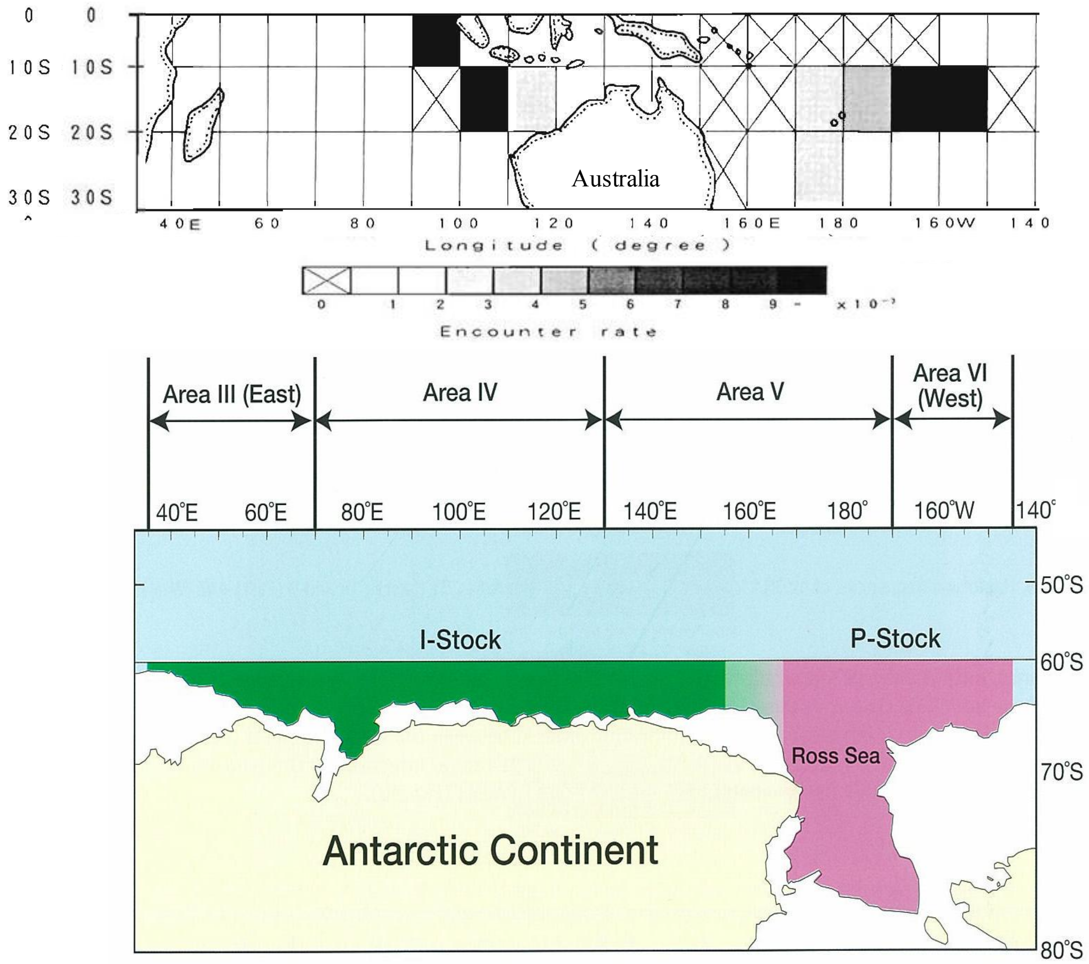

Figure 10. Stock structure hypothesis of the Antarctic minke whale based on genetic and non-genetic data from the JARPA (Pastene, 2006; IWC, 2008b). The upper figure shows the encounter rates of whales in 10° squares of latitude and longitude in waters 0º-30ºS in October (from Kasamatsu *et al*., 1995).

Abundance estimates in Areas IV and V were conducted based on the JARPA sighting surveys (Hakamada *et al*, in press). ADAPT-VPA analyses based on age and abundance data from the JARPA suggested *MSYR(1+)* values in the 4-6% range for Antarctic minke whale (Mori *et al*., 2006a).

All this information, which is important for effective management under the RMP, is refined under the JARPAII in the context of the current RMP process as well in the context of the future improvement of the RMP. At the current RMP process, particularly at the *pre-implementation assessment* and *ISTs*, information on plausible stock structure hypotheses and mixing, MSYR and abundance is fundamental. The JARPAII will provide more details about yearly changes in the longitudinal extent of the mixing area and stocks mixing proportions. SCAA models have been refined following several suggestions from IWC SC meetings. The refinement of the model and the addition of new age and abundance information from the JARPAII should allow for more robust estimations of biological parameters such as the MSYR. Such information will contribute to reduce the hypotheses on stocks structure and MSYR used in future *ISTs* for this species in the Antarctic.

Regarding improvement of the RMP itself the JARPAII can provide better estimation of MSYR for the CLA itself, as explained above. One of the deficiencies of the current RMP is the zero catch quota that it turns out when carrying capacity declines due to competition among whale species. The decrease in abundance caused by the competition is misinterpreted by the current RMP as over-exploitation so that catches are set unnecessarily low. That part needs to be improved by the use of more realistic multi-species models and the JARPAII, through its work under Objective 2, can contribute to that aim.

Management objectives of JARPA II
<u>Objective 3: Elucidation of temporal and spatial changes in stock structure</u>

As informed above the analyses of genetic and morphometric data under the JARPA suggested the occurrence of at least two stocks of the Antarctic minke whale in the JARPA research area. The data also suggest an area of transition in the region around 150-165ºE across which there is an as yet undetermined level and range of mixing.

<u>Aim</u>:
The aim of the JARPAII under this objective is first to update the analyses on stock structure of Antarctic minke whale in the context of the suggested hypothesis, by using new genetics information obtained in the JARPAII, and then to estimate the mixing proportion of the I and P Stocks in the transition region, including possible yearly fluctuation in distribution and mixing proportion. The geographical overlap between the I and P Stocks under the JARPA II is examined in a wider sector than that suggested in the IWC JARPA Final Review (IWC, 2008b): 130°-175°E (see Figure 11 and details in Annex 5).

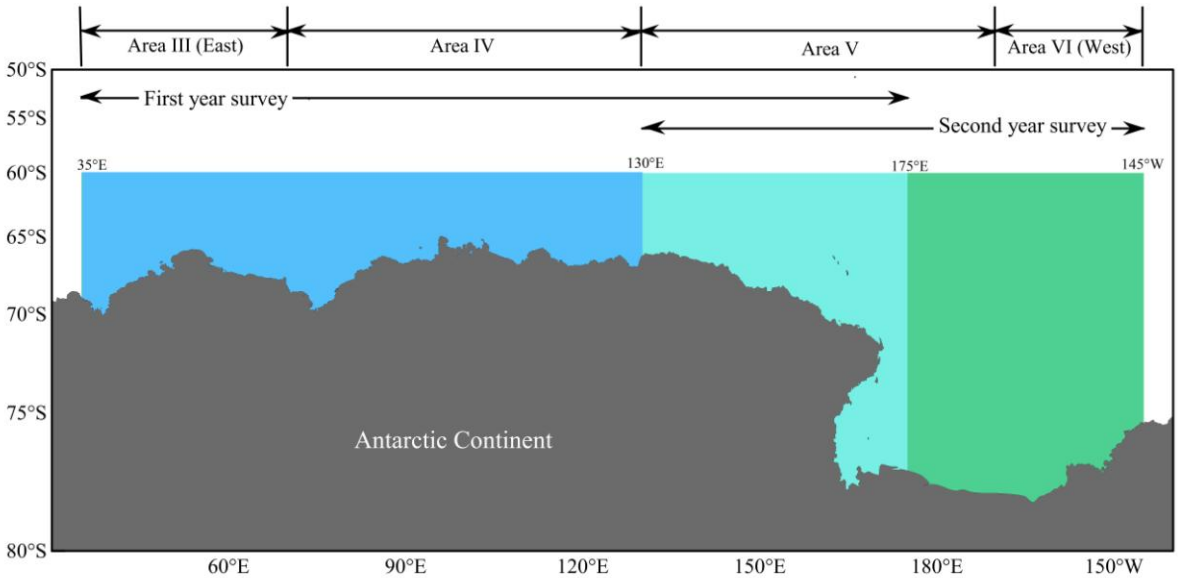

Figure 11. Research area of the JARPAII indicating the wider transition area between 130º and 175ºE (see details in Annex 5). The transition area was planned to be covered every year in order to investigate the yearly change in mixing proportion of two Antarctic minke whale stocks. Figure made using Ocean Data View (Schlitzer, 2013).

It should be noted that for the reasons given in Annex 6 not all genetic samples collected during the JARPAII were available for the analyses.

Some of the scientific questions on Antarctic minke whales under Objective 3 are the following:

- Are the additional genetics analyses based on JARPAII data consistent with the current stock structure hypothesis?
- Is the longitudinal range of the transition area the same as that proposed under the JARPA?

- Has the distribution and mixing proportion of I and P Stocks remained constant in the transition area through the years, or has it changed by year?
- What is the biological validity of the management Areas of the IWC?

Also under this objective, analyses of genetic samples of other large whale species such as the fin, humpback and southern right whales is examined to understand the pattern of distribution and population genetic structure of these species in the feeding grounds, and the phylogenetic relationship with populations from other ocean basins (southern right whales).

<u>Objective 4: Improving the management procedure for Antarctic minke whale stocks under the RMP</u>

The goals under this objective will be covered with progress of the work under the other three objectives. This objective is divided into two parts, a) contribution to the implementation of the current RMP through the attainment of key information such as abundance, stock structure and MSYR, and b) contribution to the future improvement of the RMP through the incorporation of a more realistic (and possibly species-specific) MSYR range into the RMP algorithm, and the incorporation of the effects arising from the inter-species relationships among whale species.

For a) above abundance and MSYR (through SCAA analyses) will be obtained under Objective 1) while the redefinition of Management Areas and mixing will follow results on stock structure under the Objective 3). For b) above, MSYR (through VPA and SCAA analysis) will be obtained under Objective 1) and the incorporation of the effects arising from the inter-species relationships among whales species will be examined after the development of the ecosystem model has been completed under Objective 2.

Figure 12 shows the interaction among the four objectives of the JARPAII.

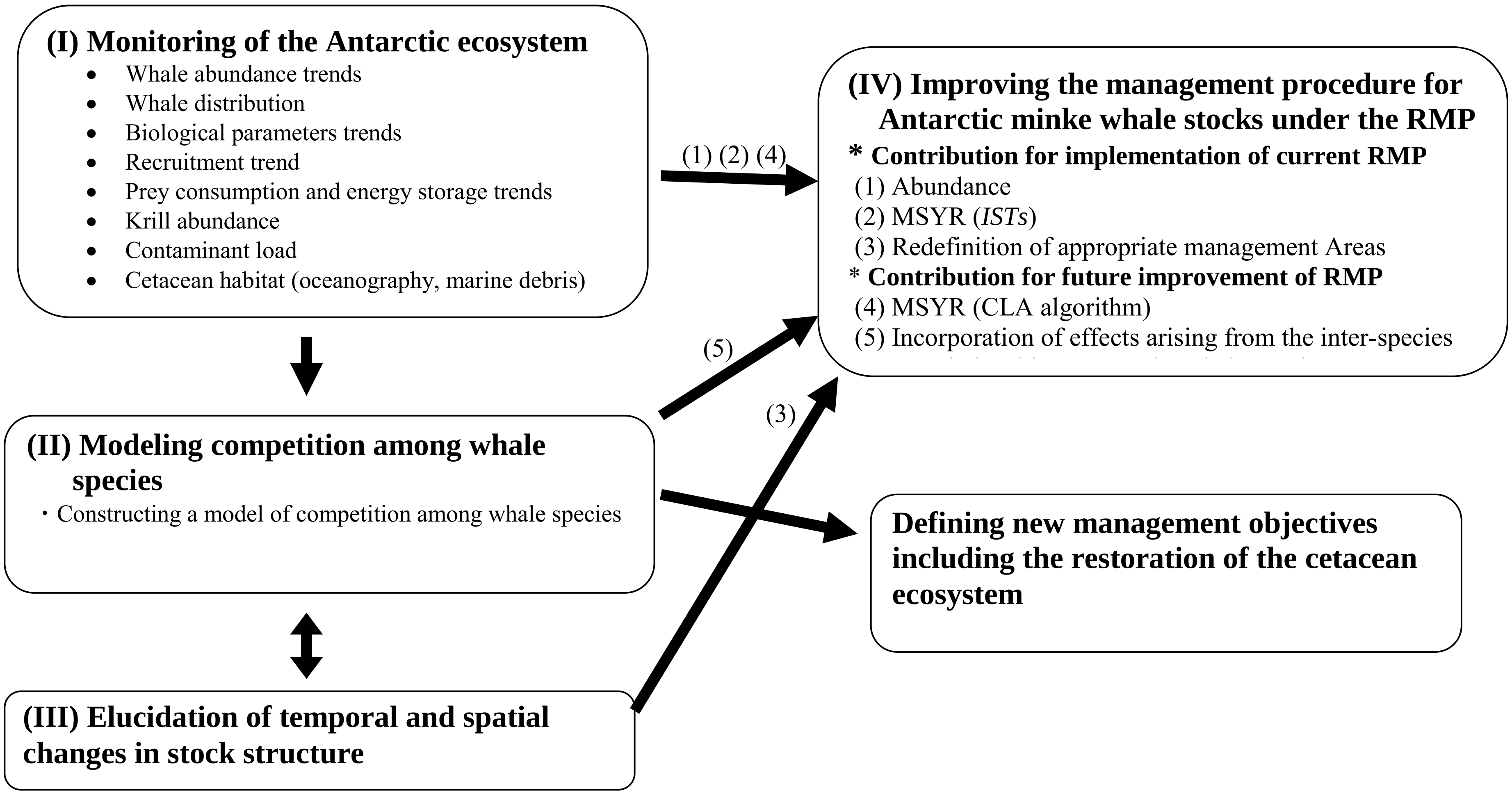

Figure 12. Objectives of the JARPA II. Several parameters considered 'indicators' of change in the ecosystem are studied and monitored under Objective 1. The modeling exercise under Objective 2 aims to provide interpretations to the pattern of changes observed under Objective 1: can these changes be explained only by the prey-predators interaction without the need for recourse to environmental change hypotheses? Objective IV depends on the results obtained under the other objectives: stock structure of Antarctic minke whale under Objective III; abundance, MSYR and natural mortality of Antarctic minke whale under Objective 1.

4. PROGRESS IN THE JARPAII RESEARCH

The samples and data obtained during the first six-year period (2005/06 – 2010/11) of the JARPAII are shown in Annex 2. An outline of the research area, target species, sample sizes and general methodology is given in Annex 5. Results of the JARPAII in the first period are presented in this section, by research objective/topics. Most of the analyses took into consideration the previous recommendations from the IWC SC (Annex 4).

Note: Throughout this document, 'significant' means statistically significant at the 5% level.

Monitoring of the Antarctic ecosystem

Abundance

SC/F14/J3 estimated abundance and abundance trend of Antarctic minke whale based on sighting data collected by the JARPA and the JARPAII (1989/90-2008/09 seasons). These analyses addressed most of the previous recommendations from the JARPA review workshop in 2006 (see recommendations Abundance 1-12 in Annex 4). Abundance estimates were based on the standard line transect method using the program DISTANCE under the assumption of g(0)=1. The annual rates of increase were estimated using log-linear models. Model error was taken into consideration in the estimates. Abundance estimates in Area IIIE ranged from 4,478 (CV=0.911) to 48,540 (CV=0.711). Those in Area IV ranged from 15,088 (CV=0.645) to 63,794 (CV=0.509) while those in Area V ranged from 67,661 (CV=0.308) to 151,072 (CV=0.326). Those in Area VIW ranged from 8,434 (CV=0.601) to 27,790 (CV=0.507). Estimates of annual rates of increase were 1.1% (95% CI: -2.3, 4.5%) for Areas IIIE+IV and 0.6% (95% CI -2.2%, 3.3%) for Areas V+VIW. Adjustments to allow for g(0) being less than 1 were made by the application of a regression model developed from the results of the Okamura-Kitakado (OK) method estimate of Antarctic minke whale abundance from IDCR-SOWER surveys, which provides estimates of g(0) from the statistics of the minke whale school size distribution in a stratum. With this adjustment, abundance estimates increased by an average of 88.0% for Area IV and 109.0% for Area V. The annual rates of increase changed to 2.5% (95%CI -1.3, 6.3%) for Area IIIE+IV and -0.6% (95%CI -3.9, 2.6%) for Area V+VIW.

SC/F14/J4 estimated abundance and abundance trend of humpback whale based on sighting data collected by the JARPA and the JARPAII (1989/90-2008-09 seasons). These analyses addressed most of the previous recommendations from the JARPA final review workshop in 2006 (see recommendations Abundance 1-13 in Annex 4). Abundance estimates were based on the standard line transect method using the program DISTANCE under the assumption of g(0)=1. The annual rates of increase were estimated using log-linear models. Results:

Season	Area IIIE		Area IV		Season	Area V		Area VIW	
	Abun.	CV	Abun.	CV		Abun.	CV	Abun.	CV
1989/90	-	-	5,325	0.302	1990/91	602	0.343	-	-
1991/92	-	-	5,408	0.188	1992/93	4,388	0.623	-	-
1993/94	-	-	2,747	0.153	1994/95	3,678	0.307	-	-
1995/96	1,378	0.190	8,066	0.142	1996/97	1,474	0.274	1,493	0.185
1997/98	671	0.360	10,657	0.166	1998/99	3,831	0.430	171	0.721
1999/00	12,081	0.130	16,751	0.143	2000/01	5,128	0.215	2,440	0.196
2001/02	4,791	0.200	31,134	0.123	2002/03	2,873	0.157	1,614	0.235
2003/04	8,045	0.100	27,783	0.115	2004/05	9,342	0.337	2,237	0.353
2005/06	13,874	0.387	25,958	0.263	2006/07	16,438	0.266	2,136	0.437
2007/08	11,904	0.261	29,067	0.255	2008/09	13,894	0.338	3,609	0.322

Estimates of annual rates of increase in Areas IIIE, IV, V and VIW are 20.8% (95% CI: 4.1, 37.6%), 13.6% (95% CI 8.4, 18.7%), 14.5% (95% CI 7.6, 21.5%) and 6.2% (95% CI -0.9, 13.4%), respectively. Except for Area VIW all the trend estimates were statistically significant.

SC/F14/J5 estimated abundance and abundance trends of blue, fin and southern right whales based on sighting data collected by JARPA and JARPAII (1989/90-2008/09). The estimates are calculated by standard line transect analysis methods using the program DISTANCE under the assumption that *g*(0)=1. The annual rates of increase were estimated using regression model. Results:

Blue whale

Season	Area IIIE		Area IV		Season	Area V		Area VIW	
	Abun.	CV	Abun.	CV		Abun.	CV	Abun.	CV
1989/90	-	-	65	0.481	1990/91	183	1.010	-	-
1991/92	-	-	18	1.078	1992/93	257	0.639	-	-
1993/94	-	-	66	0.615	1994/95	270	0.633	-	-
1995/96	192	0.430	8	0.934	1996/97	10	0.749	90	0.447
1997/98	234	0.480	145	0.604	1998/99	206	2.147	-	-
1999/00	546	0.580	225	0.385	2000/01	317	0.498	-	-
2001/02	80	0.620	300	0.460	2002/03	143	0.526	28	0.932
2003/04	546	0.340	78	0.734	2004/05	489	0.746	152	0.377
2005/06	354	0.506	196	0.527	2006/07	30	0.987	84	1.458
2007/08	551	0.559	242	0.560	2008/09	392	0.460	38	1.623

Abundance trend estimate for blue whales was 8.2% (95% CI 3.9%, 12.5%) for Areas IIIE+IV+V+VIW. The trend estimate was statistically significant.

Fin whales

Season	Areas IIIE+IV		Season	Areas V+VIW	
	Abun.	CV		Abun.	CV
1995/96	3,087	0.191	1996/97	1,879	0.226
1997/98	698	0.307	1998/99	4,423	0.379
1999/00	6,764	0.240	2000/01	6,392	0.211
2001/02	9,250	0.266	2002/03	3,705	0.285
2003/04	6,514	0.261	2004/05	5,241	0.381
2005/06	11,190	0.216	2006/07	6,298	0.628
2007/08	2,610	0.285	2008/09	14,981	0.298

Abundance trend estimate for fin whales were 8.9% (95% CI -14.5, 32.4%) and 12.0% (95% CI 2.6, 21.5%) in Areas IIIE+IV and Areas V+VIW, respectively. The latter estimate was statistically significant.

Southern right whales

Season	Area IV	
	Abun.	CV
1989/90	42	1.305
1991/92	201	0.485
1993/94	161	0.437
1995/96	165	0.463
1997/98	356	0.343
1999/00	34	0.775
2001/02	28	1.011
2003/04	6	0.761
2005/06	912	0.314
2007/08	1,557	0.282

Abundance trend estimate for southern right whales was 5.9% (95% CI -16.4, 28.1%) in Area IV. This trend estimate was not statistically significant.

SC/F14/J6 estimated abundance and abundance trends of sperm, southern bottlenose and killer whales based on sighting data collected by JARPA and JARPAII (1989/90-2008/09). The estimates are calculated by standard line transect analysis methods using the program DISTANCE under the assumption that $g(0)=1$. The annual rates of increase were estimated using regression model. Results:

Sperm whales

Season	Area IIIE		Area IV		Season	Area V		Area VIW	
	Abun.	CV	Abun.	CV		Abun.	CV	Abun.	CV
1989/90	-	-	4,115	0.255	1990/91	2,190	0.254	-	
1991/92	-	-	3,303	0.131	1992/93	1,729	0.208	-	
1993/94	-	-	3,061	0.115	1994/95	1,973	0.173	-	
1995/96	1,183	0.197	2,584	0.150	1996/97	1,206	0.163	498	0.215
1997/98	1,496	0.258	2,331	0.195	1998/99	2,171	0.315	101	1.008
1999/00	1,819	0.208	2,751	0.202	2000/01	1,187	0.212	560	0.286
2001/02	2,314	0.199	2,867	0.187	2002/03	1,691	0.196	402	0.249
2003/04	2,195	0.211	1,361	0.192	2004/05	1,860	0.214	737	0.214
2005/06	1,911	0.243	2,068	0.276	2006/07	598	0.509	554	0.369
2007/08	1,387	0.261	3,621	0.325	2008/09	1,195	0.216	505	0.344

Abundance trend estimate for sperm whales were 2.1% (95% CI -4.1, 8.2%), -2.4%, (95% CI -6.2, 1.3%) -3.9% (95% CI -8.2, 0.5%) and 6.6% (95% CI -9.0, 22.3%) in Areas IIIE, IV, V and VIW, respectively, which were not statistically significant.

Southern bottlenose whale

Season	Area IIIE		Area IV		Season	Area V		Area VIW	
	Abun.	CV	Abun.	CV		Abun.	CV	Abun.	CV
1989/90	-	-	1,159	0.340	1990/91	1,272	0.298	-	-
1991/92	-	-	1,082	0.266	1992/93	893	0.447	-	-
1993/94	-	-	4,035	0.147	1994/95	5,129	0.251	-	-
1995/96	1,454	0.273	6,818	0.118	1996/97	4,184	0.201	1,515	0.278
1997/98	4,044	0.150	10,497	0.188	1998/99	2,460	0.377	1,728	0.407
1999/00	7,364	0.383	7,974	0.186	2000/01	5,003	0.199	908	0.396
2001/02	6,732	0.238	6,328	0.151	2002/03	6,729	0.269	2,681	0.233
2003/04	3,928	0.219	6,072	0.185	2004/05	4,764	0.204	1,685	0.261
2005/06	866	0.569	11,828	0.266	2006/07	4,549	0.299	2,663	0.404
2007/08	3,591	0.263	6,967	0.208	2008/09	4,980	0.2227	1,094	0.599

Abundance trend estimate for southern bottlenose whales were -1.8% (95% CI -22.5, 19.0%), 10.4% (95% CI 3.0, 17.9%), 7.7% (95% CI 1.3, 14.2%) and 0.9% (95% CI -9.9, 11.7%) in Areas IIIE, IV, V and VIW, respectively. The increasing trend in Areas IV and V were statistically significant.

Killer whales

Season	Area IIIE		Area IV		Season	Area V		Area VIW	
	Abun.	CV	Abun.	CV		Abun.	CV	Abun.	CV
1989/90	-	-	7,432	0.263	1990/91	12,195	0.250	-	-
1991/92	-	-	7,717	0.219	1992/93	15,447	0.206	-	-
1993/94	-	-	7,132	0.181	1994/95	9,606	0.268	-	-
1995/96	1,881	0.360	11,786	0.248	1996/97	9,812	0.222	943	0.593
1997/98	1,232	0.413	10,161	0.205	1998/99	12,303	0.254	-	-
1999/00	1,239	0.501	10,678	0.219	2000/01	13,055	0.229	1,413	0.553
2001/02	524	1.036	9,009	0.206	2002/03	13,821	0.188	4,066	0.350
2003/04	2,268	0.415	14,374	0.185	2004/05	18,867	0.277	1,574	0.428
2005/06	6,300	1.157	8,737	0.362	2006/07	7,185	0.356	2,827	0.807
2007/08	2,470	0.872	2,268	0.489	2008/09	9,044	0.606	1,312	0.735

Abundance trend estimate for killer whales were 11.2% (95% CI -10.4, 32.9%), -2.2% (95% CI -9.5, 5.2%), -1.1% (95% CI -4.9, 2.7%) and 3.8% (95% CI -12.1, 19.7%), in Areas IIIE, IV, V and VI, respectively, which were not statistically significant.

SC/F14/J7 used a mark-recapture method with paternity analysis based on microsatellite DNA data from the JARPA and JARPAII samples of Antarctic minke whales to estimate their stock size and movement pattern. Throughout the paternity analysis, genotypic data of maximum 12 microsatellite DNA loci examined from 137 fetuses that were collected from the pregnant females captured during the 2003/04 JARPA were used to look for their potential fathers among 1,779 males collected from the 2001/02 JARPA to 2010/11 JARPAII. One case of matching among the fetus-mother-father trio was found. The assigned father's body length was 8.66m and the estimated age 12 years old. This matching was used to conduct preliminary estimate the mature male abundance of the I stock using Petersen mark-recapture method modified by Chapman.

Biological parameters

SC/F14/J8 examined yearly trend of age at sexual maturity in the Antarctic minke whale based on Transition Phase (TP) in earplugs collected by the JARPA (1987/88-2004/05) and the JARPAII (2005/06-2010/11). Analysis was conducted for both sexes and for two stocks (I and P) separated at 165ºE. TP of the JARPA samples were read by two readers (reader-K and reader-Z) and by a new reader (reader-B) in the case of the JARPAII samples. Truncation bias was corrected by standard procedures. Yearly trend of mean age at sexual maturity derived from two reader groups were consistent. The results confirmed that the age at sexual maturity of both stocks declined from the mid 1940s cohorts at around 10-12 years old to the early 1970s cohorts at around 7-8 years old, presumably as response to improved nutritional conditions at that time. Age at sexual maturity remained constant at 7-8 years old till the 1990s cohorts. Statistical analysis to investigate trend from the 1970s cohorts showed slight but statistically significant increasing trend for the I stock (both sexes) and P stock (females). The level of current changes in response to deteriorated conditions is not the same as the decreasing trend level observed from the 1940's cohorts in response to improved nutritional conditions at that time.

SC/F14/J9 examined yearly trend of the proportion of pregnant whales in the matured female population (PPF) of Antarctic minke whales based on samples collected by the JARPA (1987/88-2010/11) and the JARPAII (2005/06-2010/11) surveys. Linear and logistic regression analyses were conducted to estimate yearly trend in this biological parameter for I-stock and P-stock, separated at 165ºE. PPF has remained at a high level throughout the period. No significant yearly trend was detected in either stock during the JARPAII period. A significant increasing trend was observed in the JARPA and JARPA+JARPAII period analyses for the P stock by the logistic regression analysis. The latter result was influenced by just two lower pregnancy values in the 1990/91 and 1994/95 seasons, respectively.

SC/F14/J10 presented new biological information of 16 Antarctic fin whales collected by JARPAII in the first period (2005/06-2010/11). New information on body proportion, reproductive status, age/length relationship, body length/body weight relationship as well ecological markers (external parasites), is presented. When possible, comparison of these parameters with those of fin whales obtained in other period in the Antarctic was made. The main results were that body weight of whales in the JARPAII period is heavier than those previously reported for the Antarctic in the 1950's. Further, results suggested the possibility that whales are reaching sexual maturity at younger ages.

SC/F14/J11. During the JARPA final review workshop a recommendation was made that the comparability of commercial and JARPA age data be investigated by re-reading a sub-set of the commercial samples in an appropriately designed blind test (recommendation Biological Parameter 2 in Annex 4). Based on the results of the studies responding the recommendation, the IWC SC agreed in 2010 that no further experiments or analyses on age reading errors were needed to resolve ageing related problems raised at the JARPA review workshop (IWC, 2011). SC/F14/J11 presented a statistical method for quantifying age-reading error, i.e. the extent of bias and inter-reader variability among readers, which use the data produced in the blind test. The method in SC/F14/J11 assumes the availability of an independent control reader who produces reference ages for ageing structures which are also read by the subject readers. This reader is assumed to provide unbiased age estimates. Linear structures in bias and variance are incorporated in a conditional probability matrix representing the stochastic nature of age-determination for each reader. A joint likelihood function for the parameters related to ageing bias, variance and nuisance parameters is defined based on observed ageing outcomes from both the control and subject readers. The method is applied to data for Antarctic minke whales taken during Japanese commercial whaling (1971/72-1985/86) and JARPA (1986/87-2004/05). A total of 250 earplugs selected according to a predetermined protocol were used in the analyses to estimate the inter-reader variation for four Japanese readers. One of the authors acted the control reader. The Japanese readers and the control reader differed in terms of both the expected age given the true age, and variance in age-estimates. The expected age and random uncertainty in age-estimates differed among the Japanese readers, although the two readers in charge of age-reading for samples taken during JARPA and JARPA II provided quite similar ageing outcomes. These results contribute to analyses using catch-at-age data for this species. It should also be noted that the model and approach in this paper can be applied to populations other than the Antarctic minke whales, if a control reader is available, even retrospectively. An original version of this paper was presented to the IWC SC meeting in 2013 as Document SC/65a/IA04. After discussion, the IWC SC agreed that the approach and results of the study provide useable inputs data for SCAA analysis (IWC, 2013 in press).

SC/F14/ForInfo1 presented the results of the application of a Statistical Catch-at-age Analysis (SCAA) to data for Antarctic minke whales. The analysis addressed most of the previous recommendations from the JARPA final review workshop in 2006 (see recommendations Biological Parameters 2-3 in Annex 4), as well subsequent recommendations at the IWC SC meetings. The application to Antarctic minke whales considered two stocks (I and P) in five areas which cover Antarctic Areas III-E to VI-W. The parameters of the model (annual deviations about the stock-recruitment relationship, density-dependence parameters (productivity and carrying capacity), and the parameters which determine growth by stock, age-specific natural mortality by stock, and vulnerability by area and 'fleet') were estimated by fitting the model to data on catches, catch-at-length, conditional age-at-length, and estimates of absolute and relative abundance. A reference case analysis was selected and sensitivity explored by varying the assumptions on which the reference case analysis is based. The reference case analysis was able to mimic all of the data sources adequately. Most of the analyses (reference and sensitivity) indicated that Antarctic minke whales in the assessed area increased from 1930 until the mid-1970s and have declined thereafter, with the extent of the decline greater for minke whales in Antarctic Areas III-E to V-W (I stock) than for those further east (P stock). Natural mortality was consistently estimated to be higher for younger and older individuals. The estimates of $MSYR_{1+}$ were 5.3% for minke whales in Antarctic Areas III-E to V-W and 3.6% for minke whales in Areas V-E and VI-W, but these estimates were less well determined than other model outputs, and quite sensitive to the assumptions on which the SCAA was based. This document was presented to the IWC SC meeting as Document SC/65a/IA1.

SC/F14/J12 measured the eye lenses of 18 Antarctic minke whales and of 20 fetuses to examine the approach of age estimation in Antarctic minke whales by ratio of aspartic acid enantiomers. In the age estimation equation, the specific coefficient of hydrolysis effect in preparation and the constant conversion of aspartic enantiomers (*Kasp*) were estimated. The study found that the D/L ratio of aspartic acid in the lenses of minke whales had increased by 0.0102 in the hydrolysis process (7 hr at 108°C), and estimated that the *Kasp* was 1.96×10-3

(/year) calculated from the earplug age and the age index with the D/L ratio of aspartic acid in minke whales. Consequently, formulae Age (year) = 511×Ln ((1+D/L)/(1-D/L)) -13.2 was obtained.

Feeding ecology, energetic and habits

SC/F14/J13 showed the results of the annual trend in energy storage in sexually mature Antarctic minke whales based on catch data from all 24 surveys of the JARPA and JARPAII. These analyses addressed most of the previous recommendations from the JARPA final review workshop in 2006 (see recommendations Marine Ecosystem 4-6 in Annex 4), as well as more recent recommendations from the IWC SC e.g. analyses included survey trackline in random effects as recommended by IWC (2013c). Five variables which are, or could be, indices of storage of energy, were examined: total fat weight in the whale body, blubber thickness at two lateral measurement points and girth measured at two specified positions. Three of these variables were available from almost all whales sampled, but girth at axilla was measured over 20 years and fat weight was only measured over 17 years of the JARPA programme, and only for the first whale sampled on each day. A number of covariates were also recorded. A large number of linear mixed-effects statistical models were investigated for each of the dependent variables, and the Bayesian Information Criterion (BIC) was used to select the best model. All models examined had ‘year’ as a possible explanatory variable. The results show that all five measures of energy storage declined substantially over time during the JARPA period, with a more than 10% decline in total fat weight. For all five dependent variables the values for energy stores are higher for females than for males. The values increase during the feeding season and are higher for higher body coverage of diatoms. This is assumed to be a measure of how long the animal has spent in Antarctic waters. The results are similar when each sex is analysed separately, but the decrease in energy stores was somewhat larger in females than in males. The results from the JARPAII period were very different from the JARPA period. There is no clear trend towards increase, or further decrease, in any of the four measures of energy storage. The results suggest that fundamental changes have taken place in the eastern part of the Antarctic marine ecosystem during the 1990’s. These changes have resulted in less optimal feeding conditions for Antarctic minke whales.

SC/F14/J14 reported the results of an analysis of temporal trend in stomach content weight in the Antarctic minke whale, one of the major krill predators in Antarctic waters. These analyses addressed most of the previous recommendations from the JARPA final review workshop in 2006 (see recommendation Marine Ecosystem 3 in Annex 4), as well as more recent recommendations from the IWC SC e.g. analyses are now based on survey transects as recommended by IWC (2013c). A reported decline in energy storage over almost two decades indicates that food availability for the whales may also have declined until recently. To test this hypothesis, catch data from 21 survey years in the JARPA and JARPAII (1990/91-2010/11) was used to investigate whether there was any annual trend in the stomach contents of Antarctic minke whales. Linear mixed-effects analysis showed a decreasing trend in the weight of stomach contents over the 21 years since 1990/1991, which was statistically significant. A similar pattern of decrease was found in both males and females, except in the case of females sampled at higher latitude in the Ross Sea. These results suggest a decrease in the availability of krill for Antarctic minke whales in the lower latitudinal range of the research area. The results are consistent with the previously reported decline in energy storage (SC/F14/J13). The decrease in krill availability could be due to environmental changes or to an increase in the abundance of other krill-feeding predators. The latter appears more likely, given the recent rapid recovery of the humpback whale. Furthermore, humpback whales are not found in the Ross Sea, where both Antarctic krill and ice krill are available, and where no change in prey availability has been suggested for Antarctic minke whales.

SC/F14/J15 investigated the feeding habits of Antarctic minke whales based on samples obtained during the surveys of the JARPA and JARPAII for the period 1987/88-2010/11. Some of the analyses considered recommendations offered during the 2006 JARPA final review meeting e.g. those related to the duration of the feeding period, digestion rate and examination at smaller scales. The Antarctic minke whales fed mostly on Antarctic krill in offshore area, and on ice krill in coastal (shallow) area on the continental shelf of the Ross Sea and Prydz Bay. The whales fed mainly before 5AM suggesting that feeding activity decreases early in the day. The daily prey consumption was estimated using two independent methods, one based on theoretical energy requirements and the other on diurnal changes of stomach contents mass. The daily prey consumptions per capita during the feeding season based on the two methods were 95.1–127.0 and 182.6–250.3kg for immature and mature males, and 125.8–138.7 and 268.1–325.5kg for immature and mature females, respectively. This is equivalent to 2.65-4.02% of the body weight. The daily prey consumption per capita decreased between the JARPA and JARPAII periods based on the results of the method on diurnal change in stomach content mass, for all sexual classes. The seasonal prey consumption by all Antarctic minke whales in the research area was 3.51-3.98 million tons, and this figure was equivalent to 7.6-8.6% of the krill biomass estimated by acoustic survey in the total research area.

SC/F14/J16 examined the feeding habits of fin whales sampled during the surveys of the JARPAII for the period 2005/06-2010/11 (n=16). The fin whales fed mostly on Antarctic krill in the research area. The daily prey consumptions of fin whales per capita estimated by three methods ranged from 276 to 2,136kg. These values were equivalent to 0.50 and 3.84% of the body weight. The seasonal prey consumptions for all fin whales in the total research area based on three methods were 0.54-0.78million tons, 3.38-4.51million tons and 2.19-2.93 million tons, respectively. There was coincidence in the frequency of body length of the *E. superba* consumed by fin and Antarctic minke whales (*B. bonaerensis*). It seems that fin and Antarctic minke whales have similar feeding habits with no prey size selectivity.

SC/F14/J17 examined the distribution pattern of the Density Index (DIW: number of whales sighted / 100 n.miles) of blue, fin, sei, Antarctic minke, humpback, southern right, sperm, southern bottlenose, *Ziphiidae* and killer whales in the Antarctic based on the JARPA (1987/88-2004/05) and JARPA II (2005/06-2008/09) sighting data. A total of 353,134 n.miles was surveyed in Areas IIIE, IV, V and VIW, mainly south of 60^{o}S. The following table summarizes the sighting information.

Species	All Areas (IIIE, IV, V and VIW; south of 60S, 35E-145W)						Order of
	Sch.	Ind.	Calf	Mss	DIS	DIW	DIW
Blue whale	286	495	11	1.73	0.081	0.140	8
Fin whale	1,268	5,209	20	4.11	0.359	1.475	5
Sei whale	36	59	0	1.64	0.010	0.017	10
Antarctic minek whale	25,507	69,076	1	2.71	7.223	19.561	1
Humpback whale	10,036	18,770	137	1.87	2.842	5.315	3
Southern right whale	235	298	6	1.27	0.067	0.084	9
Sperm whale	3,810	3,926	0	1.03	1.079	1.112	6
Southern bottlenosed whale	1,666	3,045	3	1.83	0.472	0.862	7
Unid beaked whale	3,175	5,457	3	1.72	0.899	1.545	4
Killer whale	1,472	20,569	59	13.97	0.417	5.825	2

Among 10 whale species, Antarctic minke whales were the most frequently sighted species, followed by the killer, humpback, unidentified beaked, fin, sperm, southern bottlenose, blue, southern right and sei whales in the DIW order. Maps of the DIW by 1ºX 1º square are provided.

SC/F14/J18 examined changes in spatial distribution of Antarctic minke whales and humpback whales in Area IV during the period of the JARPA and the JARPAII. To elucidate temporal changes of their spatial distribution, data obtained in the JARPA-JARPAII were divided into three periods: early (1989/1990, 1991/1992 and 1993/1994), middle (1995/1996, 1997/1998 and 1999/2000) and late (2001/2002, 2003/2004 and 2005/2006). Spatial distribution was estimated using generalized additive models (GAM). Presence or absence of whales was used as the response variable while seafloor depth, distance from shelf break and longitude were used as explanatory variables. Mean probabilities of occurrence of Antarctic minke whales in the survey area in early, middle and late periods were 0.41, 0.46 and 0.41 while those of humpback whales were 0.14, 0.35 and 0.46. Occupied area indices (probabilities of occurrence of Antarctic minke whales minus probabilities of occurrence of humpback whales) were also calculated. If the index is 1, only Antarctic minke whales were presented in a grid cell while only humpback whales were presented if the index is -1. If the index is 0, probabilities of presence of Antarctic minke whales and humpback whales in a grid cell were identical. Mean occupied area indices in early, middle and late periods were 0.28, 0.11 and -0.07, respectively. It was concluded that the spatial distribution of humpback whales expanded during the period of the JARPA and the JARPAII while that of Antarctic minke whales remained stable. The results indicated that competition between humpback and Antarctic minke whales for habitat in Area IV during the period of the JARPA and the JARPAII was intensified as abundance of humpback whales increased.

SC/F14/J19 presented results of krill biomass estimations based on quantitative echo sounder data. Estimations were made based on data obtained in Areas IIIE/IV in the 2007/08 JARPAII survey and in Areas V/VIW in the 2008/09 JARPAII survey. The biomass estimates obtained in Areas IIIE and IV were 6.6 and 12.5 million tons, respectively while those in Areas V and VIW were 24.0 and 3.4 million tons, respectively. The information on krill biomass for Area IV was used as input parameters in the ecosystem modelling work.

SC/F14/J20 analyzed oceanographic observation data obtained by the JARPA and the JARPAII to clarify physical oceanographic conditions in the JARPA/JARPAII area as a basis for understanding the habitat environment of whales. About 2,500 profiles were obtained by XBT, XCTD and CTD observations from 1990 to

2009. Obtained profile data were converted to the same format and utilized to describe the oceanographic feature of the JARPA/JARPAII area. Based on this data set the averaged feature of the oceanographic structure in the research area for two decades was described. The Southern Boundary (SB) of the Antarctic Circumpolar Current (ACC), which is detected by a 0ºC temperature contour line on the 27.6 isopycnal surface, characterized the research area. It is evident that the position of the SB is controlled by major features of bottom topography such as the Kerguelen Plateau and the Pacific-Antarctic ridge. In the area east of the Kerguelen Plateau, the position of SB changes on a decadal timescale. The southward shift of SB in the region is observed in the early 2000's, and a northward shift is observed in the later 2000's. Although the global warming is an important factor for the Southern Ocean, unlike the Antarctic Peninsula region, the JARPA and JARPA II temperature data shows no statistically significant warming in the JARPA/JARPAII research area for the two decades.

SC/F14/J21 examined several pieces of information such as a) Kerguelen-Davis Oscillation Index (KDOI); b) the extent of sea ice; c) abundance estimates of humpback and Antarctic minke whales in Area IV from the 1989/90 to 2007/08 seasons collected by the JARPA and the JARPAII; and d) zonal average of Southern Boundary of Antarctic Circumpolar Current (SB) in the Indian Ocean sector. Time-series of these data showed trends and relations as follows: First, KDOI indicated (1) the effective data of Kerguelen had a limited number of years since 2006 while the Davis's data had 56 years since 1957. Therefore, the analytical period of KDOI was limited to seven and half years at this stage; (2) KDOI during 2006 and 2013 showed the variability of an upward trend with approximately 2-year periodicity. Second, sea ice extent in austral summer from 1979 to 2011 showed an upward trend with yearly variability suggesting some relationship with KDOI. In addition, the lower abundance estimate of Antarctic minke whale coincided with the larger sea ice extent such as 1997/98 and 2007/08, probably due to navigational limited surveys caused by sea ice. Third, the rapid southward shift of SB coincided with a rapid increase of humpback whales such as in 1995/96 and 2001/02, probably due to Antarctic Circumpolar Water southward shift.

SC/F14/J22 summarized the information on marine debris collected during the surveys of the JARPA and JARPAII for the period 1987/88 to 2010/11. Three kinds of observations were considered: marine debris on the sea surface, marine debris in the stomachs of whales caught (Antarctic minke, dwarf minke and fin whales), and entanglements. In the Antarctic research area (south of 60°S), marine debris included metals (drum, can), petrochemical products (buoy, ball, bottle, container, fender, net, rope, styrofoma). Buoys were the most abundant debris (69% of all marine debris recorded). The highest density index (DI: number of marine debris observed per 100 nautical miles) was recorded in Area V (DI: 0.15), followed by Area IV (DI: 0.12). DI of buoys in Area IV and V suddenly increased after the 2005/06 austral summer season. The increase of buoy debris coincides with an increase of longline fishery operations in this area. The stomachs of a total of 10,041 Antarctic minke whales, 16 dwarf minke whales and 16 fin whales were examined for debris. A total of 70 marine debris and objects other than prey were found in the stomachs of the three species, including feather, stone, wood, plastic and others. The number of occurrence of marine debris and objects other than prey in the fore and main stomachs per 100 Antarctic minke whales examined was estimated at 0.35. Four cases of entanglement in a total of 10,041 Antarctic minke whales examined were found. Those involved fishing hook, monofilament fishing line, rope and packing band. Given the low indices, the effect of marine debris on whales in the Antarctic is expected to be limited at the present time. This study provided the first comprehensive observations of marine debris on sea surface, inside the stomachs of whales, and in entanglements of whales in the Antarctic.

Pollutants

SC/F14/J23 measured total Hg levels in samples from Antarctic krill, and Antarctic minke whales to examine the features of accumulation and yearly changes of total Hg in Antarctic Areas IV and V. Total Hg levels in Antarctic krill from Areas IV and V were in the range 0.006-0.026 and 0.003-0.052 ppm dry wt., respectively. There were no significant differences between Areas. No yearly changes of total Hg levels in Antarctic krill were observed in samples from both Areas in the period from 2005 to 2011. Hg levels in liver of Antarctic minke whales from Areas IV and V were in the range 0.003-0.13 and <0.001-0.25 ppm wet wt., respectively. Hepatic Hg levels of minke whales of all age groups in Area IV decreased significantly with research years and that of 15-26 year old whales in Area V increased significantly.

SC/F14/J24 determined the concentrations of persistent organochlorins in the blubber of 5 mature male (21-25 years old) Antarctic minke whales from Antarctic Area V sampled by the JARPAII in 2010/11. For comparison, blubber from 40 whales sampled by the JARPA surveys in the period from 1988/1989 to 2004/2005, were used. In 2010/11 mean concentrations of HCB (140 ng/g fat wt.) were the highest followed by DDTs (100 ng/g fat wt.), PCBs (28 ng/g fat wt.), CHLs (25 ng/g fat wt.), and HCHs (0.8 ng/g fat wt.). Levels of DDTs, HCHs, HCB and CHLs in Area V decreased significantly with year, while the yearly trend of PCBs did not change significantly.

HCHs levels in minke whales in 2010/2011 were similar to those in the JARPA period from 1996/1997 to 2004/2005 however they were lower than those in the JARPA period from 1988/89 to 1996/1997. These results suggested that levels of HCHs in the Antarctic Ocean have varied from slightly decreasing to a steady state in the middle 1990's.

SC/F14/J25 determined total mercury (Hg) in 10 livers and 16 muscles of fin whales sampled by the JARPAII in 2005/2006-2010/2011. In addition PCBs, DDTs, HCHs, HCB and CHLs were determined in two blubber samples of fin whales sampled in 2010/2011. Mean concentrations of total Hg in livers and muscles were 0.052 and 0.021 (ppm wet wt.), respectively. Mean concentrations of PCBs, DDTs, HCHs, HCB and CHLs were 6.5, 13, 0.65, 39 and 4.5 (ng/g fat wt.), respectively. Hg levels in liver and muscle of fin and Antarctic minke whales from the Antarctic Ocean were similar, and these were one order of magnitude lower than those of fin whales from the western North Atlantic Ocean. Geographical differences of Hg levels within a species could be caused by food habitat and/or age. Levels of OCs, except for HCB, in fin whales from the Antarctic Ocean were similar to those in the Antarctic minke whales. These levels were extremely lower than those in fin whales from the middle latitude of the northern hemisphere nearby human activity, and those in killer whales from the Antarctic Ocean. These results suggest that the OCs levels in whales could mainly be affected by position of food in the food chain and area. OCs levels in fin and Antarctic minke whales in the Antarctic Ocean could be the lowest among whale species in the world. HCB levels in large whales would be affected by trophic levels of its preys rather than by spatial differences.

Ecosystem modeling

SC/F14/J26 showed the progress made in the development of ecosystem modelling for species in Area IV. Two types of modelling approaches were employed; one is a multi-species production model, and the other is the EwE, a comprehensive (whole-of-ecosystem) model. There are differences in the component species between them, but the baleen whales and krill play key roles in both. For the statistical estimation in the multi-species production model, a functional response function was proposed to link the dynamics of predators (four baleen whale species and crabeater seal) and prey (Antarctic krill) to both between and within-species competitions. The model was applied to the data on time series of the four baleen whale species, crabeater seal and krill, and then a likelihood function was defined based on the data with some additional assumptions on inestimable parameters. However, at this stage the estimated population trends for the component species did not fit well to the data, which might be attributed partly to lack of spatial structure in the model and partly to lack of representativeness of assumed parameters and information on prey abundance. For the EwE approach, the construction of a mass-balancing for Ecopath for 27 functional groups was attempted, which could be the basis for the next stage of analysis for projection forward using the Ecosim framework. Several suggestions were made to progress the modelling work.

Stock structure and RMP

SC/F14/J27 presents a summary of the genetic sampling and DNA laboratory protocols of the Institute of Cetacean Research used in the analyses on population genetic structure of baleen whale species under the Objective 3 of the JARPAII. In general the protocols follow the IWC SC guidelines for DNA data quality control for genetic studies relevant to IWC management advice (IWC, 2009b).

SC/F14/J28. Previous JARPA analyses based on mtDNA RFLP, microsatellite DNA and morphometrics suggested significant differences between whales in the most eastern and western sectors of the research area, and less differentiation in the central sectors. Those results were consistent with the occurrence of at least two stocks and an area of mixing in the central sectors (VW). The areal and temporal pattern of stocks mixing, which is one of the objectives of the JARPAII, is studied in detail in a separate document (SC/F14/J29). SC/F14/J28 used genetic samples from the JARPAII to test the hypothesis on stock structure derived from JARPA research by employing two genetic markers: mtDNA control region sequences and microsatellite DNA. The statistical analysis followed a step-wise fashion: first Areas IIIE, IVW and IVE were compared in individual surveys in the western sector of the research area, and Areas VE and VIW were compared in individual surveys in the eastern part of the research area. Next the yearly variation in the western and eastern sectors was investigated. Finally a comparison between western and eastern sectors of the research area was conducted. This was done for females, males and both sexes combined. A total of 2,278 mtDNA sequences were used in the analysis. Significant statistical genetic differences were found between whales from the western and eastern sectors. The microsatellite DNA analysis used samples from 2,553 individuals, which were analyzed using 12 microsatellite loci. The test results showed that the genetic differences within the western and eastern sectors were temporal rather than spatial. When all of the samples were combined into two separate samples, western and eastern, the genetic difference between sectors was clearer in females than in males as similar to the previous study. Despite the increase of the number of the markers, the level of the stock differentiation was still too low to conduct genetic analysis at the individual level (F_{ST} less than 0.001). The latter microsatellite analyses responded to some of the recommendations on stock structure offered during the 2006 JARPA final review workshop (see recommendations Stock Structure 2 and 4 in Annex 4). These results based on the JARPAII samples and two genetic markers, were consistent with the previous hypothesis of at least two stocks in the JARPAII research area, which are called I stock (Eastern Indian Ocean) in the western sector of the research area, and P stock (Western South Pacific) in the eastern sector. However substantial yearly variation was found by the microsatellite analysis, mainly within the I stock.

SC/F14/J29 used an integrated approach for estimating longitudinal segregation of two stocks using different sources of information, genetic and morphometric data. This study was in response to a recommendation made during the JARPA final review workshop (see recommendation Stock Structure 5 in Annex 4). The model was originally presented to the IWC SC in 2012 using the JARPA data (Kitakado *et al*., 2012). The IWC SC 'noted that the approach used is simple and potential powerful. Aside from the general relevance of the results to understanding Antarctic minke whale dynamics, it might in the future prove useful in allocating historical catches to stocks…' (IWC, 2013b). This time the model was applied to the JARPA and JARPAII data collected between 1989/90 and 2010/11 in Areas IIIE-VIW. A soft boundary was allowed to vary by year and sex although baseline stocks are assumed. A joint likelihood function derived from the two sources is defined for the estimation of mixing proportions. The mixing proportion was modeled by a linear logistic model with stock-specific parameters for the two sets of data. The genetic and morphometric data in the western areas (Areas IIIE and IVW) and the eastern areas (Areas VE and VIW) were used only for estimating parameters for the two putative stocks, I-stock and P-stock, respectively. It was observed that the morphometric data shown dominated information compared to the genetic data and it helped convergence in the optimization. However, the inclusion of the morphometric data altered the estimation results and tended to give softer boundaries. On the whole, the result indicated that the spatial distribution of the two populations has a soft boundary in Area IVE and VW, which depends on the year. It also suggested possible sex differences along the boundary.

The IWC SC has proposed seven breeding stocks of the southern humpback whale. Figure 13 shows the location of these stocks and their hypothetical migratory routes and feeding grounds.

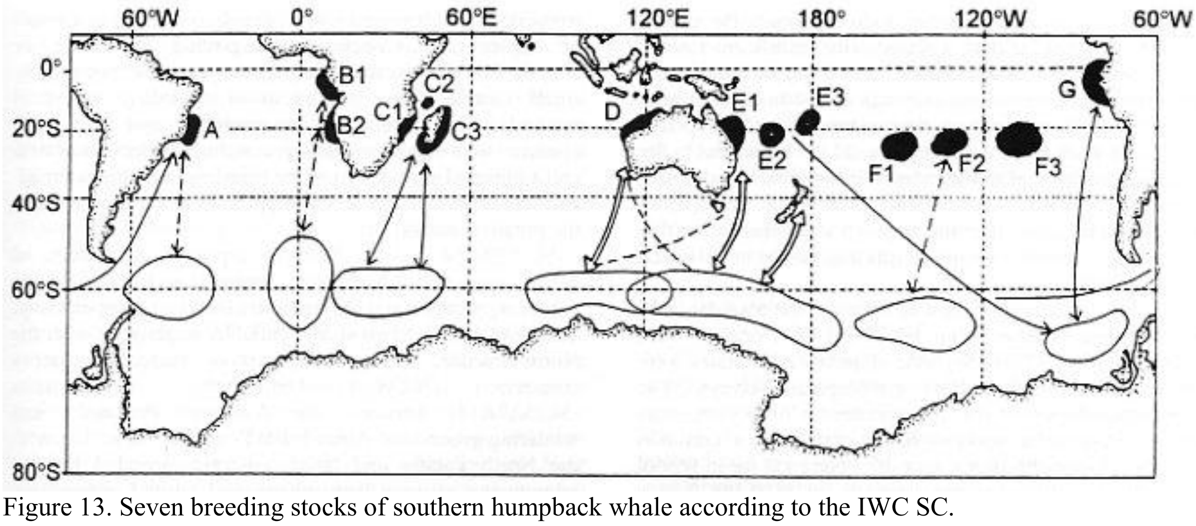

Figure 13. Seven breeding stocks of southern humpback whale according to the IWC SC.

SC/F14/J30 analyzed genetic samples from 575 humpback whales obtained in the Antarctic during surveys of the JARPA/JARPA II and the IDCR/SOWER, and from 1,057 whales from low latitude localities of the South Pacific and eastern Indian Ocean to describe the distribution and mixing of breeding stocks in the Antarctic feeding grounds. This study was conducted to respond to a recommendation from the JARPA review workshop (see recommendation Stock Structure 8 in Annex 4) and to recommendations from the IWC SC in 2012 (IWC, 2013d) to study distribution and calculate mixing proportions of breeding stocks D, E and F in the feeding grounds. Such information is important to interpret abundance estimates as well to allocate historical catches to stocks. Genetic samples of both data sets were examined for approximately the first half of the mtDNA control region. This study was one of the few that involved samples from both low latitude and Antarctic areas. The genetic characteristiscs of whales from low latitudes can be used as representative of 'pure' stocks. The genetic 'signal' of 'pure' stocks is used to examine distribution and mixing in the Antarctic. Genetic pattern of variation based on mtDNA was consistent with the geographical locations of breeding and feeding grounds of Stocks D, E and F. Western Australia whales (D) are strongly related to Area IV, Eastern Australia whales (E1) are related to Area VW and whales from New Caledonia (E2) and Tonga (E3) are related to feeding grounds east of 160ºE. Whales from Cook Island (F1) and French Polynesia (F2) are not related genetically to whales in the feeding grounds covered by the JARPAII surveys. This paper was presented and discussed at the IWC SC in 2013 as Document SC/65a/SH13.

SC/F14/J31 analyzed biopsy samples from humpback whales obtained during surveys of the JARPA and JARPAII up to the 2010/11 season as well as the International Decade for Cetacean Research/Southern Ocean Whale and Ecosystem Research (IDCR/SOWER) using microsatellite DNA loci in order to describe their stock structure in the Antarctic feeding ground. A total of 581 individuals obtained from Areas III to VI were genotyped at 14 loci (only six loci were used in a previous study submitted to the JARPA review workshop). After excluding duplicates and calves these individuals were divided into four groups based on the IWC management areas: III (n=93), IV (n=218), V (n=153) and VI (n=64). Heterogeneity tests were conducted for females, males, and both sexes combined. Although a few cases of small temporal genetic differences were detected within the areas, major genetic differences were among the samples from the different Areas. As similar to the previous report, stronger differentiation was seen in females than in males. Despite the increase of the number of loci, the level of the stock differentiation (F_{ST} less than 0.001) was still too low to conduct genetic analysis at the individual level. The microsatellite study confirmed that humpback whales from different stocks occupied the Areas with higher differentiation in females than in males.

SC/F14/J32 examined stock structure of Antarctic fin whales based on biopsies and research take during the JARPA and the JARPAII, and two genetic markers, mtDNA control region sequencing and microsatellite DNA. Genetic samples were available from Area IIIE (n=6), IV (n=23), V (n=24) and VIW (n=2). Results of the mtDNA heterogeneity test showed statistically significant differences among whales in Areas IIIE, IV and V. The microsatellite analysis showed statistically significant differences in allele frequencies of 16 loci among whales from Areas IV and V. Results of the genetic analyses suggested the possibility of genetic structuring of fin whales in the JARPAII research area, which should be further explored with the analyses of large number of samples in the future.

SC/F14/J33 analyzed biopsy samples from southern right whales obtained during the JARPA and JARPAII surveys up to the 2009/10 season using both microsatellite DNA and mitochondrial DNA (mtDNA) markers in order to describe genetic characteristics of the species in the Antarctic feeding ground. A total of 70 samples obtained from Areas III to V was genotyped at 14 microsatellite DNA loci and were sequenced for 430 bp of the mtDNA control region. In two cases of three duplicate sampling, the second samples were collected in a later year (4 and 8 years, respectively) in the same Area IV, suggesting site fidelity to feeding ground. Paternity analysis for a single calf-mother pair in the samples failed to detect a potential father. After exclusion of duplicates and calves, 66 samples were used to estimate genetic indices. The levels of genetic diversity observed from both markers were comparable to those reported from other southern right whale genetic studies. A total of eight haplotypes was generated from 21 segregation sites and these haplotypes were phylogenetically separated into two clades with the first and the second most frequent haplotypes belonging to the different clades. The eight haplotypes observed in the study were then compared on the basis of variation at the segregation sites within the 273bp consensus region to the 37 haplotypes reported in Patenaude *et al*. (2007) that were observed in the samples obtained from the Indo-Atlantic (Argentina and South Africa) and the Indo-Pacific (Southern Australia and New Zealand) basins. The comparison revealed that the two Antarctic clades were the same as their A and W clades, seven of the eight Antarctic haplotypes matched their haplotypes, three of them were found only in the Indo-Atlantic samples. The study suggested that some southern right whales migrate much longer distances between their feeding and breeding grounds than thought previously and thus whales from multiple stocks (probably including those other than the Southern Australia and New Zealand stocks) migrate to Area IV in the Antarctic.

SC/F14/J34 summarizes the information on photo-identification of blue, southern right and humpback whales obtained by the JARPA/JARPAII surveys in Antarctic Areas IIIE, IV, V and VIW during the austral summer seasons. There is a total of 3,108 photo-id pictures in the photo-id catalogue administrated by the Institute of Cetacean Research, which were selected from the total obtained in those Areas between 1989/90 and 2010/11. All the pictures were digitized to facilitate archiving.

Species	JARPA	JARPAII	Total
Blue whale	153	376	529
Southern right whale	243	671	914
Humpback whale	464	1,201	1,665
Total	860	2,248	3,108

Pictures of the blue whales from the JARPA have already been submitted to the IWC secretariat to facilitate comparisons with other catalogues. Pictures of the humpback and southern right whales from the JARPA were provided to the IWC's Antarctic Humpback Whale Catalogue and to other international research organizations, respectively, under co-operation studies. A preliminary examination of pictures within the feeding grounds and between the feeding grounds and lower latitude localities resulted in several matches. The photo-id data collected by the JARPA and JARPAII have the potential to contribute to a better understanding of the pattern of movement, distribution and abundance of blue, southern right and humpback whales, and in turn to the assessment and conservation of these three species.

Others

SC/F14/J35 used seven pregnant female Antarctic minke whales sampled by the JARPAII in the 2005/06 season to compare the concentrations of various components of follicular fluids collected from follicles of different sizes with a control that consisted of the components of umbilical serum. In the study vitrified and warned follicular oocytes derived from the three groups of follicles were also used for measurements of the diameters of the whole oocyte, ooplasm and zona pellucida after removing the cumulus cells. Main results were the following: i) the mean diameter of the oocytes from the large follicles was significantly greater than those from the small and medium follicles; ii) the osmolarity of the follicular fluid from the small follicles was significantly lower than that of the medium follicles; iii) the concentrations of lactic acid of the follicular fluid from the three groups of follicles were significantly lower than that of the umbilical serum; iv) the progesterone concentrations were not significantly different among the fluid from the three groups of follicles and the umbilical serum. The results offered new information concerning whale reproductive physiology, especially for improvement of *in vitro* oocyte maturation and related technologies for whales.

SC/F14/J36 used heart samples of Antarctic minke whale collected during the 2005/06 JARPAII surveys for a comparative morphological study of the Purkinje fiber network in mammalian hearts. The morphological varieties of the Purkinje fiber networks were studied by examining hearts of ungulates, primates, carnivores, rodents and cetaceans including four Antarctic minke whales. Purkinje fibers in mammalian hearts are known to comprise the following three groups depending on their structure: group I (ungulates), group II (human, monkeys and dog) and group III (rodents). The study showed that morphologically, whales and seals respectively belonged to Purkinje cells of group I and II. The findings indicated that the structural variety of the Purkinje network may reflect the conducting function and be related to the phylogeny of the mammalian species.

SC/F14/J37 examined the structure and steroidogenesis of the placenta in the Antarctic minke whale. The study was based on 58 placentas and 12 nonpregnant uteri collected from this species during the 2001/02, 2002/03 and 2004/05 seasons of the JARPA as well during the 2005/06 JARPAII season. The Antarctic minke whale placenta showed a fold-like shape as opposed to a finger-like shape. Many uterine glands were distributed in both non-pregnant and pregnant uteri. The uterine glands in the superficial layer of the pregnant endometrium had a wide lumen and large epithelial cells as compared with those in the deep layer. On the other hand, in the nonpregnant endometrium, the uterine glands had a narrower lumen and smaller epithelial cells than in the pregnant endometrium.

SC/F14/J38 examined the possible effects of JARPAII annual take of 850 minke whales (425 males and 425 females) on the Eastern Indian Ocean stock (I-stock) and Western South Pacific stock (P-stock), respectively. Standard Hitter methodology was used. Updated abundance information from IDCR/SOWER surveys and two stock structure scenarios were considered. From the results of the Hitter runs, it was concluded that there would be no negative effect on the Antarctic minke whale stocks of the future planned catches.

5. SUMMARY OF KEY RESULTS

Objective 1: Monitoring the Antarctic ecosystem

Abundance and distribution

- The total abundance of Antarctic minke whales in Areas IIIE-VIW has been roughly stable during the JARPA+JARPAII research period.
- The abundance trend estimates of humpback whale Stocks D in Area IV (13.6% with 95% CI: 8.4%-18.7%) and E in Area V (14.5% with 95% CI: 7.6%-21.5%) were similar, and they showed a significant increasing trend during the JARPA+JARPAII period.
- The abundance of blue whales in Areas IIIE, IV, V and VIW combined showed a significant increasing trend during the JARPA+JARPAII period (8.2% with 95% CI: 3.9%-12.5%).
- The abundance of fin whales in Areas V and VIW combined showed a significant increasing trend during the JARPA+JARPAII period (12.0% with 95% CI: 2.6%-21.5%). The increasing trend was not statistically significant in Areas IIIE+IV.
- The abundance of southern right whale in Area IV showed an increasing trend, which was not statistically significant.
- Spatial distribution of humpback whales in Area IV was expanded in the period 1989-2006 while the distribution of Antarctic minke whales remained stable in the same period.

Biological parameters

- The age at sexual maturity of Antarctic minke whale Stocks I and P has remained at between 7-8 years old from the 70's cohorts. It showed a slight but statistically significant increasing trend from the 70's cohorts.
- The pregnancy rate of Antarctic minke whale Stocks I and P maintained a stable trend at a high level during the JARPA+JARPAII period.
- The recruitment rate of Antarctic minke whale Stocks I and P maintained a stable trend at a low level (in comparison with the level observed in the 60's-70's cohorts).
- There is the possibility that fin whales are reaching sexual maturity at younger age as compared with the period of commercial whaling.

Feeding ecology/energetic

- The blubber thickness of Antarctic minke whales showed a decreasing trend throughout the JARPA+JARPAII period. When analyzed separately the trend was significant for the JARPA period but not for the JARPAII period.
- The stomach content weight of Antarctic minke whales showed a decreasing trend throughout the JARPA+JARPAII period in offshore areas. No significant trend was found in the Ross Sea for females.
- The daily prey consumptions of Antarctic minke whales per capita during the feeding season based on two methods were 95.1–127.0 and 182.6–250.3kg for immature and mature male, and 125.8–138.7 and 268.1–325.5kg for immature and mature female, respectively. These values are equivalent to 2.65-4.02% of the body weight.
- The total prey consumption by Antarctic minke whales in the research area was estimated in 3.51 and 3.98 million tons by each method, respectively. These values correspond to 7.6% and 8.6% of the estimated krill biomass in the research area.
- The daily prey consumption per capita of Antarctic minke whales decreased between the JARPA and JARPAII periods for all sexual classes, based on the results of diurnal change in stomach content mass.
- The daily prey consumption of fin whales per capita during the feeding season based on three methods ranged between 276 and 2,136kg. These values were equivalent to 0.50 and 3.84% of the body weight.
- Antarctic minke and fin whales fed on krill of similar body size implying that fin whales and the Antarctic minke whales have similar feeding habit, and no prey size selectivity.
- Body weight of fin whales in the JARPAII period is heavier than those previously reported for the Antarctic in the 1950's.

Environmental surveys

- Total Hg levels in krill sampled from the stomachs of Antarctic minke whales were similar between Areas IV (0.006-0.026 ppm dry wt) and V (0.003-0.052), and no yearly trend was observed for the period 2005-2011.
- Total Hg levels in liver of Antarctic minke whale in Areas IV and V were 0.003-0.130 ppm wet wt and <0.001-0.250, respectively. These levels are considerably lower than those in other ocean basins. Hepatic Hg levels of all age groups of Antarctic minke whale in Area IV decreased significantly, and the age group 15-26 years old in Area V increased significantly during the JARPA and JARPAII period.
- Mean concentration of organochlorine in 21-25 years old minke whale in Area V in 2010/11 were HCB (140 ng/g fat wt.), DDTs (100 ng/g fat wt.), PCBs (28 ng/g fat wt.), CHLs (25 ng/g fat wt.), and HCHs (0.8 ng/g fat wt.). Levels of DDTs, HCHs, HCB and CHLs in Area V decreased significantly with year, while the yearly trend of PCBs did not change significantly. The levels of HCHs in the Antarctic Ocean have varied from slightly decreasing to a steady state in the middle 1990's.
- Mean concentrations of total Hg in livers and muscles of fin whale were 0.052 and 0.021 (ppm wet wt.), respectively. Mean concentrations of PCBs, DDTs, HCHs, HCB and CHLs were 6.5, 13, 0.65, 39 and 4.5 (ng/g fat wt.), respectively. Hg levels in liver and muscle were one order of magnitude lower than those of fin whales from the western North Atlantic Ocean. OCs levels were extremely lower than those in fin whales from the middle latitude of the northern hemisphere, and than those in killer whales (top predator) from the Antarctic Ocean.
- The effect of the global warming was not detected in the research area.
- Annual fluctuation on the locality of the southern boundary (SB) was observed in the research area during the JARPA and JARPAII periods. Southward shift of the SB generally coincided with a rapid increase of humpback whales in 1995/96 and 2001/02 suggesting that oceanographic conditions affect the distribution of whales.

Objective 2: Modelling competition among whale species

- Progress was made toward the development of two types of ecosystem models: multi-species production model and Ecopath with Ecosim. Several additional data and analyses were identified to progress further this work.

Objective 3: Elucidation of temporal and spatial changes in stock structure

Antarctic minke whale

- Results of additional genetics (mtDNA sequencing; microsatellite DNA) analyses based on the JARPAII data were consistent with the previous stock structure hypothesis of at least two stocks in the JARPAII research area, which occupy the most western and eastern part of the JARPAII research area, respectively (I and P Stocks).
- Genetic analyses based on microsatellite showed significant yearly changes mainly within the stock in the most western side of the research area (I stock). In general, results of the new microsatellite analyses suggested stronger fidelity to migration destination in females than in males.
- The transition area where two stocks mix with each other is longitudinally wider than originally suggested under the JARPA. The spatial distribution of the two stocks has a soft boundary in Areas IVE and VW, which depends on the year.
- There is possible sex differences along the soft boundary.

Humpback whale

- Genetic pattern of variation based on mtDNA was consistent with the geographical locations of breeding and feeding grounds of Stocks D, E and F. Western Australia whales are strongly related to Area IV, Eastern Australia whales are related to Area VW and whales from New Caledonia and Tonga are related with feeding grounds east of 160ºE. Whales from Cook Island and French Polynesia are not related genetically to whales in the feeding grounds covered by the JARPAII surveys.
- Results of microsatellite analyses showed that Areas IIIE, IV, V and VIW are occupied by different stocks, which is consistent with the mtDNA results.

Fin whale

- Results of mtDNA and microsatellite analyses suggested genetic structuring in the JARPAII research area..

Southern right whale

- Genetic analyses based on microsatellites suggested site fidelity of whales to Area IV. Results of the mtDNA analysis suggested longer distance feeding migration than previously thought, and the possibility that different stocks migrate into Area IV in summer.

IWC management Areas

- Results of the stock structure studies confirmed that the current Management Areas of the IWC are not supported by biological evidence in the case of the Antarctic minke whale.
- The IWC boundaries of the Areas III, IV, V and VI match better with the genetic results found for the humpback and fin whales.
- Southern right whales occur mainly in Area IV during the austral summer.

6. INTERPRETATION OF RESULTS AND RELEVANCE FOR THE CONSERVATION AND MANAGEMENT OF WHALES AND THE ECOSYSTEM

General

- As explained in the introduction, the JARPA/JARPAII was developed to provide for a science-based management program. Continuous collection of the whale samples and thorough analysis of biological data provided useful information not only for sound and effective management of marine resources but also understanding of biological and ecological processes of species involved in the Antarctic marine ecosystem.

- A combination of lethal and non-lethal surveys in the comprehensive large-scale JARPA/JARPAII allowed us to acquire an unbiased, widely collected, large data base from all parts of ecosystem that was not available from commercial catches.

- The long term research projects provided us a great opportunity to systematically monitor long-term natural variability of biotic and abiotic factors (changes in oceanographic conditions, in the abundance of large whales, in biological parameters of predators, stock structure of whales, etc.) in the Antarctic marine ecosystem.

- In some cases of species competition, single-species models will clearly give wrong results. For example a decrease in abundance caused by the competition will be misinterpreted by the current RMP as over-exploitation, and the catches will be set unnecessarily low. This needs to be improved by the use of ecosystem models. However, no single ecosystem model can project the complex nature of the marine ecosystem. The greatest benefits are obtained from a combined use of different types of models. The JARPAII thus developed two different types of the ecosystem models: Ecopath with Ecosim and multispecies production model. The output from the ecosystem modeling study can assist in the formulation of effective ecosystem-based management policies in the future.

- It is important to monitor environmental changes and the responses of whales to such changes especially under the circumstances of progressing climate change. Whales are suited as biological indicators of environmental conditions because they are long-lived animals with ability of long-distance migration. The JARPAII investigated pollutant levels of the sampled baleen whales in relation to their sex and maturity. In addition, the JARPAII investigated the pollution levels in krill collected from the stomach contents of whales. The results from these direct examinations on the several different types of sources provided us very important information to understand the bioaccumulation process through the marine food chain.

Ecosystem research
Results of the updated analyses on temporal trends of several biological and ecological parameters that included JARPAII samples and data were used to update the ecological hypothesis explained in Section 3:

Krill surplus hypothesis

- The surplus krill produced by the over-exploitation of large baleen whales such as the blue and humpback whales in the 1930's and 1940's became available for other krill predators, such as the Antarctic minke whale.

- Krill surplus resulted in improved nutritional conditions for the Antarctic minke whale, which in turn resulted in some biological changes in the Antarctic minke whale. For example the age at sexual maturity decreased between approximately the 1940's and 1970's cohorts, which meant that whales were able to reproduce at younger ages.

- This biological process favored an increase in the recruitment (and total abundance), from 1930 until the mid 1970's.

Situation since the 1970's

- The Antarctic minke whales reached the maximum carrying capacity by the 1970's, and since then the stocks responded by stabilizing the age at sexual maturity at 7-8 years old (the decreasing trend was halted).

- A decline in the abundance of Antarctic minke whales was observed after the 1970's, with the extent of the decline greater for minke whales in the western part of the research area (I Stock) than for those in the eastern part (P Stock).

- High pregnancy rates of Antarctic minke whales were observed.

Situation since the 1980's

- The age at sexual maturity has been maintained at around 7-8 years old since the 1970's cohorts. No significant changes in the age at sexual maturity were observed in recent (1990's) cohorts. A slight but statistically significant increasing trend was observed after the 1970's cohorts.

- Recruitment, however, has not increased and has remained somewhat constant at a low level in comparison to the levels of the 1960's-1970's.

- High pregnancy rates were observed.

- Nutritional conditions have deteriorated for Antarctic minke whale as revealed by a decreasing trend in blubber thickness and stomach content weight for the JARPA and JARPAII periods combined.

- Abundance of some large whale species such as blue, humpback and fin whales has been increasing.

Therefore in recent decades we have a situation in that whales are reproducing at high rates (young age at sexual maturity and high pregnancy rates) but this is not reflected in the abundance as revealed by the constant trend in total abundance, and constant trend at low level in recruitment. Therefore Antarctic minke whales are not responding in the same manner as they responded in the 1940's and 1960's under the krill surplus hypothesis. For example in the 1940's and 1960's, the age at sexual maturity decreased and the recruitment rate increased substantially in response to better nutritional conditions. In recent years the age at sexual maturity has not increased substantially as expected under the deteriorated nutritional conditions suggested by the declining trend of blubber thickness and stomach content weight, although the recruitment rate has remained constant at a low level (in comparison with the level of the 1960's and 1970's).

There are three possible explanations for the apparent contradiction between age at sexual maturity and recruitment rate trends in recent decades:

a) Deteriorated nutritional conditions are affecting survival of juveniles.

Less krill is available for minke whales in recent years which resulted in deteriorated nutritional conditions as suggested by the decreasing trend in blubber thickness and stomach content weight since the 80's. Given this situation, weaker calves are born implying a higher mortality of juveniles. This explanation is consistent with low age at sexual maturity (7-8 years old), high pregnancy rates, constant abundance and low recruitment rates (in comparison with the 1960's-1970's).

Less krill available for the Antarctic minke whale could be the result of i) competition with other krill predators, particularly with recovering large whales such as blue and humpback whales, and/or ii) decrease in the abundance of krill because of global warming (e.g. Trivelpiece *et al*., 2011)

Option i) is favored as the results of the oceanographic surveys showed no signs of global warming in the JARPAII research area. Furthermore abundance of some stocks of humpback, fin and blue whale in the research area are increasing significantly. Also GAM-based analysis showed a geographical expansion of the humpback whales in Area IV while the distribution of the Antarctic minke whale remained stable. This result suggests competition between humpback and Antarctic minke whales for habitat in Area IV as the abundance of humpback whales increased.

Antarctic minke and fin whales fed on Antarctic krill in the same areas. The krill eaten by the two species is of a similar size suggesting similar feeding habit, and no prey size selectivity.

b) Deteriorated environmental conditions are affecting survival of juveniles in mid and low latitude areas

The length at birth of the Antarctic minke whale is approximately 2.8m. The calves remain with their mothers until they are approximately 4.5m in body length. On the other hand no mother and calf pairs are observed in the Antarctic during the summer feeding season. Therefore calves separate from their mothers before arriving into the Antarctic feeding grounds. Antarctic minke whales smaller than 5m in body length were rarely observed in the JARPA and JARPAII research area. This information suggests that calf and juveniles spend most of their time in mid and lower latitude areas where the environmental conditions are more deteriorated than in the Antarctic. Mortality of juveniles could be due to deteriorated environmental conditions in lower latitudes (contamination, overfishing, competition, etc.). This explanation is consistent with low age at sexual maturity and constant and low (in comparison with the 1960's-1970's) recruitment rates.

c) Time lag

The apparent contradiction between low age at sexual maturity and low recruitment rates are due to a temporal phenomenon in that the response of age at sexual maturity to environmental changes may be subjected to time lags.

These results confirm that the Antarctic ecosystem is a dynamic one with important interaction among species and between species and the physical environment. Under such circumstances future management of Antarctic resources should be considered under a multi-species framework rather than one based on single species.

The development of an ecosystem model (Objective 2 of the JARPA II) is a first step toward the bigger goal of managing the Antarctic marine living resources under a multi-species or ecosystem approach. Output from the model will allow the prediction of future changes of the whale resource. Surplus production will be estimated from abundance data for each species, so that appropriate management objectives can be considered through the use of the model. The JARPAII has made progress toward the development of ecosystem models, which is the first step of the process (SC/F14/J26).

The JARPAII research plan had considered biological data from humpback and fin whales e.g. prey consumption, for modeling competition among whale species (Government of Japan, 2005). Sampling of these two species in addition to Antarctic minke whale in two Areas could provide an important opportunity to gain insight into the dynamics of whale stocks and inter-species competition through comparative analysis. In Area IV, Antarctic minke whales may decrease in response to competition, recovery of humpback whales may soon slow as they approach their pristine level, and fin whales are increasing. By contrast in Area V, there is less evidence of negative impacts on Antarctic minke whales at present, humpback whales are at a relatively lower proportion of their pristine abundance than in Area IV, and hence together with fin whales seems likely to continue to increase. Thus the different comparisons possible across species and Areas provide potential insights into whale dynamics, and consequently management actions for sustainable utilization (Government of Japan, 2005).

Research under the JARPAII confirmed that the abundance of some stocks of humpback, fin and blue whale in the research area are increasing significantly. Also GAM-based analysis showed a geographical expansion of the humpback whales in Area IV while the distribution of the Antarctic minke remained stable in the same Area and period.

Though the lethal data from humpback and fin whales are not used immediately in fits to the ecosystem models being developed, monitoring qualitative changes in trends in demographic parameters through these lethal data would provide a valuable method to check on the predictions from the ecosystem models.

Relevance of results for conservation and management

Antarctic minke whale

As noted above, Japan initiated the JARPA in order to resolve the scientific uncertainties related to the implementation of the NMP on Antarctic minke whale, to contribute to the 'comprehensive assessment' (CA) of the effects of the moratorium on whale stocks prescribed by paragraph 10 (e) of the Schedule to the ICRW, and thereby pave the way for the resumption and management of commercial whaling in a sustainable manner. The IWC SC carried out a CA of the Antarctic minke whale in 1990 (IWC, 1991), and subsequently it has continued with the assessment of this species. Since the year 2000, the IWC SC has been carrying out an in-depth assessment (IA) of the Antarctic minke whale, which is equivalent to the CA.

The JARPA and JARPAII contributed substantially with data and information to both the 1990 CA (IWC, 1991) and subsequent IA (e.g. IWC, 2010, 2011, 2012a, 2013b), mainly providing information on stock structure and abundance and through biological data for the application of the SCAA on Antarctic minke whale. On the latter point the JARPA biological data have been used by the IWC SC in its SCAA, which can account for the changes in overall abundance in terms of variations over time in mortality and recruitment (e.g. Punt *et al*., 2013-ForInfo 1). This provides an independent line of evidence. The JARPA II will continue contributing with these data for this kind of analyses, which are important for assessment. Key information from the JARPA and JARPAII are the individual age and abundance.

In summary the JARPA/JARPAII has contributed to the conservation and management of the Antarctic minke whale by:

- Providing new information on stock structure and mixing of Antarctic minke whale (SC/F14/J29), which is essential for future RMP *pre-implementation assessment* of this species in the Antarctic. The *pre-implementation assessment* requires plausible stock hypotheses. Previous RMP implementation for the Antarctic minke whale considered small areas of 10° longitude. The JARPA/JARPAII research provided a plausible stock structure hypothesis of at least two stocks in the JARPAII research area. The research showed that the extent of the mixing area and the stock proportion of two stocks change by year. This information is very important not only for the *pre-implementation assessment* but also for the *ISTs* as well.
- Providing refined information on some key biological parameters of Antarctic minke whale useful for management under the RMP, e.g. MSYR, natural mortality (Punt *et al*., 2013-ForInfo1). The demonstrated rapid rate of growth in the 1950s to 1970s shows that MSYR1+ cannot be as low as 1% (Punt *et al*., 2013-ForInfo1).
- The use of more realistic estimate of MSYR from JARPAII will allow an optimization in the use of the whale resource without risks to the stocks.
- Providing new information on abundance and abundance trend in the Antarctic minke whale based on sighting survey data (SC/F14/J3). This is a essential information for the *pre-implementation assessment* and *ISTs*. Stock structure information allows for a better interpretation of the abundance estimates.
- Providing new information on abundance trend through the SCAA analyses (Punt *et a*l., 2013-ForInfo1).

Humpback whale

- The JARPA/JARPAII provided new information on stock structure in the feeding grounds of Areas IIIE-VIW, which is important for the current IWC SC comprehensive assessment of Breeding Stocks D, E and F (SC/F14/J30-31). In particular, information on stock structure will allow for a better interpretation of the abundance estimates and the allocation of historical catches to stocks.
- The JARPA/JARPAII provided new information on abundance and abundance trend in the feeding grounds of Areas IIIE-VIW, which is important for the current IWC SC comprehensive assessment of

Breeding Stocks D, E and F (SC/F14/J4). Long-time series of sighting will provide information on the recovery of stocks in the Antarctic.

Fin whale

- Genetic analyses based on the JARPA/JARPAII samples suggested the possibility of genetic structuring of this species in the feeding grounds of Areas III-VIW (SC/F14/J32). In particular the possibility that Areas IV and V are occupied by different stocks has important implications for the interpretation of the abundance.
- The JARPA/JARPAII provided new information on abundance and abundance trend in the feeding grounds of Areas III-VIW, which is important for future IWC SC comprehensive assessment of this species in the Antarctic (SC/F14/J5). Long-time series of sighting will provide information on the recovery of stocks in the Antarctic.

Southern right whale

- The JARPA/JARPAII provided data for the first time examination of population genetic structure of this species in the Antarctic feeding grounds, which is useful for the conservation of this depleted species. Southern right whales seem to concentrate in summer mainly in Area IV. It is possible that Area IV contains whales from different stocks, including some originating from distant breeding grounds (SC/F14/J33).
- The JARPA/JARPAII provided abundance information of this species in the Antarctic feeding grounds (SC/F14/J5), which is useful for the conservation of this depleted species. Interpretation of the abundance estimate should take into consideration the fact that Area IV might contain whales from different stocks in summer.

7. FUTURE DIRECTION OF THE JARPAII

Firstly it should be noted here that the second period of the JARPAII (2011/12-2016/17) has already started under the original research plan (Government of Japan, 2005).

As shown in Sections 4-6 above considerable progress has been made in the research conducted under the JARPAII in the first period. For the analysis of temporal trends of biological and ecological parameters the combination of the JARPA and the JARPAII was particularly useful because of the long period involved (22-24 years). However some issues remain unresolved and new questions have emerged. In this section the major scientific considerations relevant on the future direction of JARPAII are presented.

a) Importance of multidisciplinary surveys

As explained in Annex 5, the JARPAII conducts different surveys (whale sampling, dedicated sighting and prey species surveys) in a comprehensive way to address the main objectives of the program: ecosystem monitoring and ecosystem modeling. In order to achieve this objective there is the need to maintain these multidisciplinary surveys in the future.

b) Importance of continuing monitoring of the Antarctic ecosystem

As explained in the introduction, monitoring is scientifically valuable as it provides time-series data on biological and ecological phenomena in the environment. The JARPA/JARPAII detected changes in the abundance and in biological parameters of krill predators. This was possible because of a long and systematic monitoring of biotic and abiotic parameters. It is important to continue the monitoring of environmental changes and the responses of whales to such changes especially under the circumstances of progressing climate change. The JARPAII has the potential to provide long time series data and therefore the potential for monitoring whales and their environment.

c) Importance of continuing monitoring temporal changes in stock structure of large whales

The JARPAII research showed that the distribution and mixing proportion of Antarctic minke whale stocks changes yearly. There is a possibility that such changes respond to yearly changes in krill availability and oceanographic conditions. Monitoring of changes in distribution and mixing rates of stocks are important in the context of the RMP *Implementation*. Continuing monitoring of oceanographical conditions and krill abundance are important to elucidate the reasons for the change in distribution and mixing of whale stocks.

d) Further progress toward the development of ecosystem models

During the first attempt to develop ecosystem models (SC/F14/J26) several new analyses and data were identified to make further progress in this work. These should be implemented in the next step.

Research under the JARPAII confirmed that the abundance of some stocks of humpback, fin and blue whale in the research area are increasing significantly. Also GAM-based analysis showed a geographical expansion of the humpback whales in Area IV while the distribution of the Antarctic minke whale remained stable. This could suggest a competition for habitat between the two species. These results emphasized the importance of further development of the ecosystem modeling work.

e) Contribution to single-species and multi-species-based management

As explained in Section 6, data and results of the JARPA/JARPAII have contributed to both management under the RMP (single-species management procedure) and started the work on ecosystem modeling, which could assist in implementing a policy of multi-species-based management in the future. Future data collected by the JARPAII will continue contributing to the management of living resources in the Antarctic.

f) Target species for the lethal component, sample size and research period

As explained in d) above Antarctic minke, fin and humpback whales are important target species for the lethal component of the JARPAII, mainly for both long-term monitoring of biological and ecological parameters and ecosystem modeling. These species should be listed for the next period of the JARPAII. Our intention is to maintain the plan as original proposed.

8. SUMMARY RESPONSE TO TOR OF THE JARPAII REVIEW WORKSHOP AS SPECIFIED IN ANNEX P

a. Review the scientific work undertaken thus far against the stated objectives of the programme

A summary of the analyses conducted under the four research objectives of the JARPAII is given in Section 4. Specifically information summarized in Documents J3-6 (abundance trends); J8-9, J11, ForInfo1, (biological parameters trends); J13-14 (body condition and stomach content weight trends); J17-18 (temporal change in distribution); J20-21 (temporal changes in oceanographic conditions); J23-24 (pollutant load trends), correspond to the progress made on Objective 1 of JARPAII (Ecosystem monitoring).

Information in Documents J15 (prey consumption of Antarctic minke whales), J19 (krill abundance) and J3-6 (abundance) were used as input parameters in the development of ecosystem models. Document J26 summarized the progress made in the developing of ecosystem models. All those documents showed the progress made on Objective 2 of JARPAII (Ecosystem modeling).

Information in Documents J28-29 (stock structure of Antarctic minke whale); J30-33 (stock structure of other baleen whale species) correspond to progress made on Objective 3 of JARPAII (Stock structure).

Information on natural mortality rate and MSYR of Antarctic minke whale in Documents ForInfo1, and on stock structure of this species (Documents J28-29) correspond to progress made on Objective 4 of JARPAII.

b. Review of other contributions to important research needs

As explained earlier the number of fin whales sampled was too low to allow analyses of temporal trends in biological and ecological parameters in the JARPAII period. However Documents J10, J16, J25 and J32 provided new information on biological parameters, feeding habit, pollutants and stock structure of this species in the Antarctic, which is important given the dated nature of the previous information.

New technical developments were presented in Documents J7 (estimation of abundance based on paternity test) and J12 (age determination based on aspartic acid racemization).

Document J22 presented novel information on marine debris in Antarctic waters and in the stomach contents of whales.

Novel information on physiology and reproductive biology of Antarctic minke whale was presented in Documents J35-37.

Finally a substantial set of photo-id material of humpback, blue and southern right whales was summarized in Document J34. Some of this material has been already used by IWC SC members in different studies on distribution and movements.

c. Review the techniques used (lethal and non-lethal)

A comparison of the merit/demerit of lethal and non-lethal sampling is not among the objectives of the JARPAII therefore no direct experiments comparing both techniques for particular research objectives were carried out. The JARPAII involves both lethal and non-lethal techniques to study whales and their environment.

The utility of both kinds of techniques for particular research objectives should be examined in a wide context e.g. a) is there a lethal or non-lethal technique available to collect the data for a particular research item?, b) if so, can the technique collects samples in number large enough for statistical analyses?, and c) can the technique collects samples in a random manner, which is necessary for some of the analyses? Table 4 shows an evaluation of lethal and non-lethal techniques in the context of the three questions above for main research items used in JARPAII.

Table 4. Evaluation of the utility of lethal and non-lethal techniques for some key research items of JARPAII.

		Can the method collect the data? (Availability)	Can it collect sufficient data? (Adequacy)	Can it collect representative data? (Adequacy)
Age (age structure, age at sexual maturity, recruitment)	Lethal	Yes[1]	Yes	Yes
	Non-lethal	No[2]		
Blubber thickness and other indices of body condition (feeding ecology)	Lethal	Yes	Yes	Yes
	Non-lethal	No		
Stomach content - qualitative (feeding ecology)	Lethal	Yes	Yes	Yes
	Non-lethal	Partly Yes[3]	No[4]	No[4]
Stomach content - quantitative (stomach fullness, ecosystem modeling)	Lethal	Yes	Yes	Yes
	Non-lethal	No		
DNA data (Stock structure and mixing)	Lethal	Yes	Yes	Yes
	Non-lethal	Yes[5]	No[6]	No[6]
Pollutant and observation of internal organs (pathology)	Lethal	Yes	Yes	Yes
	Non-lethal	Partly Yes	No	No
Sighting (abundance estimates)	Lethal	No	No	No
	Non-lethal (Sighting survey)	Yes	Yes	Yes
Movements, behavior, habitat preference	Lethal	Partly Yes[7]	No	Partly Yes[8]
	Non-lethal (Tagging)	Yes[9]	No[10]	No[10]

Footnote 1 and 2. The age determination is based on earplug, which has proved to be a valid and useful tool for age determination in the Antarctic minke whale, and it is the only method providing age data accurate enough. Biological parameter estimates require examination of reproductive tracts. The expert workshop to review results of the Icelandic research program agreed that 'practicability' of lethal techniques for age determination and estimate of biological parameters is 'high' in most of the cases (IWC, 2013e). Other methods based on DNA telomere (and then potential use of biopsy) have been attempted for age determination but they are far from being reliable at this stage.

Footnotes 3 and 4. Some alternative non-lethal methods could reveal the kind of prey consumed by the whale based on DNA analysis of feces. Other non-lethal methods investigate the diet composition through stable isotopes and fatty acids in skin (biopsy). The Icelandic workshop concluded that the practicability of lethal techniques to investigate the diet composition through stable isotopes in blood (scale of few days) is 'high' and that to investigate diet composition through stable isotopes in skin (scale of up to 2-3 months) is high for both lethal and non-lethal techniques (IWC, 2013e). The same workshop agreed that the 'practicability' of lethal techniques to investigate the diet composition through stomach content analysis (most recent feeding) is 'high'

(IWC, 2013e). On this last point, a similar opinion was reached by the expert panel to review the whale research program in the western North Pacific (IWC, 2009c). For the case of analysis of energetic through lipid mass reserves, the Icelandic workshop concluded that the practicability of lethal techniques is 'high' and that of non-lethal techniques is 'low'. It can be inferred therefore that the non-lethal techniques can not provide information of diet composition of 'recent feeding'. Non-lethal techniques can provide information on diet composition based on stable isotopes in skin but the time scale is of '2-3 months'. On the other hand the difficulty in obtaining biopsy samples from minke whales means that large and representative sample sizes cannot be obtained by such techniques.

Footnotes 5 and 6. DNA can be obtained from skin samples obtained by biopsy. Biopsy samples from the Antarctic minke whales have been obtained in limited number in some studies (e.g. Gales *et al*., 2013). Biopsy sampling from Antarctic minke whales in this study was conducted on an opportunistic basis under conditions that are not representative of typical surveys e.g. optimal weather conditions, large school sizes, near the pack-ice. There is still a question of whether a large number of biopsy samples can be obtained from the Antarctic minke whale in offshore waters where the sea condition are rough and the school sizes are smaller. A large number of samples is required to study the yearly changes in distribution and mixing of Antarctic minke whale stocks.

Footnotes 7 and 8. Movement of whales within the feeding grounds can be investigated through Discovery marks. Recovery of marks depends on whaling operations. Discovery mark experiments were conducted through transect line during the IDCR sighting cruises in the past.

Footnotes 9 and 10. A limited number of Antarctic minke whales have been tagged using different types of satellite tags recently (e.g. Gales *et al*., 2013), providing information on movement, behavior and habit preference. As with the biopsy sampling satellite tagging was conducted on an opportunistic basis under conditions that are not representative of typical surveys e.g. optimal weather conditions, large school sizes, near the pack-ice. There is still a question of whether a large number of tagged whales can be obtained from the Antarctic minke whale in offshore waters where the sea condition are rough and the school sizes are smaller.

In the JARPAII the most appropriate technique (lethal or non-lethal) has been selected for the particular research items. The best approach to address the JARPAII research objectives is the combined use of non-lethal (e.g. sighting surveys, prey surveys, biopsy, etc.) and lethal (e.g. sampling of earplugs, reproductive organs, stomach contents, etc.) techniques.

d. Appropriate sample sizes

Details of the procedure for estimating sample sizes are given in the Appendices 4, 6, 7 and 8 of the original JARPAII research plan (Government of Japan, 2005).

Sample sizes were estimated with the aim of monitoring yearly changes in some biological parameters considered as 'indicators' of changes in the ecosystem e.g. pregnancy rate, age at sexual maturity, blubber thickness. The analytical procedure for estimating sample size considered three aspects, a) the level of statistical accuracy we are seeking, b) the extent (rate) of the biological changes that we wish to detect, and c) the period of time within which we wish to detect those biological changes (see Annex 5). Regarding a) the 5% level of accuracy which is the norm employed by the IWC SC was chosen; regarding b) rate of change in different biological parameters of Antarctic minke whale was obtained from observations in the 18-year long JARPA research period, while those information in the case of humpback and fin whales was obtained from the period of commercial whaling; with regards to c) a period of six years was chosen in the case of Antarctic minke whale as established in the original research plan as the period for periodic review, which coincides with the RMP *Implementation* review period (IWC, 2012d), and 12 years in the case of humpback and fin whales for precautionary reasons. It should be added here that monitoring qualitative changes in trends in demographic parameters through the lethal data for humpback and fin whales do not need results with as high precision as for Antarctic minke whales.

The annual sample size of Antarctic minke whales was set at 850 animals +/- 10%. This figure obviously represent a compromise between different parameters, chosen because it satisfies the statistical conditions for most of the research items, and because catches at that level will cause no harm to the stocks. The sample size of humpback and fin whales was set at 50 animals.

For the reasons explained in Annex 6 the estimated sample size of 850 animals in the case of the Antarctic minke whale could not be attained except for one season (2005/06). For the same reasons only 16 fin whales were sampled in the six-year period. This should decrease the statistical power to detect significant temporal changes in parameters in the six-year period.

In the case of the Antarctic minke whale the trend in three key parameters was estimated using the same method as explained in the original research plan of the JARPAII, based on the number of samples/data obtained in the period 2005/06-2010/11. SC/F14/J9 estimated the temporal trend of the apparent pregnancy rate during the JARPAII period using the method proposed in the research plan e.g. linear regression analysis. No significant trend was observed in this period. SC/F14/J8 examined temporal changes in the age at sexual maturity for recent cohorts sampled during the JARPAII period. No significant trend was observed in this period, except in the case of females of the P stock. However the precision of this estimate was considered low probably due to the small sample sizes. SC/F14/J13 examined the temporal trend in blubber thickness for both the periods of the JARPA and the JARPAII. The decreasing trend observed in the JARPA period was not observed during the JARPAII period.

In general, no significant increasing or decreasing trends were detected in those parameters in the JARPAII period. Two possible interpretations for those results are the following: a) there was no trend in the parameters in the period investigated and b) the number of samples was too small to detect any significant trend in the six-year period.

e. Effects on any catches on the relevant stocks

The study conducted in SC/F14/J38, which considered updated information on abundance and stock structure of the Antarctic minke whale concluded that there would be no negative effect on the stocks of the future JARPAII catches.

f. Relationship of the research results to relevant IWC resolutions and discussions

The following resolutions are potentially relevant to the JARPAII research.

- Resolution recommending non-lethal research

Resolution 1995-9 (IWC, 1996a) recommended Contracting Governments to use non-lethal methods and instructed the IWC SC to review Special Permit research. One of the main characteristics of the JARPAII is the combination of both lethal and non-lethal surveys, which is important for achieving the main objectives of the research program. Some of the biological information from whales can be obtained only through the lethal approach (see TOR 'c' above).

- Resolutions encourage study of environmental change

Resolution 1994-13 (IWC, 1995) encouraged Contracting Governments and the Scientific Committee to study environmental changes and impact on cetaceans. Resolution 1995-10 (IWC, 1996b) encouraged Contracting Governments to study the effects of pollutants on cetaceans as recommended by the Bergen workshop. Resolution 1997-7 (IWC, 1998b) encourages Contracting Governments to continue to provide information on environmental changes and potential effects on cetaceans. Resolution 1999-4 (IWC, 1999) request Contracting Governments to provide the IWC SC with data on contaminants in cetaceans.

As shown in Section 4.1, the JARPAII included a comprehensive monitoring and assessment of chemical pollutants in whales and their preys. Therefore the JARPAII is investigating several of the topics mentioned in those Resolutions.

- Resolution on the establishment of SWG-E (Standing Working Group on Environmental Concerns)

Resolution 1998-7 (IWC, 1998c) invited the GOJ to take full advantage of the existing mechanisms for cooperation between national research programs and the SWG-E on environmental research in the Antarctic. Japan accepted this invitation positively and will cooperate by providing the information on environmental research obtained in the JARPAII (see Section 4.1).

- Resolution on the interaction between whales and fish stocks

Resolution 2001-9 (IWC, 2001) acknowledges that a 'better understanding of marine ecosystems, including interaction between whales and fish stocks, would contribute to the conservation and management of living marine resources and is of interest to nations as well as to regional fisheries management organizations and international research organizations'. The JARPAII is in the process of contributing to the understanding of the Antarctic marine ecosystem through the development of multi-species models (see Section 4.2). The output of such models will be used as the basis for the implementation of management policies based on multi-species approaches in the future.

9. CONCLUDING REMARKS

Results of the first period of the JARPAII confirmed the shift in the Antarctic ecosystem suggested first by the the JARPA research. Notably the JARPAII research confirmed that several baleen whale species and stocks are recovering from the past over-exploitation, and as a result, the whale species composition is changing in the JARPAII research area. These species are increasing their abundance and expanding geographically, and this process has effects in the whole ecosystem.

The JARPAII also confirmed that since the 1980's, some ecological indices for the Antarctic minke whale have been changing e.g. several indicators of body conditions and stomach content weight have decreased, probably because less food is available for Antarctic minke whales in recent years. Less krill availability for Antarctic minke whale could be due to global warming which affect the krill biomass directly and/or the increase of other krill-eater, especially other whale species. Information derived from the JARPAII showed no evidence of global warming in the research area and therefore the interaction with other whale species seems to be a more plausible explanation for the change in krill availability for the Antarctic minke whale.

Despite the above-mentioned adverse environmental conditions, information derived from the JARPAII showed that the Antarctic minke whale has maintained a high reproductive rate as indicated by its high pregnancy rate and decreased age at sexual maturity. On the other hand, recruitment has maintained a constant trend at a low level in recent years compared with those in the 1960's and 1970's. Therefore one of the main outputs of the JARPAII research is the suggestion that the Antarctic minke whale is not responding to the adverse environmental conditions in the same way as it responded to improved environmental conditions in the middle of the last century. This has brought several new scientific questions that should be addressed with additional research.

Apart from these ecological findings, the JARPAII provided a substantial amount of new information on stock structure and abundance, which are useful for the assessment, management and conservation of several species such as the blue, fin, humpback southern right and Antarctic minke whales in the context of the work of the IWC SC.

These interesting and useful results and information could not be possible without a long-term, systematic and comprehensive research programme like the JARPAII in the first period. Furthermore, such comprehensive research could not be achieved without the combined use of lethal and non-lethal techniques as is the case of the JARPAII.

The new scientific questions emerging from the results from the first period of the JARPAII can be properly responded only with additional scientific information (samples and data) to be systematically collected by the JARPAII in its following periods in the same way as carried out in the first period. It should be noted however that Japan is ready to modify the JARPAII, if necessary, given full consideration to the discussions and outcome of the JARPAII review workshop.

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Annex 1. List of documents for the IWC SC JARPAII Review Workshop

Primary documents

SC/F14/J1. Pastene, L.A., Fujise, Y. and Hatanaka, H. The Japanese Whale Research Program under Special Permit in the Antarctic (JARPA II): origin, objectives, research progress made in the period 2005/06-2010/2011, and relevance for management and conservation of whales and the ecosystem.

SC/F14/J2. Nishiwaki, S., Ishikawa, H., Goto, M., Matsuoka, K. and Tamura, T. Review of general methodology and survey procedure under the JARPA II.

SC/F14/J3. Hakamada, T. and Matsuoka, K. Estimates of abundance and abundance trend of the Antarctic minke whale in Areas IIIE-VIW, south of 60°S, based on JARPA and JARPAII sighting data (1989/90-2008/09).

SC/F14/J4. Hakamada, T. and Matsuoka, K. Estimates of abundance and abundance trend of the humpback whale in Areas IIIE-VIW, south of 60°S, based on JARPA and JARPAII sighting data (1989/90-2008/09).

SC/F14/J5. Matsuoka, K. and Hakamada, T. Estimates of abundance and abundance trend of the blue, fin and southern right whales in Areas IIIE-VIW, south of 60°S, based on JARPA and JARPAII sighting data (1989/90-2008/09).

SC/F14/J6. Hakamada, T. and Matsuoka, K. Estimates of abundance and abundance trend of the sperm, southern bottlenose and killer whales in Areas IIIE-VIW, south of 60°S, based on JARPA and JARPAII sighting data (1989/90-2008/09).

SC/F14/J7. Kanda, N., Goto, M. and Pastene, L.A. Paternity analysis on Antarctic minke whales using JARPA and JARPAII samples.

SC/F14/J8. Bando, T., Kishiro, T. and Kato, H. Yearly trend in the age at sexual maturity of Antarctic minke whales examined by transition phase in earplugs collected during JARPA and JARPAII surveys.

SC/F14/J9. Bando, T. and Hakamada, T. Yearly trend in the proportion of pregnant animals among mature female Antarctic minke whales in the JARPA and JARPAII period.

SC/F14/J10. Mogoe, T., Bando, T., Maeda, H., Kato, H. and Ohsumi, S. Biological observations of fin whales sampled by JARPAII in the Antarctic.

SC/F14/J11. Kitakado, T., Lockyer, C. and Punt, A.E. A statistical model for quantifying age-reading errors and its application to the Antarctic minke whales.

SC/F14/J12. Yasunaga, G., Bando, T. and Fujise, Y. Preliminary estimation of the age of Antarctic minke whales based on aspartic acid racemization.

SC/F14/J13. Konishi, K. and Walloe, L. Time trends in the energy storage in the Antarctic minke whales during the JARPA and JARPAII research periods.

SC/F14/J14. Konishi, K., Hakamada, T., Kiwada, H., Kitakado, T. and Walloe, L. Decrease in stomach contents in the Antarctic minke whale (*Balaenoptera bonaerensis*) in the Southern Ocean. (This paper can not be cited except in the context of IWC meetings until is formally published in *Polar Biology*).

SC/F14/J15. Tamura, T. and Konishi, K. Prey composition and consumption rate by Antarctic minke whales based on JARPA and JARPA II data.

SC/F14/J16. Tamura, T. Preliminary analyses on prey consumption by fin whales based on JARPAII data.

SC/F14/J17. Matsuoka, K. and Hakamada, T. Distribution pattern of whale species sighted in the Antarctic based on JARPA and JARPAII sighting surveys (1987/88-2008/2009).

SC/F14/J18. Murase, H., Matsuoka, K., Hakamada, T. and Kitakado, T. Preliminary analysis of changes in spatial distribution of Antarctic minke and humpback whales in Area IV during the period of JARPA and JARPAII from 1989 to 2006.

SC/F14/J19. Wada, A. and Tamura, T. Estimation of krill biomass based on JARPAII acoustic surveys.

SC/F14/J20. Watanabe, T., Okazaki, M. and Matsuoka, K. Results of oceanographic analyses conducted under JARPA and JARPAII and possible evidence of environmental changes.

SC/F14/J21. Naganobu, M., Matsuoka, K., Murase, H. and Kutsuwada, K. Consideration on the Kerguelen-Davis Oscillation Index (KDOI) influencing variability on environmental ecosystem in the Prydz Bay Region, east Antarctic: data exploration.

SC/F14/J22. Isoda, T., Tamura, T., Nishiwaki, S and Pastene, L.A. Observation of marine debris in the Antarctic based on JARPA and JARPAII data.

SC/F14/J23. Yasunaga, G., Bando, T. and Fujise, Y. Pattern of mercury accumulation in the Antarctic minke whale and its prey based on JARPAII data.

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SC/F14/J25. Yasunaga, G. and Fujise, Y. A note on mercury and organochlorine accumulation in the Antarctic fin whale based on JARPAII data.

SC/F14/J26. Kitakado, T., Murase, H., Tamura, T. and Yonezaki, S. An attempt to ecosystem modelling for species in Area IV in the Antarctic Ocean using JARPA and JARPAII data.

SC/F14/J27. Kanda, N., Goto, M., Oikawa, H. and Pastene, L.A. A note on sampling and laboratory procedure protocols of the genetic work at the Institute of Cetacean Research.

SC/F14/J28. Pastene, L.A., Goto, M. and Kanda, N. An update of the genetic study on stock structure of the Antarctic minke whale based on JARPAII samples.

SC/F14/J29. Kitakado, T., Schweder, T., Kanda, N., Pastene, L.A. and Walloe, L. Dynamic population segregation by genetics and morphometrics in Antarctic minke whales.

SC/F14/J30. Pastene, L.A., Kitakado, T., Goto, M. and Kanda, N. Mixing rates of humpback whales from Stocks D, E and F in the Antarctic feeding grounds based on mitochondrial DNA analyses (Doc. SC/65a/SH13. This paper can be cited only in the context of the IWC meetings).

SC/F14/J31. Kanda, N., Goto, M. and Pastene, L.A. Stock structure of humpback whales in the Antarctic feeding grounds as revealed by microsatellite DNA data.

SC/F14/J32. Goto, M., Kanda, N. and Pastene, L.A. Genetic analysis on stock structure of fin whales in the Antarctic based on mitochondrial and microsatellite DNA.

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For information documents

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Annex 2. A summary of sample and data collected by JARPAII in the first period (2005/06-2010/11)

This annex shows the list of sample/data produced by JARPA II in the first six-year period, including both lethal and non-lethal techniques. It should be noted that the items and number of samples by item in this annex are not necessarily the same as those shown in cruise reports and in SC/F14/J2. This annex considered the samples and data loss due the 2011 earthquake and tsunami.

Abundance estimate several species[1]

	Seasons	Sample size
1. Angle and distance experiments	2005/06-2010/11	2,617 tests
2. Ice edge line	2005/06-2010/11	4,234 points
3. Effort data	2005/06-2010/11	43,161 activities
4. Weather data	2005/06-2010/11	34,694 records
5. Sighting Ant. minke whale	2005/06-2010/11	7,344 sch.
6. Sighting fin whale	2005/06-2010/11	605 sch.
7. Sighting humpback whale	2005/06-2010/11	4,570 sch.
8. Sighting blue whale	2005/06-2010/11	146 sch.
9. Sighting southern right whale	2005/06-2010/11	150 sch.
10. Sighting sperm whale	2005/06-2010/11	894 sch.
11. Sighting southern bottlenose whale	2005/06-2010/11	310 sch.
12. Sighting killer whale	2005/06-2010/11	352 sch.

Ecological data (oceanographic, marine debris, krill)

13. Temperature (XBT)	2005/06-2010/11	18 stations
14. Temp. Salin. (XCTD)	2005/06-2010/11	347 stations
15. Temp. Salin. (CTD)	2005/06-2010/11	361 stations
16. Temp. Salin. (EPCS)	2005/06-2010/11	482 days
17. Marine debris (stomach)[2]	2005/06-2010/11	3,280 whales
18. Marine debris (sea surface)	2005/06-2010/11	88 cases of debris observations
19. Echo sound (krill abundance/dist.)	2007/08, 2008/09	326 days
20. IKMT net	2007/08, 2008/09	68 stations
21. Body length krill	2007/08, 2008/09	68 stations

Antarctic minke whale (biological, feeding ecology, pollutants, stock structure data)

	Seasons	Sample size
Biological data		
22. Catching date	2005/06-2010/11	3,264 whales
23. Catching location	2005/06-2010/11	3,264 whales
24. Sex	2005/06-2010/11	3,264 whales
25. Body length	2005/06-2010/11	3,264 whales
26. Age (earplug)[3]	2005/06-2010/11	3,264 whales
27. Age (racemization)[4]	2005/06-2010/11	41 whales
28. Transition phase[5]	2005/06-2010/11	3,264 whales
29. Presence/absence of corpora[6]	2005/06-2010/11	1,701 whales
30. Testis weight[7]	2005/06-2010/11	1,563 whales
31. Fetus length	2005/06-2010/11	1,127 whales
32. Fetus weight	2005/06-2010/11	1,127 whales
33. Fetus number[8]	2005/06-2010/11	1,701 whales
34. Fetus sex	2005/06-2010/11	1,127 whales
35. Lactation condition	2005/06-2010/11	1,701 whales
Feeding Ecol/Energetic		

36. Blubber thickness (two points)	2005/06-2010/11	3,264 whales
37. Body weight	2005/06-2010/11	1,598 whales
38. Freshness stom. contents	2005/06-2010/11	1,925 whales
39. Main prey	2005/06-2010/11	332 whales
40. Organ weight including fat weight	2005/06-2010/11	76 whales
41. Girth (two points)	2005/06-2010/11	3,264 whales
42. Stom. content (IWS)	2005/06-2010/11	3,264 whales
43. Stom. content weight	2005/06-2010/11	2,953 whales
44. Lipid content in blubber	2005/06-2010/11	35 whales
Pollutants/health[9]		
45. Heavy metals (whale)	2005/06-2010/11	195 whales
46. Organochlorine (whale)	2005/06-2010/11	10 whales
47. Heavy metal (prey)	2005/06-2010/11	20 preys
48. Gross pathological observations of internal organs[10]	2005/06-2010/11	3,264 whales
Stock structure		
49. Body proportion (8 measurements)	2005/06-2010/11	3,264 whales
50. mtDNA (sequences) (from catches)	2005/06-2010/11	1,803 whales
51. mtDNA (RFLP) (from catches)	2005/06	764 whales
52. Microsatellite DNA (from catches)	2005/06-2010/11	2,553 whales

Antarctic fin whale (biological, feeding ecology, pollutants, stock structure data)

	Seasons	Sample size
Biological data		
53. Catching date	2005/06-2010/11	17 whales
54. Catching location	2005/06-2010/11	17 whales
55. Sex	2005/06-2010/11	16 whales
56. Body length	2005/06-2010/11	16 whales
57. Age (earplug)[3]	2005/06-2010/11	16 whales
58. Transition phase[5]	2005/06-2010/11	16 whales
59. Presence/absence of corpora[6]	2005/06-2010/11	8 whales
60. Testis weight[7]	2005/06-2010/11	8 whales
61. Fetus length	2005/06-2010/11	3 whales
62. Fetus weight	2005/06-2010/11	3 whales
63. Fetus number[8]	2005/06-2010/11	8 whales
64. Fetus sex	2005/06-2010/11	3 whales
65. Lactation condition	2005/06-2010/11	8 whales
Feeding Ecol/Energetic		
66. Blubber thickness (14 points)	2005/06-2010/11	16 whales
67. Body weight	2005/06-2010/11	15 whales
68. Freshness stom. contents	2005/06-2010/11	14 whales
69. Main prey	2005/06-2010/11	15 whales
70. Organ weight including fat weight	2005/06-2010/11	15 whales
71. Girth (three points)	2005/06-2010/11	16 whales
72. Stom. content (IWS)	2005/06-2010/11	16 whales
73. Stom. content weight	2005/06-2010/11	15 whales
74. Lipid content in blubber	2005/06-2010/11	10 whales
Pollutants/Health[9]		

75. Heavy metals (whale)	2005/06-2010/11	16 whales
76. Organochlorine (whale)	2005/06-2010/11	16 whales
77. Gross pathological observations of internal organs[10]	2005/06-2010/11	16 whales
Stock structure		
78. External measurements (41)	2005/06-2010/11	16 whales
79. mtDNA (sequences) (catches and biopsy)	2005/06-2010/11	C: 17; B: 13 whales
80. Microsatellite DNA (catches and biopsy)	2005/06-2010/11	C: 17; B: 13 whales

Stock structure other species

	Seasons	Sample size
Humpback whale		
81. mtDNA (sequences) (biopsy)	2005/06-2010/11	133 whales
82. Microsatellite DNA (biopsy)	2005/06-2010/11	? whales[11]
83. Photo-ID data	2005/06-2010/11	1,201 pictures
Blue whale		
84. mtDNA (sequences) (biopsy)	2005/06-2010/11	11 whales
85. Photo-ID data	2005/06-2010/11	376 pictures
Southern right whale		
86. mtDNA (sequences) (biopsy)	2005/06-2010/11	34 whales
87. Microsatellite DNA (biopsy)	2005/06-2010/11	34 whales
88. Photo-ID data	2005/06-2010/11	671 pictures

Annotations

1. Standard Line Transect data. It should be noted that in some JARPA II surveys some areas could not be covered due to external interferences and sabotages from anti-whaling groups, and that some kind of interpolation will be necessary.

2. The figure given corresponds to the total number of stomachs examined.

3. JARPA II age data of Antarctic minke whale were obtained by a new reader with expertise and training enough for this kind of work. The figure given here are the total number of earplugs examined. Age information could be obtained for 81.8% of the total samples. An ageing calibration exercise was carried out (see Kitakado et al., 2013). In the case of the fin whales age information could be obtained for 100% of the samples.

4 .This sample size corresponds to the results of a pilot study to investigate the feasibility of the racemization method for ageing purposes. At this stage these data were not produced for the purpose of biological parameters estimates but for examining the feasibility of the technique.

5. The figure given corresponds to the total earplugs examined. Transition Phase information in the Antarctic minke whales could be obtained for approximately 42.1% of the total samples (mature+immature). In the case of the fin whales transition phase information could be obtained for one animal out of 16.

6. Ovary samples were lost as an effect of the 2011 earthquake and tsunami so information on the number of corpora is not available. Information on the presence/absence of corpora (information necessary for determining sexual maturity in females) is based on examination of the ovaries conducted at the field.

7. While in JARPA both testis weight and histological approaches were used for determining sexual maturity in males, in JARPA II maturity of males was determined only by the testis weight criterion (due to 'man-power' limitation and economical considerations).

8. The figure given corresponds to the total females examined.

9. The 2011 earthquake and tsunami affected heavily the samples collected for pollutant studies. This explains the particular smaller samples size for this item.

10. This figure corresponds to the total number of whales examined for abnormal tissues or organs in gross pathology.

11. Due to 'man-power' limitation, the microsatellite data could not be obtained in time for this report. It is possible that some microsatellite data are produced at a later stage. People interested in genetic data for stock structure studies of humpback whales should consult the person in charge directly (see 'Contact details' below).

Annex 3. Protocol for access to samples/data from the Institute of Cetacean Research (ICR), Tokyo, Japan, under Procedure B

INTRODUCTION

This protocol has been developed in the context of Procedure B of the IWC Scientific Committee's rules for data availability adopted at the 55th Annual Meeting (*Journal of Cetacean Research and Management* 6 (suppl.): in press). Procedure B applies to data required for analyses deemed important in providing advice to the Committee other than catch limits. Conditions for data recipients (repeated below) as specified in the rules for data availability are applicable.

It was agreed that the Committee shall specify the nature of the work and the data required during the meeting at which the recommendation is made, to the fullest extent possible in the time available at the meeting and in accord with the published protocol. Requests to the ICR for data under Procedure B of the Scientific Committee's rules for data availability shall be submitted by the Data Availability Group assisted by a nominated member of ICR.

It was also agreed that if the correct process is followed, the data owners will normally approve the applications within a 'specified time period'; in this case ICR agrees that it will respond within two weeks of receiving an application.

FORMAT OF THE APPLICATION

The format for the application is based on the revised application for catch-at-age analyses agreed by all members of the Scientific Committee at the end of the Scientific Committee meeting in 2003 (Annex G, Appendix 11).

(a) *Title* of the proposal, giving the broad subject of the proposed analyses.

(b) *Investigators:* the full name and affiliation of the principal investigator(s) and co-investigator(s) should be provided. This should include at least one scientist from ICR.

(c) *Objectives and rationale of the study* as specified by the by the Scientific Committee along with the appropriate reference to the report(s) of the Scientific Committee. This will include the reasons why the proposed analyses are important and how they fit into previous work.

(d) *Data to be used* will include a general description of all data to be used as well as data held by ICR. For the ICR-held data, the precise requirements will be given, including the level of disaggregation.

(e) *Description of the methods* likely to be used. The level of detail must be in accordance with the level of novelty of the proposed methods and the particular research questions they will address. References to similar analyses should be included where available.

(f) *Schedule of the work:* this should include estimated times for the various analyses to be carried out and an indication of which investigators will collaborate on individual components. If the project is a long-term project, annual progress reports will be required by ICR and the Scientific Committee.

(g) *Output of the research:* this will follow the rules for publication agreed at the Scientific Committee meeting and given below. ICR may consider requests for less stringent conditions (e.g. presentations at non-IWC scientific meetings, publications, etc.). Such requests should be detailed here.

CONSIDERATION OF THE PROPOSAL

If an application has been approved by the whole Scientific Committee at an annual meeting, it will normally be approved by ICR. However, the final decision will always remain the prerogative of ICR. ICR may request reviews by an internal review group and/or external experts. The following factors will be taken in to account by ICR when considering applications.

(a) *Priority:* highest priority for analysis/research of samples/data produced by Japan's Whale Research Programs under Special Permit, will be for the scientists that collected and obtained the data in any particular field.

(b) Suitability of the requested data in the context of the proposed methods and the objectives of the research.

(c) *Level of co-operation with ICR scientists.*

The response to an application for data will be communicated by the ICR's Director General to the Data Availability Group and may include requests for further information. If the research proposal is accepted, ICR will nominate a scientist, (normally one of the co-investigators) who shall be responsible for making the necessary arrangements to provide the required samples/data.

Agreed Scientific Committee conditions for data recipients

Applications deemed suitable under Procedure A or Procedure B below are granted under the following conditions:

(1) Data shall not be transmitted to third parties.
(2) Papers may only be submitted to a Committee meeting in accordance with the time restrictions given below. Such papers must not include the raw data or the data in a form in more detail than is necessary to understand the analysis.
(3) Papers must carry a restriction on citation except in the context of IWC meetings.
(4) Data owners are offered co-authorship.
(5) Publication rights remain strictly with the data owner.
(6) Data shall be returned, to the Secretariat or the data owner as appropriate, immediately after the meeting at which the paper is submitted and any copies destroyed, unless an extension is granted.
(7) Data requesters sign a form agreeing to the above conditions. Such forms will be held by the data owner and the Secretariat. In the case of Procedure B, the Data Availability Group will sign the agreement on the Committee's behalf and ensure that the conditions of any agreement are met by any individual scientists involved in the analysis.
(8) In the event of a breach of the conditions in (6), serious sanctions [to be determined] will apply.

Annex 4. Summary of the work carried out by Japanese scientists in response to several recommendations and suggestions on JARPA research offered by the IWC SC in 2007 (Update of the table published in IWC, 2008, pp 349)

Recommendation or suggestion	**In the JARPA review report**	**Updated status (as for June 2013)**
AE (Abundance estimates for-Antarctic minke whales)		
1. Conduct further investigation of SC/D06/J3 approach using simulation studies to assess correction performance	Suggested	Not addressed yet.
2. On Skip C, investigate the possibility of post-application of the adaptive sampling to closing mode survey for finding better correction formulae	Suggested	Not addressed yet.
3. Investigate whether satellite data may provide more accurate information on the ice-edge for the DSM (density surface model)	Suggested	Not addressed yet.
4. To fit a model which is able to account for heteroscedascity in sampling variance and incorporate additional variance	Agreed	Addressed in a published paper: Hakamada, T., Matsuoka, K., Nishiwaki, S. and Kitakado, T. Abundance estimates and trends for Antarctic minke whales (*Balaenoptera bonaerensis*) in Antarctic Areas IV and V based on JARPA sighting data (*Journal of Cetacean Research and Management*- in press)
5. Regarding detection function estimation, as a guideline, detection functions should be estimated using an absolute minimum of 15 sightings. Where fewer sightings occur pooling should be undertaken	Recommended	Addressed in a published paper: Hakamada, T., Matsuoka, K., Nishiwaki, S. and Kitakado, T. Abundance estimates and trends for Antarctic minke whales (*Balaenoptera bonaerensis*) in Antarctic Areas IV and V based on JARPA sighting data (*Journal of Cetacean Research and Management*- in press)
6. Regarding variance estimation from the SSV data, the data to be re-analyzed treating all three parallel transect legs as the sampling unit	Recommended	Addressed in a published paper: Hakamada, T., Matsuoka, K., Nishiwaki, S. and Kitakado, T. Abundance estimates and trends for Antarctic minke whales (*Balaenoptera bonaerensis*) in Antarctic Areas IV and V based on JARPA sighting data (*Journal of Cetacean Research and Management*- in press)
7. Regarding the accounting for the order that the strata were surveyed (which is relevant for trend estimation), a generalized linear modeling approach (similar to that conducted in SC/D06/J6) be taken whereby appropriately chosen covariates or factors (such as the middle date that a stratum was surveyed in a given year) could be included to enable more valid between-year comparisons	Recommended	Addressed in a published paper: Hakamada, T., Matsuoka, K., Nishiwaki, S. and Kitakado, T. Abundance estimates and trends for Antarctic minke whales (*Balaenoptera bonaerensis*) in Antarctic Areas IV and V based on JARPA sighting data (*Journal of Cetacean Research and Management*- in press)
8. Additional variance be estimated as well as taking due account of estimates of sampling variance for each stratum	Recommended	Addressed in a published paper: Hakamada, T., Matsuoka, K., Nishiwaki, S. and Kitakado, T. Abundance estimates and trends for Antarctic minke whales (*Balaenoptera bonaerensis*) in Antarctic Areas IV and V based on JARPA sighting data (*Journal of Cetacean Research and Management*- in press)
9. Regarding estimation of effective strip width and mean school size from the SSV data, sensitivities to the pooling of three SSV tracklines for estimation of effective strip width and mean school size, be investigated	Recommended	Addressed in a published paper: Hakamada, T., Matsuoka, K., Nishiwaki, S. and Kitakado, T. Abundance estimates and trends for Antarctic minke whales (*Balaenoptera bonaerensis*) in Antarctic Areas IV and V based on JARPA sighting data (*Journal of Cetacean Research and Management*- in press)
10. Regarding extrapolation into	Recommended	Addressed in a published paper:

unsurveyed areas, it would be valuable to bound the problem by examining results for which the abundance in the unsurveyed area is treated as zero		Hakamada, T., Matsuoka, K., Nishiwaki, S. and Kitakado, T. Abundance estimates and trends for Antarctic minke whales (*Balaenoptera bonaerensis*) in Antarctic Areas IV and V based on JARPA sighting data (*Journal of Cetacean Research and Management*- in press)
11. Where such (primary E-W) extrapolation are necessary, the ratio of density in the unsurveyed area to the surveyed area be calculated from data in other years. The product of this ratio and the density in the surveyed area in that year would be used as the estimated density to extrapolate into the unsurveyed area in that year	Recommended	Addressed in a published paper: Hakamada, T., Matsuoka, K., Nishiwaki, S. and Kitakado, T. Abundance estimates and trends for Antarctic minke whales (*Balaenoptera bonaerensis*) in Antarctic Areas IV and V based on JARPA sighting data (*Journal of Cetacean Research and Management*- in press)
12. Regarding analysis using the saw-tooth track line design, all transects would be useful at least in estimating effective strip width and mean school size (and their variances). In order to more fully understand the results in Table 4 of J6 and their implications, the sensitivity analyses of J6 are repeated but with appropriate weighting of the data (e.g. in proportion to the number of sightings within a stratum), and/or by bootstrapping (conditional on the total number of sightings)	Agreed	Addressed in a published paper: Hakamada, T., Matsuoka, K., Nishiwaki, S. and Kitakado, T. Abundance estimates and trends for Antarctic minke whales (*Balaenoptera bonaerensis*) in Antarctic Areas IV and V based on JARPA sighting data (*Journal of Cetacean Research and Management*- in press)
Abundance estimates for humpback whale		
13. Regarding the estimation of trend in humpback whales further refinement of the linear model, as discussed for minke whales, by incorporating process error as well as a trend parameter, an area effect and the survey sampling error be examined	Recommended	Addressed in a published paper: Matsuoka, K., Hakamada, T., Kiwada, H., Murase, H. and Nishiwaki, S. 2011. Abundance estimates and trends for humpback whales (*Megaptera novaeangliae*) in Antarctic Areas IV and V based on JARPA sighting data. *J. Cetacean Res. Manage*. (Special Issue) 3, 75-94.
SS (Stock structure of Antarctic minke whale)		
1. In addition to genetic studies it would be useful to include potential alternative stock markers such as stable isotopes (e.g. Carbon, Oxygen, Hydrogen and Strontium)	Suggested	This suggestion has not been taken further because studies on stock structure under JARPA/JARPA II already consider several markers, with the results being consistent among them
2. Clustering methods based on individual genotypes, that avoid a priori assumptions about population boundaries may be usefully applied (e.g. MDS or PCA methods).	Recommended	As first step toward these analyses, the number of microsatellite loci was increased in JARPA II from six to 12, and clustering methods were tried (SC/F14/J28).
3. Spatial correlation and Mantel test were suggested to resolve the position and nature of this transitional pattern	Suggested	This suggestion has not been taken further because there is no consensus at the Scientific Committee on the power (resolution) of the Mantel Test to resolve stock structure questions (IWC, 2001, pp 98)
4. Other analyses based on individual genotypes such as landscape genetics as assessed in the program 'alleles in space' may help resolve the pattern of structure and mixing (though this would likely require 15+ microsatellite loci to provide sufficient power)	Suggested	As first step toward these analyses, the number of microsatellite loci was increased in JARPA II from six to 12, and clustering methods were tried (SC/F14/J28).
5. Transitional area could be studied by fitting a mixing model where the fraction of whales belonging to one putative population is a function of the longitude at which it was sampled. This could be a simple logistic regression model coupled with two-product	Suggested	This was addressed by developing the model in: Kitakado, T., Schweder, T., Kanda, N., Pastene, L. and Walloe, L. 2012. Progress report on the estimation of longitudinal mixing proportions for the Antarctic minke whales using genetic and morphometric measurements. Paper SC/64/IA4 presented to IWC Scientific Committee, June

multinomial models describing the allele frequencies in the two putative stocks either side of the transition area. It could be extended beyond two populations, and incorporate both genetic and morphometric data		2012, Panama City, Panama (unpublished) 13pp The model is applied to JARPA and JARPAII data in SC/F14/J29
6. Conduct satellite tracking to investigate location of breeding grounds	Emphasized	A first attempt to attach satellite tags was made in the 1993/94 JARPA survey (SC/46/SH15). More recent attempts were made in 2005/06 JARPA II survey (SC/58/O7), 2006/07 (SC59/O4) and 2011/12 (SC/64/O2).
7. Conduct analysis of available samples for the potential extension of the analysis geographically (e.g. Areas III and VI)	Raised	This suggestion has not been taken further because samples collected by commercial whaling around the pack ice are not particularly useful for studies on stock structure as demonstrated by the earlier study below: Goto, M., Zenitani, R., Fujise, Y. and Pastene, L.A. 1998. Examination of mitochondrial DNA heterogeneity in minke whale from Area IV considering temporal, longitudinal and latitudinal factors. Paper SC/50/CAWS7 presented to the IWC Scientific Committee, April 1998 (unpublished). 10pp
Stock structure of humpback whale		
8. Every effort should be made for scientists to share data from low and high latitude and carry out DNA analysis on southern humpback whales under the IWC Data Availability data access protocol	Reminded	This was addressed in: Pastene, L.A., Kitakado, T., Goto, M. and Kanda, N. 2013. Mixing rates of humpback whales of Stocks D, E and F in the Antarctic feeding grounds based on mitochondrial DNA analyses. Paper SC/65a/SH13 presented to the IWC Scientific Committee, June 2013 (unpublished), 11pp.
Stock structure of dwarf minke whale		
9. Apparent paraphyly of dwarf minke whale should be investigated further	Suggested	This was addressed in: Pastene, L.A., Goto, M., Kanda, N., Zerbini, A.N., Kerem, D., Watanabe, K., Bessho, Y., Hasegawa, M., Nielsen, R., Larsen, F. and Palsbøll, P.J. 2007. Radiation and speciation of pelagic organisms during periods of global warming: the case of the common minke whale, *Balaenoptera acutorostrata. Molecular Ecology* 16: 1481–1495.
BP (Biological parameters)		
1. In order to verify age readings using known age animals the feasibility of detecting the bomb radiocarbon signal in earplug laminae be looked into	Recommended	This suggestion has not been taken further. Previous studies of fin whales as well as corpora counts and animals with known histories indicated that the growth layers counted to age whales were laid down annually (IWC, 2011a, pp191). There are no reasons to think a different pattern occur for minke whales
2. The comparability of commercial and JARPA age data be investigated by re-reading a subset of the commercial samples in an appropriately designed blind test	Recommended	This was addressed in: Zenitani, R., Kishiro, T., Hakamada, T. And Kato, H. 2007. Current status and future plan of age reading by earplugs in baleen whales under the scientific permits, with note on age reading of Antarctic minke whales. Paper SC/59/O8 presented to the IWC Scientific Committee, May 2007 (unpublished). 8pp., and Lockyer, C. 2010. Report of the Antarctic minke whale ear plug experiment. Paper SC/62/IA11) presented to the IWC Scientific Committee, June 2010 (unpublished), 4pp. Based on latter study the IWC SC agreed in 2010 'that no further experiments or analyses on age reading errors are needed to resolve ageing related problems raised in e.g. the JARPA review' (IWC, 2011b, pp26)
3. The ADAPT-VPA could be run without using the commercial age data	Task identified	This was addressed in: Mori, M., Butterworth, D. and Kitakado, T. 2007. Further progress on application of adapt-VPA to Antarctic minke

		whales. Paper SC/59/IA13 presented to the IWC Scientific Committee, May 2007 (unpublished). 32pp. Several other SC recommendations were addressed in: Punt, A.E., Bando, T., Hakamada, T. and Kishiro, T. 2013. Assessment of Antarctic minke whales using statistical catch-at-age analysis. Paper SC/65a/IA1 presented to the IWC Scientific Committee, June 2013 (unpublished), 42pp.(SC/F14/ForInfo1), and in Document SC/F14/O1.
ME (Marine ecosystem)		
1. Determination of the duration of the feeding period is fundamental to estimate total consumption and must be adequately addressed	Recommended	This was considered in SC/F14/J15.
2. Examination at smaller spatial scales	Recommended	This was considered in SC/F14/J15.
3. Use of GLM or similar to examine trend, incorporating covariates such as age, size and reproductive status of whales as well as the date and time of day	Recommended	This was addressed in: Konishi, K., Hakamada, T., Kiwada, H., Kitakado, T. and Walloe, L. 2012. Decrease in stomach contents in the Antarctic minke whale (*Balaenoptera bonaerensis*) in the Southern Ocean. Paper For Info 16 presented to the IWC Scientific Committee, June 2012 (unpublished), 17pp. A revised versions of this document was accepted for publication in *Polar Biology* (see also SC/F14/J14)
4. Examination of other factors including age, latitude, distance from the ice-edge and non-linearity in trends in the analysis of blubber thickness (JCRM 10 (Suppl.), 2008, pp 350)	Suggested	This was addressed in: Konishi, K., Tamura, T., Zenitani, R., Bando, T., Kato, H. and Walloe, L. 2007. Decline in energy storage in the Antarctic minke whale (*Balaenoptera bonaerensis*) in the Southern Ocean using JARPA data. Paper SC/59/O10 presented to the IWC Scientific Committee, May 2007 (unpublished). 10pp., and, Konishi, K., Tamura, T., Zenitani, R., Bando, T., Kato, H. and Walløe, L. 2008. Decline in energy storage in the Antarctic minke whale (*Balaenoptera bonaerensis*) in the Southern Ocean. *Polar Biol* 31:1509-1520. Results of the latest analyses were presented to the 2013 IWC SC meeting: Konishi, K. and Butterworth, D.S. 2013. Further investigation of whether correlations amongst data are invalidating the conclusion of a statistically significant trend in Antarctic minke body condition over time. Paper SC/65a/EM4 presented to the IWC Scientific Committee, June 2013 (unpublished), 3pp. During the 2013 IWC SC meeting, a new analysis using total body fat as a dependent variable was presented (Appendix 6 Annex K1 of the 2013 IWC SC meeting report) Further analyses are presented in SC/F14/J13
5. Consideration should be given to whether the particular blubber thickness measurement chosen was actually a good proxy for energy storage (for example lipid content can vary considerably within blubber)	Suggested	This was addressed in: Konishi, K. 2006. Characteristics of blubber distribution and body condition indicators for Antarctic minke whale (*Balaenoptera bonaerensis*). *Mammal Study* 31: 15-22. See also SC/F14/J13.
6. Analysis should be expanded to incorporate the other extensive information available from the JARPA datasets that relates to energy storage in an integrated manner (e.g. other blubber	Recommended	This was addressed in: Konishi, K., Tamura, T., Zenitani, R., Bando, T., Kato, H. and Walloe, L. 2007. Decline in energy storage in the Antarctic minke whale (*Balaenoptera bonaerensis*) in the Southern

measurements, organ weights, etc.)		Ocean using JARPA data. Paper SC/59/O10 presented to the IWC Scientific Committee, May 2007 (unpublished). 10pp., and Konishi, K., Tamura, T., Zenitani, R., Bando, T., Kato, H. and Walløe, L. 2008. Decline in energy storage in the Antarctic minke whale (*Balaenoptera bonaerensis*) in the Southern Ocean. *Polar Biol* 31:1509-1520. See also SC/F14/J13.

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International Whaling Commission 2011a. Report of the Scientific Committee. Annex G. Report of the Sub-Committee on In-Depth Assessments. *J. Cetacean Res. Manage. (Suppl.)* 12: 185-202.

International Whaling Commission 2011b. Report of the Scientific Committee. *J. Cetacean Res. Manage. (Suppl.)* 12: 1-75.

Annex 5. Brief outline of the research area, target species, sample size and general methodology of the JARPAII

The research area, rational for target species, sample sizes and general methodology of the JARPAII were explained in the original JARPAII plan (Government of Japan, 2005). In this annex the main aspects of those topics are summarized.

Research area
The research area of the JARPAII is basically the same as in the JARPA: the eastern part of Area III, Areas IV and V, and the western part of Area VI (35°E - 145°W) (Figure 1). The JARPA II surveys cover alternatively the western part of this area in one year (35°E - 175°E) and the eastern part in the next year (130°E - 145°W). Thus, surveys repeat in the western and eastern parts every two years. The area from 130°E to 175°E was planned to be covered every year in order to investigate the yearly change in mixing proportion of two Antarctic minke whale stocks in that sector. That is to say, Antarctic minke whales were taken west of 175°E in the first year and east of 130°E in the second (Figure 1).

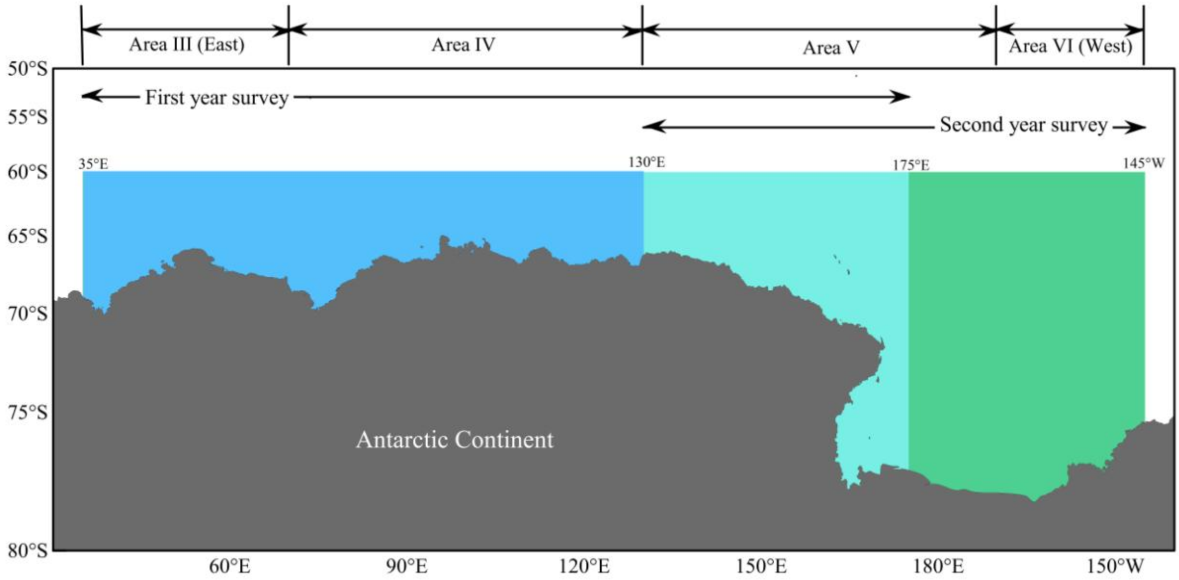

Figure 1. Research area and survey procedure of the JARPAII. The total longitudinal span of the JARPAII surveys is from 35ºE to 145ºW. For Antarctic minke whale surveys are conducted in the western part (35º-130ºE) plus transition area (130º-175ºE) in one year, and in the eastern part (175ºE-145ºW) plus transition area in the second year. Then surveys repeat in the western and eastern parts every two years. The area from 130°E to 175°E was planned to be covered every year in order to investigate the yearly change in mixing proportion of two Antarctic minke whale stocks in that transition area. That is to say, Antarctic minke whales are taken west of 175°E in one year and east of 130°E in the next. Sampling of humpback whale is confined to Area IV in one year and to Area V in the next. Sampling of fin whales is confined to Areas IIIE plus IV in one year and to Areas V plus Area VIW in the next (see details in Government of Japan, 2005). Sighting surveys are conducted from 60ºS while sampling from 62ºS. Figure made using Ocean Data View (Schlitzer, 2013).

Target species and stocks
The western part of the research area comprises the main area of distribution of the Antarctic minke whale I-Stock. In this part but especially in Area IV (70°-130°E), humpback whales from the so-called Breeding Stock D (Western Australia-Area IV) have shown a rapid increase in recent years, and have surpassed the Antarctic minke whale in biomass (Matsuoka *et al*., 2011). Fin whales have also shown a rapid increase in abundance (Matsuoka *et al*., 2006). The eastern part of the research area, mostly made up of the Ross Sea, comprises the main area of distribution of the Antarctic minke whale P-Stock. This stock has a remarkably large abundance. In this part, humpback whales have also shown an increase in recent years. Therefore the research area offers a unique opportunity to study the interactions among whale species-stocks, and the environment.

The species and stocks targeted for the lethal component of the JARPAII as indicated in the original research plan are Antarctic minke whales of the I and P Stock; humpback whales of the Breeding Stocks D and E; and fin whales of the Indian Ocean and Western South Pacific stocks. Viewed overall, sampling of the three species in two Areas was considered to provide an important opportunity to gain insight into the dynamics of whale and inter-species competition through comparative analyses (Government of Japan, 2005).

Sample size for the lethal component of the JARPAII
Details of the sample size estimates procedure are given in the Appendices 4, 6, 7 and 8 of the original JARPAII research plan (Government of Japan, 2005).

Sample sizes were estimated with the aim of monitoring changes in some biological parameters considered as 'indicators' of changes in the ecosystem e.g. pregnancy rate, age at sexual maturity, blubber thickness, monitoring pathologies, abundance from paternity via DNA in the case of Antarctic minke whale; age at sexual maturity and pregnancy rate in the case of humpback and fin whales, which is related to Objective 1 of the JARPAII. The analytical procedure for estimating sample size considered three aspects, a) the level of statistical accuracy sought, b) the extent (rate) of the biological changes that we wished to detect, and c) the period of time within which we wished to detect those biological changes. With regard to a) the 5% level of accuracy which is the norm employed by the IWC SC was chosen; regarding b) rate of change in different biological parameters of Antarctic minke whale was obtained from observations in the 18-year long JARPA research period, while those information in the case of humpback and fin whales was obtained from the period of commercial whaling; with regards to c) a period of six years was chosen in the case of Antarctic minke whale as established in the original research plan as the period of periodic review, which coincides with the RMP *Implementation* review period (IWC, 2012). Considering a precautionary approach in the case of the humpback and fin whales (species not considered for management under the RMP), a period of 12 years was chosen for the calculations. The use of biological information from humpback and fin whales is qualitative compared to the quantitative use of Antarctic minke whale data. Ecosystem models input the Antarctic minke whale stomach fullness trend, but biological data from fin and humpback would be used only for independent qualitative checks of model predictions.

The annual sample size of Antarctic minke whales was set at 850 animals +/- 10% while those for humpback and fin whales were set at 50 each. These figures obviously represent a compromise between different parameters, chosen because they satisfy the statistical conditions for most of the research items, and because catches at that level will cause no harm to the stocks.

It should be noted that the examination of trend in biological parameters in the six-year period of the JARPAII was not possible because the estimated target sample size for Antarctic minke whale (850) was attained only in the 2005/06 season. No humpback whale was sampled and the number of fin whales sampled was very low. This was due mainly to the continued violent sabotage activities by an anti-whaling NGO, which substantially limited the capacity of sampling and the temporal/spatial survey coverage in most of the surveys of the JARPAII in this first period (see Annex 6 for details).

Length of the JARPAII
The original research plan stated that the JARPAII will be a long-term research program and that a comprehensive review will be conducted following completion of the first 6 years of the research (Government of Japan, 2005).

JARPAII started from the 2005/06 austral summer season. The first two seasons (2005/06 and 2006/07) were dedicated to feasibility studies in order to examine the practicability and appropriateness of sighting methods in the enlarged area and sampling procedures given the increased sample size and additional species in relation to the previous JARPA (the sample sizes for Antarctic minke, fin and humpback whales in each of these two feasibility years were 850+/- 10%, 10 and 0, respectively). Since the target species of JARPAII included larger whales, methods for catching, flensing and taking biological measurements of large body-sized whales were also tested. Results of the feasibility surveys were presented in Government of Japan (2007). The full-scale JARPAII started from the 2007/08 season.

The JARPAII is a long-term research program with no specified termination date because its primary objective, that is, monitoring the Antarctic ecosystem requires a continuing program of research. While the JARPA was designed to estimate such items as age at sexual maturity, pregnancy rate, and blubber thickness for a whale species over a particular period, the JARPAII has the purpose of detecting changes in those parameters over a period of time. In this regard it should be noted that Article VIII, paragraph 4 of the ICRW recognizes the necessity of 'continuous collection and analysis of biological data' in connection with the whaling operation.

While a termination date is not set, the JARPA II is to be kept under periodic scientific review on the basis of its six-year term research phases. With the accumulation of data from the six-years phases, revisions of the program will be made as appropriate based primarily on IWC SC reviews.

General methodology
There are three kinds of surveys in the JARPA II:

- Dedicated sighting surveys and the application of the Line Transect Method for estimating the number of whales present in a particular area at a particular season. Abundance estimates are important for Objectives 1 (monitoring of whale abundance trend) and 2 (input parameter to the ecosystem models).
- Whale surveys on pre-determined track-lines to obtain samples and data related to Objectives 1 (the monitoring of biological parameters trend, stomach content trends, blubber thickness trend, pollutant level trend, etc.) and 3 (stock structure). Some of these data are used as input parameters to the ecosystem modeling.
- Prey species surveys to investigate distribution and biomass of krill (through echo-sounder and net surveys). This is related to Objective 1 (monitoring of krill abundance trend) and 2 (input parameter to the ecosystem model). During the surveys detailed oceanographic information is also obtained using CTD and XCTD so that distribution of whales and prey species can be studied together with the oceanographic information. This is important for Objective 1 (cetacean habitat).

The following is a brief description of the methodology used for each research objective of the JARPAII:

Analytical procedures
Objective 1: Monitoring the Antarctic ecosystem

a) Whale abundance

The sighting procedures in the JARPAII have been established to match the IWC/IDCR (International Decade for Cetacean Research) and SOWER (Southern Ocean Whale and Ecosystem Research) cruises to the extent possible. Sighting data were collected by the Line Transect Method. The track-line was designed in order to cover the strata uniformly and all the whale or cetacean schools sighted were recorded. It should be noted that sighting surveys could not be carried out as originally planned due to the violent sabotage activities of the NGO (Annex 6) and consequently several adjustments and interpolations to un-surveyed areas were made. Whale abundances were estimated from the sighting data and the program DISTANCE. Several sensitivity analyses were conducted. Annual rates of increase in abundance were estimated using log-linear models.

b) Whale distribution

Sighting and effort data obtained through systematic surveys in Areas IIIE-VIW, from south of 60ºS to the pack ice edge in austral summer were examined to study the distribution pattern of large whales. The spatial and temporal pattern of distribution of large baleen whales in the JARPAII research area was studied by investigating the monthly changes in density index (number of whales sighted by 100 nm) in each of the Areas and Sectors.

Spatial modeling analyses were also used to examine changes in whale species distribution with time.

c) Age at sexual maturity and pregnancy rate

Age at sexual maturity in the Antarctic minke whale was estimated using standard techniques, by counting growth layers at the transition phase in earplugs. Apparent pregnancy rate in this species was estimated as the ratio of pregnant females within the total number of sexually matured females. Sexual maturity in females was determined by observation of corpora in the ovaries. Whales with at least one corpus luteum or corpus albicants in the ovaries were identified as sexually mature. Yearly trend in age at sexual maturity and pregnancy rates was estimated by regression analyses.

On methodological development, enantiomers of aspartic acid in lens of whales were measured by high performance liquid chromatography (HPLC) to investigate an alternative method of ageing Antarctic minke whales.

d) Recruitment rate

Recruitments over the years were estimated by catch-at-age analyses such as SCAA and ADAPT-VPA based on age (JARPA/JARPAII and commercial) and abundance (JARPA/JARPAII and IDCR/SOWER) data. Recruitments were fitted to the Pella-Tomlinson reproduction model to estimate *MSYR*.

e) Stomach content weight

In the case of the Antarctic minke whale, weight in the forestomach was used to investigate yearly trend in this parameter. This analysis was conducted by regression models with several covariates using both the JARPA and JARPAII datasets.

f) Body condition

Blubber thickness was used as one of the body condition indicators. It was measured in the field to the nearest mm, by dissecting perpendicularly without including skin on board the research vessel. The main measurement point was the lateral part of the body at the level of dorsal fin. The analysis of yearly trend of this parameter in the Antarctic minke whale was conducted by regression models with several covariates using both the JARPA and JARPAII dataset.

g) Krill biomass

Krill biomass was estimated based on data collected by echo-sounder and IKMT net surveys.

h) Contaminant load

The level of accumulation of pollutants was measured using standard analytical protocols: Cold Vapor Atomic Absorption Spectrophotometry (CV-AAS) for Hg in biological tissues of predators and prey species, and Gas chromatography–mass spectrometry (GC-MS) for organochlorines in biological tissues of predators. In order to understand the accumulation characteristics of pollutants in whales, biological information such as sex and maturity stage of the animals was considered.

i) Oceanography

Hydrographic observations were made using CTD (Conductivity-Temperature-Depth profiler) and XCTD (Expendable CTD) to understand the oceanographic features and dynamics of water fronts and masses in the JARPAII research area. Temperature and salinity profiles were obtained for the depth range from 0 to 1,000m by XCTD and from 0 to 500m for CTD. Oceanographic data obtained by CTD and XCTD were combined and stored.

j) Marine debris

The occurrence of marine debris in the Antarctic environment and in the stomach content of whales was summarized for the JARPA and JARPAII periods.

It should be noted that for the reasons given in Annex 6 a) the analyses of changes in biological and ecological parameters under this objective was possible only for the Antarctic minke whale, and that those analyses combined both the JARPA and JARPAII data; b) time trend analysis under this objective was not possible for krill abundance; c) yearly trend analysis under this objective was not possible for pollutant load.

Objective 2: Modelling competition among whale species

Two types of modelling approaches were employed; one is the Ecopath with Ecosim (EwE), a comprehensive (whole-of-ecosystem) model, and the other is a multi-species production model. There are differences in the component species between them, but the baleen whales and krill play key roles in both. For the EwE approach, once completed the mass-balancing for Ecopath for 27 functional groups, the next step is to move on to projection forward (and backward if possible) by using the Ecosim framework. Statistical estimation was conducted for tuning the parameters of the dynamics based on the time series of biomass trends for some species including toothed and baleen whales. For the multi-species production model, some bioenergetics reasoning was used especially in the functional responses to reduce the number of parameters to be estimated in the predators-prey model. Then the model was applied to the data of time series of baleen whales, seals and krill. Priority is being given to the production model in the light of recent IWC SC discussions.

Input data for the models comes from the JARPA and JARPAII surveys (e.g. prey consumption of whales, abundance of krill, abundance of cetaceans including baleen whales and some toothed whale species), as well from published information from other sources.

The analysis of prey consumption in Antarctic minke and fin whales follows similar methodology used in the eastern North Atlantic by Norwegian scientists (Haug *et al*., 1995a; 1995b, Nordoy *et al*., 1995). The daily prey consumption was estimated using two independent methods, one based on theoretical energy requirement and the other based on diurnal changes of stomach contents mass. Estimates are based on data collected from the first (forestomach) and second (fundus) compartments.

Objective 3: Elucidation of temporal and spatial changes in stock structure

An update of the stock structure studies in the Antarctic minke whale was made using genetics markers, nuclear (microsatellites) and mitochondrial (control region sequencing) DNA.

The extent of genetic differentiation among Areas and Sectors was examined by standard analyses including hypothesis testing. In the case of the microsatellite analyses clustering methods based on individual genotypes that avoid a priori assumptions about population boundaries were also used.

The transitional area was studied by fitting a logistic mixing model where the fraction of whales belonging to one putative population is a function of the longitude at which it was sampled. Both the genetic and non-genetic (morphometric) data contribute to the likelihood function simultaneously for this integrated analysis.

Stocks structure in the JARPAII research area was also studied for humpback, fin and southern right whales based mainly using biopsy samples, and mtDNA control region sequencing and microsatellites. Analytical techniques are standard, involving individual identification using microsatellite, hypothesis testing and phylogenetic analyses.

Objective 4: Improving the management procedure for Antarctic minke whale stocks under the RMP

The goals under this objective will be covered with progress of the work under the other three objectives (See Figure 1). This objective is divided into two parts, a) contribution to the implementation of the current RMP through the attainment of key information such as abundance, stock structure and MSYR, and b) contribution to the future improvement of the RMP through the incorporation of a more realistic MSYR range into the RMP algorithm, and the incorporation of the effect arising from the inter-species relationships among whale species.

For a) above abundance and MSYR (through SCAA analysis) will be obtained under Objective 1) while the redefinition of Management Areas and mixing will follow results on stock structure under the Objective 3). For b) above, MSYR (through SCAA analysis) will be obtained under Objective 1) and the incorporation of the effect arising from the inter-species relationships among whales species will be examined after the development of the ecosystem model has been completed under Objective 2).

Other analyses not related to JARPAII objectives

Several analyses were conducted on the reproductive biology and physiology of the Antarctic minke whale. See details of the technical aspects in Nagai *et al*. (2007), Ono *et al*. (2009) and Sasaki *et al*. (2013).

An update of the effect on the stocks of the JARPAII catches of Antarctic minke whales will be carried out based on new abundance and stock structure information, and Hitter-Fitter methodology.

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Annex 6. Difficulties in the implementation of the JARPAII in the first period

This annex summarizes some difficulties encountered during the implementation of the JARPAII in the first period. Basically those difficulties resulted in smaller sample sizes than the originally planned/estimated, and in smaller areas covered by the surveys in most years. The strategy followed for the data analyses given this situation is also explained in this Annex.

Original research plan and results of the implementation in the first period

Political decisions affecting sampling

The original research plan of the JARPAII specified three target species for the lethal component of the research, the Antarctic minke (*Balaenoptera bonaerensis*), fin (*B. physalus*) and humpback (*Megaptera novaeangliae*) whales (Government of Japan, 2005). No humpback whales were sampled in the first period for political reasons. The Government of Japan decided to suspend sampling of humpback whales in response to a request from the Chair of the IWC in order to contribute to the creation of a positive atmosphere for the negotiations to resolve the stalemate in the IWC (i.e. the 'Future of the IWC' process) that were initiated at the 2007 Annual Meeting of the Commission.

Sabotage activities by a NGO (Sea Shepherd Conservation Society-SS) affecting sampling and geographical coverage (see details in: http://www.icrwhale.org/gpandsea.html)

In the case of Antarctic minke and fin whales, the numbers of samples obtained in most years during the first phase were significantly smaller than originally planned. This was due mainly to the continued violent sabotage activities by anti-whaling non-governmental organizations (NGOs), which substantially limited the capacity of sampling in most of the surveys of the JARPAII in this first period. Disturbances from anti-whaling SS resulted not only in smaller sample sizes but also in diminished temporal/spatial sampling coverage in most of the years (see details in SC/F14/J2).

The sabotage activities affected non-lethal research activities of the JARPAII as well. Dedicated sighting surveys aimed to obtain data for abundance estimate of whales were also severely restricted due to SS's sabotage activities and several areas were uncovered by the surveys (see details in SC/F14/J2).

Also due to the sabotage activities of the SS, the planned survey of prey species (krill) using echo sounder-equipped vessel and sampling by IKMT could not be carried out as originally planed. As a result, complete data sets were obtained for only two surveys in the first period, and no prey surveys were conducted from the 2009/10 season (see details in SC/F14/J2).

The appendix shows how the sabotage activities by SS increased through the years, qualitatively and quantitatively, and how this affected the number of Antarctic minke and fin whale sampled. There is a relationship between the increase in sabotage activities and the number of samples obtained. The appendix also shows the percentage of the original surveys plan by the dedicated sighting vessels (SVs) and sighting sampling vessels (SSVs) that were completed. Both were markedly affected by the sabotage activities.

With regards the sighting surveys of the JARPAII, the IWC SC expressed 'regret that such actions (of violence by SS) had prevented the sighting survey from being conducted as planned', and noted that 'following the end of the IDCR/SOWER programme in 2009, these (JARPA II) surveys now provide the only dedicated cetacean sighting data in this region and are extremely valuable to the work of the Committee' (IWC, 2012a).

Other reasons affecting sampling

A fire onboard the research base vessel *Nishin Maru* during the 2006/07 survey hampered the sampling in that particular survey in addition to the sabotage activities by SS (see also SC/F14/J2).

In the case of the fin whale an additional logistical reason (i.e. limitation of *Nishin Maru* facility to pull up larger animals onboard) also explains in part the smaller sample size of this species obtained in comparison to the original research plan (see also SC/F14/J2).

Finally it should also be noted that some samples obtained by the JARPAII in the first period were lost as a consequence of the earthquake and tsunami that affected Japan in March 2011. This affected particularly samples collected for pollutant, reproductive (females) and genetic analyses. The status of the JARPAII data and samples after the 2011 tsunami was given in IWC (2012b) and the status of each of the JARPAII surveys in the period (2005/06-2010/11) is shown in SC/F14/J2.

Principle for data analyses

Because of the reasons explained above no humpback whales were sampled and the resulting number of Antarctic minke and fin whale samples obtained in the first JARPAII period was substantially less than the planned/estimated numbers (Table 1).

Table 1. Planned and actual (in parenthesis) numbers of Antarctic minke and fin whale samples in the first period of the JARPAII, by season and stock.

Season	Antarctic minke whale		Fin whale	
	I-Stock	P-Stock	Indian Stock	Western South Pacific Stock
2005/06	850 (853)		10 (10)	
2006/07		850 (505)		10 (3)*
2007/08	850 (551)		50 (0)	
2008/09		850 (679)		50 (1)
2009/10	850 (506)		50 (1)	
2010/11		850 (170)		50 (2)

* One of these three whales could not be loaded into the research base

Furthermore the planned number of samples to be taken in the transition area (130ºE-175ºE) (Annex 5) for the aim of studying yearly change in mixing proportion of I and P stock Antarctic minke whale was 300 (Government of Japan, 2005). For the reasons explained above the actual number of samples obtained in the first period in the transition area was substantially lower (Table 2).

Table 2. Planned and actual number of samples of Antarctic minke whales in the transition area.

Season	Transition area (130ºE-175ºE)	
	Planned number of samples	Actual number of samples
2005/06	300	150
2006/07	300	138
2007/08	300	87
2008/09	300	193
2009/10	300	158
2010/11	300	10

Because the number of samples of Antarctic minke whale was less than the planned/estimated number, a reconsideration of the data analysis principle for Objective 1 of the JARPAII (yearly monitoring of biological parameters) was made. However, two time periods were taken into consideration in the analyses, as stated in the original research plan. First, for the key parameters (age at sexual maturity, pregnancy rate and blubber thickness) the trend analysis was made only for the first period of the JARPAII (six years, three points for each stock), although this analysis was not always informative probably due to the smaller sample sizes obtained. Consequently the analyses on yearly trends in most of biological parameters under the first objective were made for combined data from the JARPAII (six years) and the JARPA (18 years). The detection power of significant changes in the first period of the JARPAII (six years) could not be sufficient because the sample size estimated in the original plan were not attained, while yearly trends in a longer period (24 years from 1987/88 to 2010/11) can be detected with smaller sample size.

A new model for mixing proportion analysis of Antarctic minke whale stocks in the transition area was developed (Kitakado *et al*., 2012). It is more complex than that used in the estimation of sample size in the transition area in 2005.

The number of samples from fin whales sampled was not large enough for estimating yearly trend in biological parameters. However new biological, feeding habits, pollutant and stock structure information from fin whales obtained in the JARPAII was summarized in four documents so that those data can be used in future analyses of larger data sets.

Comprehensive data sets for krill abundance were obtained only for two seasons. Comparability of the estimate procedure between the JARPA and the JARPAII was difficult and as a result calculation of the yearly trend in this parameter was not possible. However the JARPAII estimates obtained for Area IV were used as input data in the ecosystem model. As explained above, the yearly trend for pollutant levels was not possible in the first period of the JARPAII. However the available data were examined to update the study of pollutants and environment that was started in the JARPA.

There were significant geographical gaps during the JARPAII sighting surveys in the first period. Several adjustments and interpolations were made in order to get estimates of abundance and abundance trends.

Biological data from humpback and fin whales e.g. prey consumption, had been considered for the development of ecosystem models. However no humpback and only a limited number of fin whales were sampled by the JARPA II. For the development of ecosystem models, data that the JARPAII has collected from these two species by non-lethal methods, e.g. abundance and abundance trends from sighting data were used. Though the lethal data from humpback and fin whales would not be used immediately in fits to the ecosystem models being developed, monitoring qualitative changes in trends in demographic parameters through these lethal data would provide a valuable method to check the predictions from the ecosystem models.

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Appendix: Summary of a NGO (Sea Shepherd Conservation Society)'s sabotage activities during the JARPAII surveys 2005/06-2010-2011*[1]

Year	Catch Number **M**: minke **F**:fin	Research Days **GR**: Gross Research Days **IN**: Interrupted Days **NR**: Net Research Days	Research Vessels **RB**: Research base **SV**: Dedicated sighting survey **SSV**: Sighting and sampling vessels	SS Sabotage ships (maximum speed and equipment onboard) **FM**: Farley Mowat **RH**: Robert Hunter **SI**: Steve Irwin **BB**: Bob Barker **G: Gojira** **BRB: Bridgit Bardot**	SS weapons/strategies (**newly introduced ones highlighted in red**)	Note	Percentage surveyed by SV (of the original plan)*[2]	Percentage surveyed by SSV (of the original plan)*[2]
2005/06	**M:853** F:10	GR: 108 IN: 9 **NR: 99**	1 RB 2 SVs 3 SSVs **Total: 6 vessels**	FM (10 knot, 2 Rigid Inflatable Boat (RIB), 1 jetski, 1 heli)	* deploy **propeller entanglement device** * attack to a fuel tanker using a structure called "**can opener**"	* 1st year of feasibility study (850+/-10% minke and 10 fin planned) * 9-day interruption for ensuring refueling	82	81
2006/07	**M:505** F:3	GR: 76 IN: 13 **NR: 63**	1 RB 2 SVs 3 SSVs **Total: 6 vessels**	RH (15.5 knot), FM (10 knot, 2 RIB, 1 heli)	* deploy propeller entanglement device * **throw butyric acid containing glass bottles** and **smoke bombs by hand** * **launch life line rocket** * **collide** with a research vessel	* 2nd year of feasibility study (850+/-10% minke and 10 fin planned) * 3-day interruption by SS activities * 10-day interruption for fire accident * then the survey was discontinued because research equipments were damaged	74	67
2007/08	**M:551** F:0	GR: 101 IN: 31 **NR: 70**	1 RB 2 SVs 3 SSVs **Total: 6 vessels**	SI (15.5 knot, 2 RIB, 1 heli)	* deploy propeller entanglement device * throw a number of projectiles (butyric acid containing glass bottles and **chemical powder packet**) * **two SS activists boarded** on a research vessel	* 30-day interruption by SS activities * 1-day interruption for rescue activity * Australian patrol ship Oceanic Viking stalked Research Base Vessel for 22 days * 1 crew and 2 coastguard officer were injured by acid bottles	100	72

2008/09	**M:679** F:1	GR: 103 IN: 11 **NR: 92**	1 RV 2 SVs 3 SSVs **Total: 6 vessels**	SI (15.5 knot, 2 RIB, 1 heli)	* deploy **propeller entanglement device (with floats)** * throw a number of projectiles (butyric acid containing glass bottles, paint containing bottles and chemical powder packet) * launch life line rocket * launch **rocket signal** * collide with research vessels	* 11-day interruption by SS activities	100	46
2009/10	**M:506** F:1	GR: 97 IN: 31 **NR: 66**	1 RB 2 SVs 2 SSVs **Total: 5 vessels**	SI (15.5 knot, 2 RIB, 1 heli) BB (16 knot, 1 RIB) AG (40 knot, 1 jetski): damaged by collision	* deploy **propeller entanglement device (with iron pipe enhancement)** * shoot butyric acid containing glass bottles and paint containing bottles by **launcher and slingshot launcher** * irradiate **laser beam** * collide with research vessel * launch rocket signal * an SS activist **cut the protective net and boarded** a research vessel	* 31-day interruption by SS activities * AG collided with a research vessel and it is damaged, then AG was abandoned by SS * three crew were injured by butyric acid	26	25

2010/11	**M:170** F:2	GR: 52 IN: 21 **NR: 31**	1 RB 1 SVs 2 SSVs **Total: 4 vessels**	SI (15.5 knot, 2 RIB, 1 heli) BB (16 knot, 2 RIB) G (24 knot)	* deploy propeller entanglement device (with iron pipe enhancement) * hand-throw and shoot a number of projectiles (butyric acid containing glass bottles, paint containing bottles, smoke bombs, chemical powder packet and **incendiary devices**) by launcher, and slingshot launcher * **attach propeller entanglement device to broadside of research vessels** * shoot **paint ball ammo by machine airgun** * irradiate laser beam * launch rocket signal *** balloons to detect research vessels**	* 21 days interruption by SS activities * research vessels were in danger of fire because of incendiary device used by SS * a research vessel sent mayday call when its propeller was damaged by prop fouler thrown by SS and god cripped for a while * withdrew research vessels earlier than planned (Feb 18)	0	81

*1 Apart from the SS sabotage activities, vessels from another organization (Greenpeace) intervened in 2005/06, 2006/07 and 2007/08 affecting the research activities.

*2 Those figures refer to the percentage surveyed of the whole original planned area. Those figures however do not reflect the survey intensity in the area (e.g. actual number of tracklines designed/covered). For example in the 2010/11 season the SSV covered 81% of the original area however the actual number of tracklines was very limited (see details in SC/F14/J2).