Plan for the Second Phase of the Japanese Whale Research Program under Special Permit in the Antarctic (JARPA II) - Monitoring of the Antarctic Ecosystem and Development of New Management Objectives for Whale Resources

GOVERNMENT OF JAPAN

ABSTRACT

The Japanese Whale Research Program under Special Permit in the Antarctic (JARPA) was conducted between 1987/88 and 2004/05 austral summer seasons, under Article VIII of the International Convention for the Regulation of Whaling. The IWC Scientific Committee conducted an interim review of JARPA results in 1997. In January 2005, a JARPA review meeting called by the Government of Japan was held.

JARPA provided a wide variety of information on biological parameters of the Antarctic minke whale such as the natural mortality coefficient and changes over time in the age at maturity as well as narrowing down the parameters of relevance for sock management. JARPA also elucidated that there are two stocks in the research area but their geographical boundaries are different from those used by the IWC. Further, JARPA found that pollutant concentration in whale tissues, such as heavy metals and PCBs, was extremely low. JARPA has thus successfully obtained data related to the initially proposed objectives. The review meeting conducted in January 2005 agreed that results from JARPA are consistent with the behaviour to be expected of baleen whale populations competing for a dominant single food resource, krill. The meeting also agreed that the results obtained provide clear support for the need to take species-interaction (ecosystem) effects into account in understanding the dynamics of the baleen whale species in the Antarctic ecosystem, and predicting future trends in their abundance and population structure.

Based on these considerations, the Government of Japan will launch a new comprehensive study under the Second Phase of the Japanese Whale Research Program under Special Permit in the Antarctic (JARPA II), combining lethal and non-lethal methods, starting from the 2005/06 austral summer season. The first two seasons (2005/06 and 2006/07) will be dedicated to feasibility studies. The practicability and appropriateness of sighting methods in the enlarged area and sampling procedures given the increased sample size and additional species will be examined. Methods for catching, flensing and taking biological measurements of large body-sized whales will be tested. The full-scale JARPA II will start from the 2007/08 season. It will be a long-term research program with the following objectives 1) Monitoring of the Antarctic ecosystem, 2) Modelling competition among whale species and developing future management objectives, 3) Elucidation of temporal and spatial changes in stock structure and 4) Improving the management procedure for the Antarctic minke whale stocks. JARPA II will focus on Antarctic minke, humpback and fin whales and possibly other species in the Antarctic ecosystem that are major predators of Antarctic krill. Annual sample sizes for the full-scale research (lethal sampling) are 850 (with 10% of allowance) Antarctic minke whales (Eastern Indian Ocean and Western South Pacific Stocks), 50 humpback whales (D and E-Stocks) and 50 fin whales (Indian Ocean and the Western South Pacific Stocks). During the feasibility study, a maximum annual sample size of 850+-10% Antarctic minke whales will be sampled. A maximum of ten fin whales will be sampled in each season. Humpback whales will not be taken during the feasibility study.

The research methods for the JARPA II are basically the same as the previous JARPA with some modifications. The program involves both non-lethal research techniques such as sighting surveys, biopsy sampling, acoustic surveys for prey species and the collection of oceanographic data as well

as lethal sampling since collection of certain information, of vital importance to the overall study, requires examination of internal organs such as ovaries, earplugs and stomachs.

A comprehensive review will be conducted following completion of the first 6 years of the research. Cruise reports will be submitted annually to the IWC/SC.

CONTENTS

I. INTRODUCTION

In 1982, the IWC adopted the moratorium on commercial whaling on the grounds of insufficient scientific knowledge concerning whales. The Government of Japan lodged an objection, but withdrew it in 1985, and the 1986/87 whaling season marked the last commercial operation in the Antarctic by Japan. Thereafter, all commercial whaling in the Antarctic has been suspended to this day.

In order to resolve the scientific uncertainties and pave the way for the resumption of sustainable whaling, Japan started a research program, the Japanese Whale Research Program under Special Permit in the Antarctic (JARPA), under Article VIII of the International Convention for the Regulation of Whaling. The main purpose was to elucidate biological parameters of Antarctic minke whales (GOJ, 1987). The program was launched in the 1987/88 austral summer season as a two-year feasibility study (1987/88 and 1988/89 seasons). The full program started in the 1989/90 season and it was a long-term program over eighteen years, including the two years of feasibility studies. Since all commercial whaling had been suspended in the Antarctic, the world's largest source of whale resources, JARPA was in effect the only comprehensive research program that provided a time series of useful biological and ecological information for the management of whale stocks in the Antarctic.

The IWC Scientific Committee conducted an interim review of JARPA results in 1997 (IWC, 1998). It was agreed that information from JARPA has the potential to improve the management of Antarctic minke whales.

In January 2005, a review meeting of JARPA was hosted by Japan, in which scientists from various countries participated. JARPA provided a wide variety of information on biological parameters such as the natural mortality coefficient and changes over time in the age at maturity as well as narrowing down the parameters of relevance for stock management. The program had also elucidated that there are two stocks in the research area but the geographical boundaries between these stocks are different from those used by the IWC to manage baleen whale species in the Antarctic. Further, JARPA found that pollutant concentration in whale tissues, such as heavy metals and PCBs, was extremely low. JARPA has thus successfully obtained data related to the initially proposed objectives. It is considered that the results will greatly contribute to the rational management of the Antarctic minke whale stocks.

The effect of worldwide climate changes, including global warming, is becoming apparent in the Antarctic Ocean. Elucidating the impacts of these changes requires monitoring of the Antarctic marine ecosystem.

The results of the JARPA sighting surveys indicate a rapid recovery of the once depleted humpback and fin whales, while the increasing trend in abundance of Antarctic minke whales, that had been indicated after other larger baleen whales were substantially decreased due to past over hunting, has been halted. These results suggest the possibility that the composition of baleen whales in the Antarctic is starting to undergo a major shift at the present time.

Against the backdrop of these changes in the Antarctic ecosystem, the Government of Japan will launch a new comprehensive study under the Second Phase of the Japanese Whale Research Program under Special Permit in the Antarctic (JARPA II), combining lethal and non-lethal methods, starting from the 2005/06 austral summer season. The first two seasons (2005/06 and 2006/07) will be dedicated to feasibility studies. The full-scale JARPA II will start from the 2007/08 season. It is expected to be a long-term research program focused on Antarctic minke, humpback and fin whales, crabeater seals, and possibly other species in the Antarctic ecosystem that are major predators of Antarctic krill (*Euphausia superba*). JARPA II intends to monitor the quantitative and qualitative changes of important species of whales, pinnipeds and possibly sea birds, and the environmental factors surrounding them. The goal is to construct a competition model among whale species based on the data obtained. JARPA II thus aims to contribute to the establishment of a new and improved management system for whales based on the ecosystem approach.

Initially, there were as many as 200,000 blue whales in the Antarctic, but their number was greatly reduced by over-hunting, and their take was banned in 1964. After forty years, however, they still number less than 2,000 and are far from reasonably recovered (Branch *et al.*, 2004). Certainly the humpback and possibly also the fin whales, on the other hand, although they too had been greatly reduced in number and their take also subsequently banned, have made appreciable recoveries in recent years. In Area IV of the Antarctic Ocean, there have been as many sightings of the humpback as of the Antarctic minke whales (Ishikawa *et al.*, 2004). We should consider a management scheme that will provide for the recovery of blue whales.

In 1992, the Revised Management Procedure (RMP) was completed by the Scientific Committee. It was adopted by the IWC in 1994 as the procedure to be used in future commercial whaling (IWC, 1995). However with the exception of whaling operations carried out by Norway, which has lodged an objection to the commercial whaling moratorium, it has not been implemented after twelve years since its completion. Some aspects of the RMP require improvements because it has become clear during the twelve years that the current formulation of the RMP could make the implementation process almost unworkable. In JARPA II, better estimates of the Maximum Sustainable Yield rate (MSYR), which is an important parameter for improving the RMP, will be obtained. Also new definitions of the management areas based on stock information will be developed. This information is important for the improvement of the RMP and its implementation.

The Government of Norway intends to develop a management procedure based on the ecosystem approach in an effort to control the size of marine mammal populations given their impact on fishery resources (Ministry of Fisheries, 2004). The U.S. government implements a fishery management scheme in the Bering Sea and the Gulf of Alaska that takes into consideration the securing of prey for marine mammals (North Pacific Fishery Management Council, 2003). Japan also has been active in multi-species management through the implementation of the Japanese Whale Research Program under Special Permit in the North Pacific, Phase II (JARPN II), and is working to develop a more accurate management system for fishery resources using data obtained from JARPN II.

Looking to the future, the IWC will need to consider a multi-species management approach in the Antarctic Ocean, which has the world's largest whale resources, for the conservation and sustainable use of these resources. Multi-species management also should allow for the recovery of depleted whale species. JARPA II should make great contributions towards this goal.

II. RESEARCH BACKGROUND

1. Outline of JARPA results

As mentioned earlier, JARPA was launched in the austral summer season of 1987/88. The Antarctic minke whale was the only whale species that was still commercially harvested immediately prior to that time, but the uncertainties of the biological parameters used in the 1980s to calculate catch quotas under the New Management Procedure (NMP) were the target of much criticism at the IWC Scientific Committee. Thus, the main objective of the JARPA program was to estimate biological parameters, including the natural mortality coefficient, required for the effective management of this species. The second objective was to elucidate the role of cetaceans in the Antarctic ecosystem, and 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 and hence chosen as representative of baleen whale species. The program was to be implemented over eighteen years (including two years as feasibility studies) and to cover Areas IV and V with a sampling of 300±10% Antarctic minke whales from each Area in alternate years (GOJ, 1987).

The efforts of the IWC Scientific Committee then shifted to the completion of an RMP, which was finished in 1992. The key factors of the RMP are abundance estimates and stock structure, and MSYR takes on much of the role played previously by natural mortality. In the meantime, environmental changes such as global warming and the ozone hole became worldwide concerns, and interest in their effects on cetaceans grew in the IWC. In response, Japan added the elucidation of minke whale stock structure and the effects of environmental changes on cetaceans to the research objectives of JARPA from the 1995/1996 austral summer season (GOJ, 1995). The research area was expanded to include the eastern part of Area III and the western portion of Area VI with an additional sampling of 100±10% whales. JARPA was thus continued with a sample size of 400±10% and ended in March 2005.

Much has been achieved by JARPA. The IWC Scientific Committee conducted an interim review in 1997, and evaluated the program as shown below (IWC, 1998):

i. 'JARPA has already made a major contribution to understanding certain biological parameters (e.g. direct measures of the age at sexual maturity) pertaining to minke whales in Areas IV and V, yet such analyses have not fully addressed potential problems related to stock structure'.

ii. 'Under the objective of elucidating the role of minke whales in the Antarctic ecosystem, JARPA has collected data on body condition that, in conjunction with the data on biological parameters, should result in

an improved understanding of the status of minke whales in these Areas. These data are likely to be useful in testing various hypotheses related to aspects of the 'krill surplus' model.'

iii. 'Under the objective of elucidation of the effects of environmental change on cetaceans, there is considerable uncertainty in how biological parameters of minke whales may vary in relation to environmental change. Therefore, more effort is needed to develop meso-scale studies to integrate physical and biological oceanography and prey distribution with minke whale studies'

The results of JARPA were also evaluated in the following manner:

'The results of JARPA, while not required for management under the RMP, have the potential to improve the management of minke whales in the Southern Hemisphere in the following ways: a) reductions in the current set of plausible scenarios considered in Implementation Simulation Trials; and b) identification of new scenarios to which future Implementation Simulation Trials will have to be developed (e.g. the temporal component of stock structure)'.

'The results of analyses of JARPA data could be used perhaps to increase the allowed catch of minke whales in the southern hemisphere without increasing the depletion risk above the level indicated by the existing Implementation Simulation Trials of the RMP for these minke whales'.

The IWC Scientific Committee will review the results of JARPA following the 2005 Annual Meeting. Prior to this meeting, the Government of Japan has held a JARPA Review meeting in January 2005 so that the results from JARPA can be taken into account in the plan for JARPA II. The JARPA results can be summarized as follows.

Regarding the estimation of biological parameters, improved age data have been obtained and age composition data that reflects the stock structure have been collected. Sighting information, collected along with these biological data, has not shown any statistically significant change in minke whale abundance. The natural mortality coefficient of the Antarctic minke whale has been calculated using the planned Tanaka's method (Tanaka, 1990) and the ADAPT VPA as well, and found to be M = 0.05 for Tanaka's method (Tanaka *et al.*, 2005) and 0.05-0.08 for ADAPT VPA (Mori and Butterworth, 2005 and Kitakado *et al.*, 2005). As for the age at sexual maturity, it was found that it had changed to eight years old in the late 1970s from eleven to twelve in the late 1940s (Kato, 1987; Cooke *et al.*, 1997; Thomson *et al.*, 1999). This result would probably be an important one to elucidate the reason for the earlier likely rapid increase of minke whales.

As for the research on the role of cetaceans in the ecosystem, quantitative analyses on the stomach content of Antarctic minke whales were conducted by evaluating the weight of the stomach in relation to the weight of the whale. It was found that the daily amount of krill consumed by one minke whale was 200 to 300 kg. (corresponding to 3 to 5% of body weight). The yearly amount consumed by Antarctic minke whales in Area IV was estimated to be 1,740,000 to 1,930,000 tons, equivalent to about 30% of the rough krill biomass estimate in that Area (Tamura and Konishi, 2005). Also a halt, after the 1980s, in the trend of whales to become sexually mature at younger age (Zenitani and Kato, 2005), an increase in age at physical maturity (Bando *et al.*, 2005) and a decrease in blubber thickness (Ohsumi *et al.*, 1997; Konishi and Tamura, 2005) have been reported. Australian coastal surveys as well as JARPA results have confirmed that humpback whales are increasing surprisingly rapidly; assessments combining all the data (Johnston and Butterworth, 2005) indicate current abundance for the stocks in Areas IV and V to be approaching 20,000, with the Area IV stock soon to reach its pre-exploitation abundance. Sighting surveys during JARPA have also found that there are some 9,000 fin whales. Their distribution range has also expanded southwards, strongly indicating increasing competition among the whale species for krill in that region (Appendices 1 and 2).

In the JARPA Review meeting, it was agreed that, viewed broadly, results from JARPA are consistent with the behavior to be expected of baleen whale populations competing for a dominant single food resource, krill.

Surveys on the effect of environmental changes on cetaceans indicated that pollutant concentration such as heavy metals and PCBs in whales can be used as indicators of global contamination. It was also found that pollutant concentration in whales in the Antarctic was extremely low, compared with common minke whales in the Northern Hemisphere, and that there was a declining trend in such concentration in recent years (Fujise *et al.*, 1997; Yasunaga *et al.*, 2005).

With regard to stock structure of the Antarctic minke whale, results of the analyses based on mtDNA have been reported annually to the Scientific Committee. The Committee had noted that only preliminary

conclusions about stock structure can be drawn at this stage and that more concrete conclusions will be able to be made following the completion of different analyses. It further supported the suggestion that additional analyses using alternative groupings and analytical methods should be conducted (IWC, 2003).

It has been recognized that the most effective way to address questions on stock identity is to consider results from several techniques: genetics and non-genetics (Donovan, 1991; Perrin, 2001; Rugh *et al.*, 2003).

In response, the study on stock structure under the JARPA was extended by using several biological markers (genetic and non-genetic) and more detailed groupings of samples. These approaches were used for examining samples of JARPA from 1987/88 to 2003/04 and results were presented to the JARPA Review Meeting (Pastene *et al.*, 2005a).

Results from the different approaches showed similar patterns and were consistent in regard to the hypothesis of two stocks in the JARPA research area. Probably these stocks are related to breeding areas in the eastern Indian Ocean and western South Pacific Ocean, respectively. A soft boundary between stocks at 165°E has consequently been proposed for management purposes. Names have been proposed for these two stocks: the Eastern Indian Ocean Stock (I-Stock) and, the Western South Pacific Ocean Stock (P-Stock). It should be noted that the pattern of stock structure found is not consistent with the traditional IWC boundary between Areas IV and V.

2. Global environmental changes

Various phenomena caused by global warming have been observed recently worldwide, including frequent floods, receding and diminishing glaciers, rise in seawater temperature and coral reef bleaching. There is concern in the Arctic regarding the effect of melting ice on marine mammals, including the polar bear (Hassol, 2004). Air and seawater temperatures have risen in the Antarctic, resulting in the major break-up of the Larsen Ice Shelf in 2002. The rise in temperature is particularly evident in the Antarctic Peninsula, where it has risen by as much as 5 degrees Celsius in winter, and the receding ice has caused a shift in penguin species distribution (Croxall *et al.*, 2004).

Further, it has been reported that Antarctic krill abundance in the south western Atlantic has been reduced by 80% from the level in 1970s due to the rise in seawater temperature (Atkinson *et al.*, 2004). In Areas IV and V, which are covered by JARPA, there has been no clear indication of any connection between the rise in sea water temperature and the decrease of krill, but we cannot rule out the possibility that such a phenomenon may occur in the entire Antarctic Ocean in the future.

Major environmental changes such as global warming may greatly affect krill reproduction in the Antarctic Ocean and thus change the carrying capacity for cetacean species, as well as altering the behaviour and habits of other krill predators.

It is therefore necessary to promote surveys of global marine ecosystems including the polar regions such as the Antarctic, as well as research on and the collection of data about the effects on the marine ecosystem and on possible future changes of ecosystems. This is because the effects of global environmental change are unlikely to be limited to the Antarctic Ocean and will affect all the world's oceans.

In addition to global warming, it is important to monitor environmental contaminants such as mercury and PCBs on a global scale since they are dispersed worldwide. Organochlorines, heavy metals and other highly residual pollutants spread worldwide, once they are released into the atmosphere. To have an accurate account of global contamination by these pollutants and to predict future contamination, it is necessary to identify their temporal and spatial behaviour. The monitoring of contamination levels in the atmosphere and seawater is important as a direct method, but the amount in the environment is generally extremely low. However, certain kinds of pollutants will be highly concentrated in top predators of the food web. It is necessary, therefore, to investigate the pattern of pollutant accumulation in the top predators themselves and to examine how they are biologically affected in order to determine the effect of the contaminants.

3. Necessity to improve the implementation of management procedure on Antarctic minke whale stocks

Although the IWC Scientific Committee completed the Revised Management Procedure for the regulation of commercial whaling in 1992 (IWC, 1993), with the exception of operations carried out by Norway that has lodged an objection, whaling based on the RMP has not been resumed to this day. The RMP is overly concerned with the protection of whale stocks and thus too conservative in terms of rational utilization of

resources. Stock hypotheses, tuning levels, MSYR and other parameters are chosen unduly conservatively because of argued uncertainties in biological understanding. One of the deficiencies of the RMP is the large variation in catch quotas depending on such choices, and agreement is difficult to achieve as shown in the case of RMP implementation simulation trials for North Pacific common minke whales (IWC, 2004). It is therefore of primary importance to conduct research that will reduce the range of uncertainties in such factors, as is the aim of JARPA II.

Furthermore, although the matter has not yet been taken up at the IWC, the necessity of a multi-species management approach has been recognized worldwide, and some such approaches are already in place in the U.S. and Norway (North Pacific Fishery Management Council, 2002; Ministry of Fisheries, 2004). Many baleen whales commonly consume krill in the Antarctic ecosystem, and as stated above, results from JARPA are consistent with the behaviour to be expected of baleen whale populations competing for a dominant single food resource, krill. Therefore, it is necessary for the IWC, as well as its member countries, to develop a management method based on multi-species models.

III. RESEARCH NEED AND OBJECTIVES

1. Research need

The large cetacean community in the Antarctic has historically undergone extensive changes and another major transition has been taking place in recent years, with the recovery of some whale species from past over-hunting. In addition, significant global environmental changes that have the potential to affect whale populations are occurring.

In view of the above, there is a need to systematically monitor changes of environmental conditions in the Antarctic over the long-term, as well as changes of biological parameters and changes in the abundance of cetaceans inhabiting the Antarctic Ocean. There is also a need to monitor how cetaceans adapt to global warming and the shifts in the ecosystem structure caused by human activities so as to provide scientific basis for the comprehensive management of whale stocks, employing control of whale populations if needs be.

More than forty years have gone by since the severe decline in the size of blue whale population, but this species remains at a low level of abundance even though some increase has recently been confirmed. There is a possibility that their niche has already been mostly taken over by Antarctic minke and other whale species that have been showing an increasing trend of abundance in recent years. To deal with this situation, which has anthropogenic roots, all management options should be considered.

As has been already mentioned, JARPA data have shown that the increase in minke whales has been halted together with the reversal in the trend of age at maturity towards younger ages and a trend of decreasing blubber thickness. The humpback and fin whales, on the other hand, have shown a rapid increase in abundance. In Area IV, for instance, humpback whale biomass is now much larger than that of the Antarctic minke whale, indicating that the balance among the whale species is in transition (Ishikawa *et al.*, 2004; Appendices 1 and 2). It is necessary to study and analyse these changes by conducting research that includes not only minke whales but also humpback and fin whales. Also, the effects of global warming are becoming apparent in the Antarctic and we need to study the effect on the cetaceans as soon as possible.

The RMP, which has been developed as a management procedure, is based on a single species management model, although it is supposedly applicable even when carrying capacity increases twofold or declines to half. However, the need to allow for such a wide range of uncertainty renders the RMP overly conservative in its utilization of whale resources, and this could be improved if good multi-whale-species models were developed as a basis upon which to create a better RMP. Also, it seems plausible that the take of one whale species may have positive effect on the recovery of another, but such processes have not been incorporated into the current RMP.

Since the ecosystem is undergoing a major shift, we should have a better management tool to achieve appropriate utilization of more than one whale species with a better RMP, as the current RMP is a basically single species management model.

To this end, there is a need to: a) to monitor cetaceans and various environmental factors in their habitats (population trend, biological parameters such as age at maturity, krill abundance, oceanographic environment, etc.); b) to construct a competition model among whale species, verifying various hypotheses based on the data obtained by past JARPA and through future monitoring, and c) to establish future management

objectives. For instance, it may be possible and desirable, through selective harvesting, to accelerate the recovery of blue and fin whales toward the early days when the blue and fin whales were the dominant species. Sustainable use of these resources as a management objective would be assisted by models that investigate the effects of takes of one species of whales on another.

It is essential for the construction of such models to obtain data not only of the Antarctic minke but also humpback and fin whales through the research programs. There is a need to build an ecosystem model, taking due account of the competition for krill among whale species, based on the monitoring data obtained and other information, while utilizing data from CCAMLR concerning other krill predators.

Information on stock structure of the main whale species comprising the Antarctic marine ecosystem is also important for a better interpretation of the abundance estimates and trends, for estimation of biological parameters and for the implementation of management procedures. The amount of information on stock structure differs among blue, fin, humpback and minke whales.

As for fin and blue whales, there is very little information on their stock structure. The available information is based on mark-recapture studies conducted during the period of commercial whaling. There is a need to collect new relevant data, including genetics data, to elucidate the present stock structure in these species and to investigate how the structure may differ from what has been postulated in the past. Both blue and fin whales have experienced substantial changes in abundance and some changes in stock structure might be expected with time (e.g. changes in geographical boundaries between stocks).

As a result of JARPA much more information on stock structure in the Antarctic feeding ground is now available for Antarctic minke and humpback whales (Pastene *et al.*, 2005a; Pastene *et al.*, 2005b). However, as noted above, changes in abundance with time have been observed in these two species and it is possible that such changes have had an effect on stock distribution and boundaries for these species. Monitoring of stock status and trends require that these changes in stock structure be investigated. This is important for management purposes. For example catch quotas based on stocks will have to be adjusted for shifting stock boundaries; otherwise, there is the risk of a negative impact on the stock.

The IWC has adopted the RMP for the regulation of commercial whaling, but it has yet to be applied, with the exception of operations carried out by Norway that has lodged an objection. We need better estimation of the MSYR in order to respond to any concerns over the implementation of the RMP and to improve its likely deficiencies concerning inefficient utilization of whale resources. Currently, RMP *Small Areas* for minke whales in the Antarctic have been established as longitudinal sectors of 10°, but at the very least, we need to redefine appropriate *Small Area* according to information on stock structure. Also, another 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 an over-hunting so that catches are set unnecessarily low. That part needs also to be improved by the use of more realistic multi-whale-species models.

2. Research objectives

The objectives of the research program can be summarized into the following four categories. The first two years will be spent on feasibility studies, which will be described in Chapter VI.

1) Monitoring of the Antarctic ecosystem

As has been already mentioned, the Antarctic ecosystem is undergoing a major change. JARPA II will monitor the changes over the years of various environmental variables, prey density and abundance, and abundances and biological parameters of three baleen whales: the Antarctic minke, humpback and fin whales. The obtained data will be indicators of changes in the Antarctic ecosystem, and the observations and records will have a great significance in themselves. Appropriate utilization and management of whale stocks will become possible by understanding how whales respond and adapt to changes in the environment and the ecosystem structure. The data will also be used for the construction and operation of a model of competition among whale species, which is the second objective of the research program.

I) MONITORING OF WHALE ABUNDANCE TRENDS AND BIOLOGICAL PARAMETERS

JARPA II will monitor changes over the years in abundance by mean of sighting surveys, and changes in recruitment, pregnancy rate, age at maturity and other biological parameters by sampling survey.

II) MONITORING OF KRILL ABUNDANCE AND THE FEEDING ECOLOGY OF WHALES

JARPA II will monitor the yearly amount of prey consumption and the change in blubber thickness of whales over the years. Meso-scale surveys will be conducted, if possible, to investigate prey distribution and abundance. Changes in the biological environment of whales will be monitored.

III) MONITORING OF THE EFFECTS OF CONTAMINANTS ON CETACEANS

The temporal and spatial behavior of pollutants is global and they become highly concentrated through the food web. By investigating top predators including cetaceans, JARPA II will elucidate the pattern of contaminant accumulation and the effects of the toxins on them. Together with other data it should also give an accurate picture of global contamination and help predict future trends.

Species unaffected by contaminants are important as the controls for wildlife studies (IWC, 1999) and JARPA II will collect data on these species in the Antarctic Ocean. Results from JARPA II will also be linked with those obtained by JARPN II in the western North Pacific to elucidate pollutant behavior in cetaceans using methods of comparative biology. Concurrent analysis on prey species and environmental samples (air and sea water) in both the North Pacific and Antarctic will also be carried out in order to elucidate and consider pollutant behavior in the marine ecosystem and their global dynamics. Results will be compared to those obtained in the North Atlantic if access to the data is possible. Effects of these contaminants on whale species will also be considered using epidemiological, pathological, and toxicological methodologies. Specific objectives are as follows:

* To elucidate the pattern of pollutant accumulation in whales in the Antarctic and the western North Pacific, and the pattern of changes in their biological processes;

* To elucidate the pollutant behavior in the marine ecosystems of the Antarctic and the western North Pacific; and

* To elucidate the biological effects of pollutants on cetaceans.

IV) MONITORING OF CETACEAN HABITAT

Monitoring of changes in water temperature, salinity, ice and other oceanographic and meteorological factors will be conducted. This will make it possible to promptly note changes in the environment in connection with the ecosystem model (the second research objective) and the management of minke whale stocks (the fourth research objective).

2) Modelling competition among whale species and future management objectives

I) CONSTRUCTING A MODEL OF COMPETITION AMONG WHALE SPECIES

There is a strong indication of competition among whale species in the research area. We need to consider hypotheses related to this competition and clarify the mechanism of resource fluctuation to be able to construct a model that will show the dynamics of competitive whale species to better allow the sustainable use of resources in the future.

Several hypotheses, including the krill surplus hypothesis and the process of resource increase due to the age at sexual maturity changing to younger ages will be tested. A model of competition among whale species incorporating these results will be constructed. Some details of the model are discussed to in Section IV-4-2.

II) NEW MANAGEMENT OBJECTIVES INCLUDING THE RESTORATION OF THE CETACEAN ECOSYSTEM

Little can be achieved by using a single species management system for monitoring the whole ecosystem and identifying measures for the recovery of depleted cetaceans, in the context of changing cetacean population balance. Management objectives and policies including the major whale species are necessary. JARPA II will look into specific matters shown below and contribute to the future work of the IWC Scientific Committee.

* Establishing future management objectives

Possible management objectives or goals would include: maintaining the present condition, in other words, preserving the existing relative abundances among the whale species; promoting relative abundances that favour whale species with high economic value; or accelerating the recovering of blue and fin whales. The advantages and disadvantages as well as the practicability of achieving alternative objectives need to be considered.

* Estimating surplus production (and hence allowable catch) by species under some of the management objectives.

Surplus production (and hence allowable catch) under different suitable management objectives will be estimated and the advantages and disadvantages examined.

* Contribute towards a multi-whale-species management

Management strategies and tactics to achieve a selected management goal and to maintain that goal once achieved will be considered.

3) Elucidation of temporal and spatial changes in stock structure

As shown in Appendix 3, there is not sufficient information on current stock structure of fin and blue whales in the Antarctic. Most of the available information comes from the period of commercial whaling and is based on non-genetic data (e.g. distribution of catches and mark-recapture). According to that information, boundaries among IWC Areas were probably valid for blue whales (Donovan, 1991, Mackintosh, 1942). In the case of the fin whale the information obtained in the past suggested a structure based on oceanic basin. These species have experienced substantial changes in abundance and it is possible that the current stock structure does not match that described in the past. The research objective here is to investigate current stock structure and to compare it to that suggested in the past.

As indicated in Appendix 3, in the cases of humpback and Antarctic minke whales much more information on stock structure in the Antarctic is now available for the feeding ground (Pastene *et al.*, 2005a; Pastene *et al.*, 2005b). These species have also experienced changes in abundance over the years and therefore temporal changes in the stock structure can be expected. The research objective here is to investigate shifts in stock boundaries (or equivalently changes of the relative proportions of stocks in mixing areas) on a temporal (yearly) basis.

In the case of the Antarctic minke whale an additional objective is to investigate the western boundary of the East Indian Ocean Stock (Pastene *et al.*, 2005a). This objective will be covered through surveys in an extended research area (west of Area IIIE) to be conducted in the future.

4) Improving the management procedure for Antarctic minke whale stocks

JARPA II research objectives will ultimately lead to the improvement of the whale stock management procedures. In other words, the first objective will provide information on biological parameters (such as MSYR) necessary for managing the stocks more efficiently under a revised RMP, the second will lead to examining a multi-species management model for the future and the third will supply information for establishing management areas in the Antarctic Ocean.

An unrealistic rate of 1% of mature female population size was used as the MSYR for the implementation of the RMP on Antarctic minke whales agreed in 1993. Also, because there was little data on stock structure at that time, *Small Areas* were defined by 10° longitudinal sectors, which is also unrealistic. In view of the above, JARPA II will attempt to provide data for the following improvements:

* Improvement of MSYR estimates for Antarctic minke whales;

* Redefinition of appropriate management Areas; and

* Incorporation of effects arising from the inter-species relationships among the whale species. For instance, should the carrying capacity for the minke decline due to competition with other whale species, minke whale stocks would still be at their full capacity and a robust level even if abundance decreased for this reason. With the current RMP, the catch quota for the foregoing scenario would be heavily (but unnecessarily) reduced, even to zero; it would fail to function as a realistic basis for management and needs to be improved.

IV. RESEARCH METHOD

1. Research area

JARPA began with surveys in Areas IV (70°-130°E) and V (130°E-170°W). From the austral summer season 1995/96, the research area was extended to include the eastern part of Area III (35°-70°E) and the western part of Area VI (170°-145°W). The stock structure of Antarctic minke whales was therefore investigated in an area spanning 180 degrees in longitude. With regard to the Antarctic minke whale, it was found that there were two independent stocks in the research area and a soft boundary at 165°E (middle of Area V) was proposed for management purposes (Pastene *et al.*, 2005a). To the west of this boundary line, but especially in Area IV, humpback whales have shown a rapid increase in recent years, and have surpassed

the Antarctic minke whale in biomass. Fin whales have also shown a rapid increase with an abundance estimate of about 9,000 animals in Area IV+IIIE (Appendix 1). On the other hand, there has been significant decrease in blubber thickness of the minke whales and a reversal in the trend of age at maturity toward younger ages (Bando *et al.*, 2005; Konishi and Tamura, 2005; Zenitani and Kato, 2005), which strongly indicates competition among the whale species in the area.

The eastern part of Area V, mostly made up of the Ross Sea, comprises the main area of distribution of the West South Pacific Stock of Antarctic minke whales. This stock has a remarkably large abundance. The level of competition in this sector might be different from that in the area west of 165°E, because some differences in the temporal trend of some biological parameters of minke whale were found between whales distributed west and east of this boundary (Bando *et al.*, 2005). Comparative studies of both areas will be useful to understand the pattern of competition among whale species.

The area to be covered by JARPA II will basically be the same as in JARPA: the eastern part of Area III, Areas IV and V, and the western part of Area VI (35°E - 145°W). In the first year, JARPA II will survey the East Indian Ocean Stock of Antarctic minke whales in a longitudinal span of 140° on the western side of the research area (35°E - 175°E). In the second year, JARPA II will survey the Western South Pacific Stock in a longitudinal span of 95° on the eastern side of the research area (130°E - 145°W). Thus, surveys repeat in the western region and eastern region every two years (Fig. 1).

The area from 130°E to 175°E will be covered every year, and the reason is as follows. At the JARPA Review Meeting, it was pointed out that there exists a 'soft boundary' between the East Indian Ocean Stock (I-Stock) and the Western South Pacific Stock (P-Stock) of minke whales in the vicinity of 165°E and that further survey is necessary to better establish the range over which the stocks mix. Therefore, it has been decided to survey the area from 130°E to 175°E every year in order to elucidate the pattern of stock mixing at that particular sector. That is to say, minke whales will be taken west of 175°E in the first year and east of 130°E in the second.

Regarding humpback whales, the stock boundary between the D and E stocks is currently placed at 130°. The D-Stock (breeding grounds located off the west coast of Australia) occurs on the west of the boundary, in Area IV, while the E-Stock (breeding grounds located off the east coast of Australia) is distributed to the east in Area V (IWC, 2001). This boundary also applies to fin whale stocks: the Indian Ocean Stock occurs on the west of 130°E and the Pacific Stock on the east. However, some mixing on the feeding grounds between the two humpback stocks has been postulated in the past, and is supported by mark return data. The D stock is currently estimated to return to its pristine abundance over the next 10 years (Johnston and Butterworth, 2005), providing an ideal opportunity which should not be missed to gain understanding of the dynamics of the population and how biological parameter values change in such circumstances, while the E stock which is still at a relatively lower level serves as a control.

In the Ross Sea, especially, a comprehensive ecosystem survey (a meso-scale survey) might be conducted, if possible.

2. Research period

JARPA II will start in the 2005/06 season and the first two seasons are the feasibility study, investigating the feasibility and practicability of sighting and sampling survey methods.

Full-scale research will commence from the 2007/08 season and a period of six years (including two years of feasibility study) has been established as the research phase. At the end of this phase, a review will be held and revisions made to the program if required.

3. Target whale species for lethal sampling

The species to be caught for research purposes are the Antarctic minke whales of the Eastern Indian Ocean and Western South Pacific Stocks; humpback whales of the D and E-Stocks, and fin whales of the Indian Ocean and the Western South Pacific Stocks.

Viewed overall, sampling of the three species in two Areas provides an important opportunity to gain insight into the dynamics of whale and inter-species competition through comparative analysis. In Area IV, 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 minke whales at present, humpbacks are at a relatively lesser proportion of their pristine

abundance than in Area IV, and hence together with fin whales seem likely to continue to increase. Thus the different comparisons possible across species and Areas provide important potential insights into whale dynamics, and consequently appropriate management actions for sustainable utilization.

4. Survey methods and items

Sighting and sampling methods are planned as described below. Their practicability and suitability will be examined in the feasibility studies, after which they will be improved and changed as necessary.

* Sighting survey method

As a general rule, the surveys will cover areas south of 60°S. The areas will be divided into six sectors (eastern Area III, western Area IV, eastern Area IV, western Area V, eastern Area V and western Area VI). As a general rule the four sectors on the west side (eastern Area III, western Area IV, eastern Area IV, and western Area V) will be surveyed in the first year and the three sectors on the east side (western Area V, eastern Area V and western Area VI) in the second year. After the first two years, JARPAII will cover the survey area alternately. These sectors will be divided further into southern and northern strata, over which surveys will be conducted using two dedicated sighting vessels, basically employing the method used in SOWER. However, JARPA II will record sightings of seals and possibly other krill predators in additions to whales.

* Sampling method

Three sampling/sighting vessels will be employed. Antarctic minke whales will be taken in the area south of 62°S. Density index of Antarctic minke whales based on sighting data from JARPA is low in the latitudinal band between 60°S and 62°S (less than 10% of the whole latitudinal range). This indicates that sampling of Antarctic minke whales in this latitudinal band has a low importance. As described in section IV-1 above, the longitudinal sector from 35°E to 175°E will be stratified and surveyed in the first year and that from 130°E to 145°W in the second year. Survey courses will be established by the line transect method as in JARPA. A maximum of two minke whales per school sighted will be taken by random sampling. Humpback and fin whales will be taken by the same method as for the Antarctic minke whale.

Analytical methods by research objective are shown below.

1) Monitoring of the Antarctic ecosystem

In monitoring whales and habitat conditions, it is very important to detect any changes as soon as possible, identify the factors and predict their effects on the stocks, and to provide information necessary for the development of appropriate management policies. Data collected by the JARPA program were for the purpose of estimating biological parameters of minke whale stocks, but they included useful monitoring items. Thus, in order to secure continuity with the data collected in JARPA, we will continue to monitor the following:

I) MONITORING OF WHALE ABUNDANCE TRENDS AND BIOLOGICAL PARAMETERS

According to the results of JARPA the current abundance of Antarctic minke whales migrating to the research area shows no statistically detectable trend. However, as mentioned earlier, the trend of the age at sexual maturity toward younger ages has halted and blubber thickness has decreased, which may affect recruitment and abundance in the future. JARPA II intends to elucidate quantitative changes in minke whale stocks by carrying out sighting surveys and by estimating parameters, including recruitment and mortality, with population demographic model analyses such as VPA. This will also serve to monitor possible changes in carrying capacity.

JARPA II will monitor changes in the ages at sexual and physical maturity, pregnancy rate, blubber thickness and other items using the whales sampled in the program. Analysis of the JARPA data has indicated that the earlier decrease in the age at maturity of Antarctic minke whales has either now stabilized or even reversed. Changes in this biological parameter are considered to be a key factor in understanding minke whale stock abundance trends. JARPA II will, therefore, elucidate qualitative changes in the stocks by focusing analyses on mature whales, which are directly involved in reproduction, through the monitoring of changes in the age at sexual maturity, pregnancy rate, etc.

In order to monitor changes in the level of genetic diversity over time, JARPA II will examine the temporal variation of key genetic indices: the number of mtDNA haplotypes and nucleotide diversity, the number of

microsatellite alleles per locus and the level of microsatellite heterozygosity. Changes in the indices of genetic diversity will be used as a rough index for abundance variations.

II) MONITORING OF KRILL ABUNDANCE AND THE FEEDING ECOLOGY OF WHALES

As in JARPA, stomach content and weight will be examined by direct sampling. Apart from identification of the prey species, body length and growth stage will be investigated for krill in the stomachs and for those obtained by net sampling. In this way prey species and prey size selectivity by whales can be investigated. JARPA II will also monitor the changes in diurnal consumption, calculated by stomach content weight and basal metabolism rate, as was done in JARPA.

Changes in nutritional condition, including meal size, body fatness, girth and blubber thickness will be monitored as in JARPA. Prey availability will be evaluated by comparing the nutritional condition of whales with oceanographic conditions and information on prey.

At the mid-term review of JARPA held in 1997, the necessity of an ecosystem survey at the meso-scale level was pointed out (IWC, 1998). In the 2004/05 JARPA, *Kaiyo Maru*, the research vessel of the Japanese Fisheries Agency, conducted ecosystem surveys linked with sampling surveys by the *Nisshin Maru* fleet. In Phase II, if possible, the habitat environment of whales will be monitored and also the biomass of lower trophic level species will be surveyed once every two or three years using an echo sounder.

III) MONITORING OF THE EFFECTS OF CONTAMINANTS ON CETACEANS (APPENDIX 4)

The Antarctic is a remote area, far from the middle latitude regions of the Northern Hemisphere, which is the main source of pollutants including organochlorines. The Antarctic Ocean is considered the terminus of global contamination, and therefore monitoring of the area is important in considering future global contamination. The area also has significance as a control region for considering biological effects on cetaceans in the North Pacific, which is close to the contamination sources. Monitoring will be done with the following points in mind:

* Elucidation of changes in pollutant accumulation in cetaceans of the Antarctic Ocean and the western North Pacific and their biological processes;

* Elucidation of pollutant behavior in the marine ecosystem of the Antarctic and the western North Pacific; and

* Elucidation of the biological effects of pollutants on cetaceans.

In the Antarctic Ocean (a non-contaminated area), JARPA II intends to examine the distribution and behavior of contaminants such as organochlorines and heavy metals in cetaceans that are at the top trophic level and their prey, together with those in the marine ecosystem, including samples from the environment such as of air and of sea water. Data will be compared to those obtained in the western North Pacific (a contaminated area). We will also collect background readings on the biological effects of pollutants on wild animals in the Antarctic Ocean and in the western North Pacific, and gather data on the thresholds of toxic effects through environmental toxicological research and pathological monitoring. Also, the data obtained will be compared with data on minke whales in the western North Atlantic, if possible.

IV) MONITORING OF CETACEAN HABITAT

Oceanographic and meteorological observations will be carried out while monitoring the environment, including sea ice, surface temperature, sea surface height and chlorophyll α concentration over the entire research area, using satellite data. JARPA II will investigate the relationships between oceanographic data and species distribution, including cetaceans, by real-time or time series analysis. JARPA II also intends to actively cooperate with international organizations and projects on oceanographic surveys.

2) Modelling competition among whale species and future management objectives

I) CONSTRUCTING A MODEL OF COMPETITION AMONG WHALE SPECIES

JARPA II will test several hypotheses explaining changes in abundance of baleen whale species in the Antarctic ecosystem (i.e. blue, fin, humpback, and Antarctic minke whales that prey on Antarctic krill south of 60°S) and aim to construct a model that simulates their changes. The model is called a "model of competition among whale species". The following sets out the concepts underlying the model and related hypotheses (Appendix 6).

CONCEPTS OF THE MODEL

Regions south of 60°S in the Antarctic have a high bio-productivity and are rich in Antarctic krill. They are the major feeding grounds of large whales such as blue, fin, humpback and Antarctic minke whales. The carrying capacity of whale species depends on the available biomass of krill.

Before the start of commercial whaling in 1904, all whale stocks were at the level of full carrying capacity, with a balance maintained among whale species (1- Hypothesis of constant overall carrying capacity).

Whaling first began on the blue whale, the largest species yielding the greatest oil production, and the humpback whale that was a species relatively easy to catch. The level of catches on these two species increased rapidly and the stocks were greatly diminished. Next, whaling moved on to fin whales in the mid 1930s, and the stocks of this species were also severely depleted. The substantial reduction in abundance of these species, which are important components of the ecosystem, resulted in a substantial surplus of krill (2- Krill surplus hypothesis).

Because of its small size and limited oil output, Antarctic minke whale was not exploited at that time. They fed on the surplus of krill and rapidly increased their abundance, with the age at sexual maturity changing to younger ages (2- Hypothesis of krill surplus and 3 - Hypothesis of changing carrying capacity by species).

The catch of humpback, blue and fin whales was banned in 1963, 1964 and 1976, respectively. The age at sexual maturity shifted to younger ages in the humpback and fin whales and an increasing trend in their abundance has become apparent in recent years. Humpback whales now surpass the Antarctic minke whales in biomass in Area IV (4- Hypothesis of stock increase due to a declining age at sexual maturity and 5- Hypothesis of a predominant species in the ecosystem).

Antarctic minke whale stocks would probably decrease in number if the current conditions continue (6- Hypothesis of declining pregnancy rates and/or juvenile survival rates due to inadequate trophic conditions and 7- Hypothesis of competition among whale species).

The current extent of recovery of blue whales is very limited despite the fact that catch of this species has been banned since 1964. It is possible that the chance of mating is low as a consequence of the extremely small number of animals (8- Hypothesis about the causes of slow recovery).

Extensive climatic changes, including global warming, have become apparent in the Antarctic. For instance, the average winter temperature in the Antarctic Peninsula has gone up as much as by 5°C. There is also a possibility of a major decline in the abundance of prey species (krill) due to the rise in surface temperature. Such changes or variations in krill abundance could consequently affect the baleen whale stocks (9- Hypothesis about the effects of environmental changes on cetaceans).

Along with humpback and fin whales, the recovery rate of the blue would probably increase from now on (Branch *et al.*, 2004) and the balance among whale species in the Antarctic ecosystem will continue to change, although the pace of such changes would likely differ by geographical areas.

JARPA II will aim to construct a multi-whale species balance model among whale species that will reproduce the processes described above. The changes in abundance by species in the research area and the factors affecting these changes need to be investigated. Also, further changes in the future will be predicted, and surplus production will be estimated from abundance data for each species, so that appropriate management objectives can be considered through use of the model.

There is an initial ecosystem model of the Antarctic Ocean developed by Mori and Butterworth (2004): a cetacean competition model over krill. For the western North Atlantic, Scenario C（Schweder *et al.*, 2000; Zhu *et al.*, 2004) and Gadget (Begley, 2004; Olafsdottir and Begley, 2004), which also take competition into account, are being developed. JARPA II will make selections after carefully considering the advantages and disadvantages of these models and their appropriateness to the Antarctic ecosystem.

The construction of the model will start with krill as the sole prey species and the four baleen whale species, which will compete for the prey. Although it seems a simple ecosystem model and we expect to be able to match population abundances and trends indicated by JARPA II. In the future, JARPA II will incorporate pinnipeds such as crabeater seals, and seabird predators as well as cephalopods, which all prey on Antarctic krill, to construct a more realistic ecosystem model.

II) NEW MANAGEMENT OBJECTIVES INCLUDING THE RESTORATION OF THE CETACEAN ECOSYSTEM

JARPA II will consider establishing new management objectives or goals including the recovery of the blue whale when the model of competition among whale species has been developed to a certain extent. This can also be done by comparing the results of work to improve the minke whale management procedure with the knowledge obtained directly from monitoring activities.

Possible management goals could be accelerating the recovery of blue and fin whales, maximization of total production or increasing the productivity of specific whale species in relation to their economic value.

JARPA II will further examine the advantages and disadvantages of alternate management goals. JARPA II will also examine the possible effects of the resumption of commercial whaling on the relative numbers of the various species and stocks and aim to provide advice on management policies for whaling that will meet chosen management objectives.

3) Elucidation of temporal and spatial changes in stock structures
Genetic and biological markers will be sampled and/or observed from samples taken in the monitoring surveys of whales. Biopsy sampling will be conducted on blue, fin and humpback whales.

Analyses of mtDNA control region sequencing and nuclear DNA microsatellites will be conducted. Other biological markers will also be analyzed.

Further, JARPAII will develop tagging methods for data loggers (TDR) and satellite tagging transmitters, and trace migration routes of the tagged whales in order to elucidate stock structure.

Based on the analysis, we will better elucidate fin and blue whale stock structure. Also, the spatial and temporal variation in stock boundaries (or equivalently changes of the relative proportions of stocks in mixing areas) of the Antarctic minke and humpback whales will be tracked.

4) Improving the management procedure for Antarctic minke whale stocks
* Estimation of MSYR

Recruitments over the years are estimated by VPA based on age and abundance data. Recruitments are fit to the Pella-Tomlinson reproduction model to estimate MSYR.

* Re-establishment of management Areas for the Antarctic minke

The management area for the East Indian Ocean Stock and West South Pacific Stock should be re-established using the results obtained from the third research objective. That is to say, by elucidating the degree of intermingling and changes according to year in sector VW where the Indian Ocean Stock is expected to be mixed with the West South Pacific Stock, *Small Areas* would be specified. As for the other sectors, *Small Areas* that have been established by a longitudinal span of 10 degrees should be abolished in favour of more biologically realistic choices.

* Incorporation of effects due to inter-species relations among species

An examination will be made of whether or not the current RMP has functions that meet inter-specific phenomena (for instance, decline in carrying capacity and abundance decrease) that have become apparent from research under the first and second objectives. If not, consideration will be given as to how to incorporate them into the calculation of catch limits under a refined RMP.

V. SAMPLE SIZES

1. Antarctic minke whales

First, the sample size necessary for the monitoring of biological parameters has been calculated. The sample size was calculated not in relation to the precision of the parameter estimates themselves, but to detect significant temporal changes in the estimates. Changes in the age at sexual maturity and blubber thickness are very important since they indicate changes in abundance trends or shifts in prey conditions. A sample size needed to detect changes in a six-year period (by applying past rate of change, that is, the slope of the regression) has been adopted as the pertinent criterion. Required sample sizes are then calculated as follows:

Age at sexual maturity: Age at sexual maturity shifted toward younger age at an annual rate of 0.2 years during the period of commercial whaling years, but presently it has stabilized. It is important to determine when it starts to increase. It is not plausible that the changes of age at sexual maturity starts at the rate of 0.2 year, rather it will have a period of slower change rate, and therefore annual rate of 0.1 year was chosen. Sample size at a detection level of yearly rate of change of 0.1 year is 1,288 animals/year (Appendix 6).

Apparent pregnancy rate: The apparent pregnancy rate of minke whales is high and is 90% or more. Sample size necessary to detect the change of 1.0-1.5% at the initial stage when change begins is 663-1,617 animals (Appendix 6).

Blubber thickness: Similarly, sample size for the detection of a yearly rate of change of 0.5 mm. observed in the past is 818 to 971 animals (Appendix 7).

The sample size necessary for pathological monitoring (effect of contaminant on whale species) is 864 animals/year at 10% of the prevalence rate, which was expected for the free-ranging whale by using data from the feasibility observation in the JARPA surveys (Appendix 4).

The sample size necessary for detecting yearly change in mixing proportion between Antarctic minke whale stocks in Area VW is shown in Appendix 3. The mixing rate in the 1996/97 season was different from those of other seasons. Results obtained showed that for non-overlapping 95% credibility intervals between the estimates of the mixing proportions over Area VW, a sample size in that region of about 300 will be required. This sample size will provide the power to detect an annual change as big as the one that appears to have occurred in 1996/97. The abundance in Area VW is approximately 1/3 of that in the research area of each year. Therefore, about 300 samples are expected in Area VW under the total sample size of 900 animals. This means that the necessary sample size in Area VW will be ensured.

Mark-recapture analysis is useful for abundance estimates and the elucidation of behavior patterns. Such analysis has been conducted in recent years based on biopsy sampling and genetic identification of individuals. However, this has not proved to be practical since non-lethal sampling has been involved, which means that the numbers of samples obtained are small in relation to the amount of effort involved. Large-scale biopsy sampling is also inefficient in offshore waters for baleen whale species.

An alternative method that offsets these deficiencies has been developed recently based on catches. Mother-fetus pairs in the catches are examined using a set of microsatellites. Based on the genetic profiles, the potential father of the fetus is sought among the rest of whales in the catches. Attempts are being made to estimate the abundance and to elucidate stock structure and behavior patterns based on the positions where the parents were taken (for example, Skaug and Oien, 2004). The method could also be useful for estimating differences in reproductive success rates between individuals or groups of whales differing in life histories and ages.

In Norway, a total of 288 mother-fetus pairs were examined out of 3,301 whales in the DNA register, and five possible fathers were identified. Based on this, the abundance of male minke whales was estimated to be 38,400, but the figure is imprecise. If this method is applied in JARPA II, at least 800-1,000 animals per year will be necessary even if the samples are pooled for the three seasons in the six years (Appendix 8).

In summary, as the minimum number of sample size, 663 animals were calculated for apparent pregnancy rate. However, for most of the other parameters, the sample sizes calculated were in a range of 800-1,000 animals with more than 800 being desirable. Therefore, the sample size of minke whales was set at 850 +-10 %. The allowed range of +-10% was applied since, based on the past data on school density, there are annual changes in school density on the line transects, which are determined in advance.

2. Humpback whales

The sample size required for the monitoring of important biological parameters in this species has been examined. Changes in the pregnancy rate and age at sexual maturity are very important since they indicate changes in the trend of abundance or shifts in prey conditions. A sample size needed to detect changes observed in past years (that is, slopes of regression) has been adopted as the criterion.

The results of sample size calculations for pregnancy rate and age at sexual maturity (Appendix 6) are outlined below. There were hardly any data on the age at sexual maturity so those for fin whales were used instead. A sample size for a six-year period is preferable since the research program will be reviewed every six years, but in the case of humpback whales the resulting values for this period were large so that we have decided to use the sample size required for twelve years, as a precautionary approach.

Apparent pregnancy rate: 41 to 181 animals for a yearly rate of change of 1.5 to 3% observed in the past (Appendix 6).

Age at sexual maturity: 131 animals for a yearly rate of change of 0.1 years (for fin whales) (Appendix 6).

Considering these results, we have decided on a sample size of 50.

3. Fin whales

Sample size was determined under the same conditions and criteria as for the humpback whale.

Apparent pregnancy rate: 55 to 107 animals for a yearly rate of change of 2 to 2.5% observed in the past (Appendix 6).

Age at sexual maturity: 131 animals for a yearly rate of change of 0.1 years (Appendix 6).

For the DNA analysis, samples of 20 to 50 animals have been recommended (Hoelzel, 1991).

As with humpback whales, we have decided on a sample size of 50.

VI. FEASIBILITY STUDIES

1. Necessity and objectives

As explained earlier area will be enlarged, sample size will be increased and new species added. The objective of the feasibility study is to examine the practicability and appropriateness of sighting methods and sampling procedures, and improve them as necessary.

Catches of humpback and fin whales were banned in the Antarctic in 1963 and 1976, respectively. Crews and research staff of the research fleet have no experience in catching and flensing these two large-sized whales. Thus, it is necessary to examine the practicability of methods of hunting, hauling, flensing and biological sampling.

If possible, detailed surveys of krill and the marine environment will be also carried out during the feasibility studies.

2. Survey period

The first two seasons (2005/06 and 2006/07) will be allocated to the feasibility studies.

3. Survey methods

As a general rule, sighting and sampling methods will be the same as explained in Section IV-4 above.

4. Sample size

As mentioned in Section V-1, a maximum of 850+-10% Antarctic minke whales will be sampled from the first year. The practicability and appropriateness of sighting methods in the enlarged area and sampling procedures given the increased sample size will be examined.

A maximum of ten fin whales will be sampled in each season. These samples will be used to check the practicability of catching, flensing and taking of biological measurements of large whale species. There is little information for fin whales in recent years, and preliminary data on food habit and maturity will be obtained in the feasibility study.

Humpback whales will not be taken during the feasibility study.

VII. EFFECT ON THE STOCKS

Based on the results of the Hitter-Fitter Method (Appendix 9), no adverse effect on Antarctic minke whale stocks is expected.

As regards humpback whales, their steady recovery has been reported (Bannister and Hedley, 2001; Paterson, Paterson and Cato, 2001; Johnston and Butterworth, 2005). Using the population dynamics model by Johnston and Butterworth (2005), the effect of take of 50 animals on the stock was examined. The results showed that the take of 50 animals per year hardly delays their recovery to the pristine level (Appendix 9).

The abundance estimate of fin whales (Appendix 1) does not cover their entire range and is therefore greatly underestimated. The planned sample size is fifty animals each year, which comes to twenty-five a year from each stock which is less than 1% of the underestimated abundance. Therefore it is considered to have no adverse effect on the stocks. During the feasibility study the sample size is ten animals each year (effectively only 5 a year from each stock). The effect is therefore negligible.

VIII. RESEARCH VESSELS, RESEARCH ORGANIZATIONS AND FOREIGN PARTICIPATION

1. Research vessels

The whale research fleet will be composed of two dedicated sighting vessels (*Kyoshin Maru No.2* and the other undecided vessel), three sampling vessels (*Yushin Maru No.2*, *Yushin Maru*, and *Kyo Maru No.1*) and one research base vessel (*Nisshin Maru*). If possible, other vessel will engage in more detailed surveys on prey and marine environment.

2. Research organizations

(1) Institute of Cetacean Research (ICR)

(2) National Research Institute of Far Seas Fisheries (NRIFSF) and other institutes of the Fisheries Research Agency (FRA)

(3) Other research institutes

3. Participation of foreign scientists

Participation of foreign scientists will be welcomed, so long as they meet the qualifications established by the Government of Japan. The required qualifications are the same as for JARPN II.

IX. NECESSITY OF LETHAL METHODS

The necessity of using lethal methods was already discussed at the 1997 JARPA Review meeting (IWC, 1998).

Parameters related to age and stomach content surveys, which are essential for the objectives of JARPA II, cannot be obtained using non-lethal methods alone. JARPA results showed that the meal size, blubber thickness and age at physical and sexual maturity strongly suggested inter and intra species competitions (Tamura and Konishi, 2005; Bando *et al.*, 2005; Zenitani and Kato, 2005; Konishi and Tamura, 2005; Fujise *et al.*, 20005). These parameters are essential for monitoring of the Antarctic ecosystems, and therefore lethal sampling is necessary for JARPAII.

X. UTILIZING EXISTING DATA

1. Data from commercial whaling

Pregnancy rates and age at sexual maturity, of humpback, fin, and blue whales have been estimated based on data from commercial whaling (Appendix 6, Lockyer, 1979). They are valuable information and will be compared with the data obtained in JARPA II.

Biological data on Antarctic minke whales obtained from past commercial whaling and JARPA have been already compared. They are a valuable time series of data required for connecting from past to future.

2. Data from JARPA

Data from JARPA are highly valuable from the standpoint of monitoring. In JARPA II environmental and biological data will be collected as a continuation of JARPA.

XI. OTHERS

1. Processing of whale samples

All the whales sampled will be treated as stipulated in Paragraph 2, Article VIII of the International Convention for the Regulation of Whaling. Tissue samples will be taken from all whales and DNA data registered for market control (individual identification).

2. Report to the IWC Scientific Committee

A report of research cruises will be submitted to the annual or other meetings of the IWC Scientific Committee and other organizations, every time a cruise has been completed. The report of the two feasibility cruises will be submitted to the IWC/SC after they have been completed. When the full-scale research

program has been launched, a comprehensive report will be submitted to the IWC/SC after each six-year research period.

3. Whale killing methods

All whales will be taken using explosive grenades. If instantaneous death is not achieved by the primary killing method, a suitable secondary method, such as a large caliber rifle or another explosive grenade will be chosen, depending on whale species and the condition of the hunted animal.

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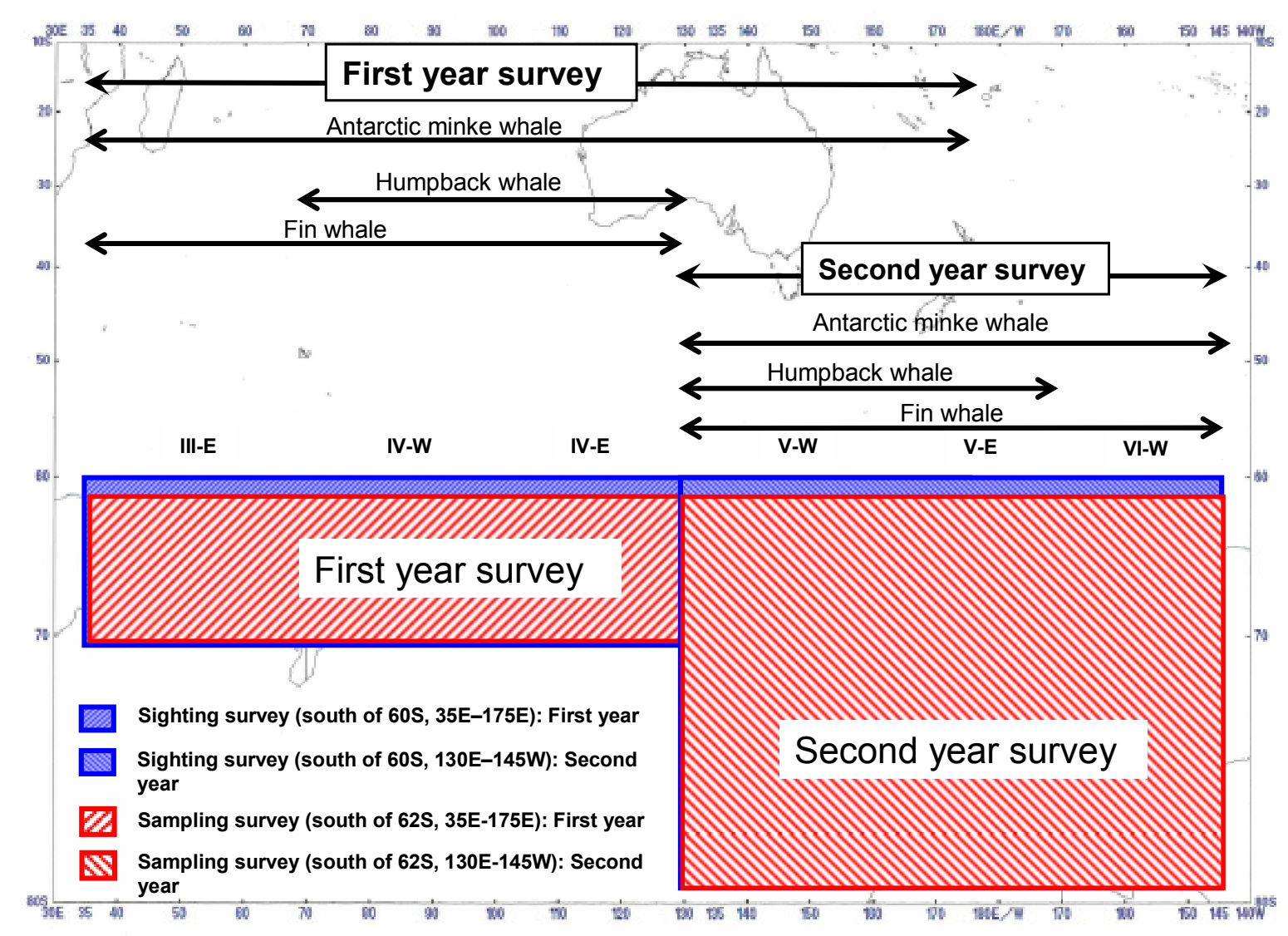
First year survey
Antarctic minke whale
Humpback whale
Fin whale
Second year survey
Antarctic minke whale
Humpback whale
Fin whale
III-E
IV-W
IV-E
V-W
V-E
VI-W
First year survey
Second year survey
Sighting survey (south of 60S, 35E–175E): First year
Sighting survey (south of 60S, 130E–145W): Second year
Sampling survey (south of 62S, 35E-175E): First year
Sampling survey (south of 62S, 130E-145W): Second year