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Research Plan for Cetacean Studies in the Western North Pacific under Special Permit (JARPN II)

Government of Japan

ABSTRACT

JARPN, the Japanese Whale Research Program under Special Permit in the western North Pacific was conducted between 1994 and 1999 with two main objectives related to population structure and feeding ecology of common minke whales (*Balaenoptera acutorostrata*). IWC Scientific Committee's review of JARPN (JARPN Review Meeting, February 2000) agreed that there were unresolved scientific issues related to minke whale stock structure and also made a series of recommendations to strengthen the feeding ecology part of the program (IWC, 2001a). Taking into account the results of the Review Meeting, a two-year feasibility study of the second phase of JARPN (JARPN II) was conducted in the years 2000 and 2001. This paper presents the research plan for the full JARPN II research program taking into account results from the JARPN II feasibility study.

Based on the success of the feasibility study (Government of Japan, 2002) and increasingly strong support from international fisheries organizations, including FAO, for research to improve multispecies approaches to management, the Government of Japan is convinced that it should start JARPN II as a full-scale research program from 2002. Considering the increased importance of and interest in the issue of competition between marine mammals and fisheries, the priority of JARPN II is placed on feeding ecology and ecosystem studies, involving studies of prey consumption by cetaceans, prey preferences of cetaceans and ecosystem modeling. The second priority is to monitor environmental pollutants. Further data related to stock structure, particularly for minke whales, will also be collected.

One hundred minke whales (effectively O Stock and putative W Stock), 50 Bryde's whales (*Balaenoptera edeni*; Western North Pacific Stock), 50 sei whales (*Balaenoptera borealis*; Asian Stock) as a new study component and, as the continuation of the feasibility study, 10 sperm whales (*Physeter macrocephalus*; Western Division Stock) will be sampled each year by the *Nisshin Maru* research fleet. To cover the temporal and spatial gaps, which cannot be sampled by the *Nisshin Maru* fleet, another 50 minke whales will be sampled each year by small type whaling catcher boats as a two-year feasibility study. These species were chosen for sampling because they occupy an important niche in the pelagic zone of the North

Pacific and also because their populations are relatively abundant. The effects of the research catches will be negligible on whale stocks sampled.

The research methods for the full JARPN II are basically the same as in 2000 and 2001 feasibility studies 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.

The research area for the feeding ecology studies will be extended eastwards to sub-area 9 and stratified mainly on oceanographic conditions. Small type whaling catcher boats will be operated in the coastal strata in spring and autumn. If permission to enter Russian waters is obtained from Russian authorities, this research plan will be modified in order to conduct sampling of minke whales in sub-area 12 to meet the objective of JARPN (i.e. stock structure) while the total sample size will be the same. In such case, the research plan for other species may be modified and but will be carried out to the extent possible. Cruise reports will be submitted annually to the IWC/SC.

JARPN II is designed as a long-term research program of undetermined duration. A comprehensive review will be conducted following completion of the first 6 years of the research. JARPNII is fully consistent with IWC resolution 53-1 in which the Commission unanimously decided to make the study of interactions between whales and fish stocks a matter of priority.

CONTENTS

Pacific particularly in sub-areas 7, 8 and 9, and biological aspects of cetaceans species to be sampled by JARPN II

Appendix 2: Prey species of seven cetacean species distributed in the western North Pacific

Appendix 3: Biology and fisheries of the prey species of cetaceans in the western North Pacific

Appendix 4: Two types of ecosystem models to analyze multi-species interactions in the western North Pacific

Appendix 5: Sample size of minke whale, Bryde's whale and sei whale required for statistically significant examinations of consumption of various prey items

Appendix 6: Examination of the effect on the whale stocks of future catches under JARPNII

I. INTRODUCTION

The introduction of the moratorium on commercial whaling in the 1980's has provided protection to both abundant and depleted species of whales. Furthermore, other marine mammals including seals have for a number of decades, also been protected by many countries irrespective of their stock status. As a result, many species of marine mammals have increased in abundance and are now exerting a significant influence as top predators consuming huge amounts of fisheries resources within the marine ecosystem.

The issue of competition between fisheries and marine mammals (whales, seals, and sea lions) is of increasing concern to fishers worldwide as well to many governments and international fisheries research and management organizations, including the United Nations' Food and Agriculture Organization (FAO). Fish consumption by marine mammals is related to world food security and has the potential to undermine fishery conservation efforts (Tamura and Ohsumi, 2000; Morishita and Goodman, 2001; FAO, 2001).

For this reason, the main purpose of the second phase of the Japanese Whale Research Program under Special Permit in the Western North Pacific (JARPN II) is to study the competition between whales and fisheries, and to elucidate the role of the cetaceans in the marine ecosystem of the western North Pacific, which is a very important fishing ground for the coastal countries of the region, including Japan.

Data on fish consumption by whales, including what, when, where, and how much they eat will be collected and used together with oceanographic and other marine living resource data to construct an ecosystem model which will contribute to improved fisheries management in the region. The JARPN II feasibility study conducted in 2000 and 2001 has shown that in the waters around Japan, common minke whales *(Balaenoptera acutorostrata*) and Bryde's whales *(Balaenoptera edeni*) are consuming large amounts of several species of prey that are also the target of commercial fisheries (Government of Japan, 2001; 2002).

The second purpose of JARPN II is data collection to continue monitoring the levels of environmental pollutants such as organochlorines and heavy metals in whales and the ecosystem as a whole. Since marine mammals can function as indicators of changes in the environment this has been a part of previous studies. However, this component has been strengthened in the current research plan to reflect increasing concern about the issue of environmental pollutants. Specifically, subjects such as the temporal and spatial variations of accumulations of pollutants in cetaceans, the characteristics of their accumulation pattern, and the process of bioaccumulation through the food chain will be examined.

JARPN II is also designed to collect data for the ongoing analysis of the stock structure in minke whales since some questions remain unresolved. The analysis of stock structure is essential for the application of the IWC Scientific Committee's (SC) Revised Management Procedure (RMP) on this species.

JARPN II is designed as a long-term research program that takes into full account information and scientific data from JARPN (1994-1999) and the JARPN II feasibility study (2000 and 2001). Sampling of minke whale, Bryde's whale and sperm whale *(Physeter macrocephalus*) as in the JARPN II feasibility study will be continued in the full research program with the addition of 50 sei whales *(Balaenoptera borealis*) in each year and 50 minke whales to be taken by small-type whaling catcher boats. Sei whale is newly selected as a target species as they feed on fisheries resources such as common squid and the estimated biomass is larger than that of Bryde's and minke whales. The additional 50 minke whales will provide full coverage of the spring and autumn seasons in coastal waters where the competition between cetaceans and fisheries is likely to be substantial. Ten sperm whales will continue to be sampled because their biomass is too large to be ignored in the ecosystem models.

Sampling will be conducted in sub-areas 7, 8 and 9 with an extension of sampling eastward to 170 E. Sampling of minke whales will be conducted in sub-area 12 if permission is obtained from Russian authorities.

II. BACKGROUND

1. Feeding ecology and ecosystem studies

Marine mammal interactions with fisheries have become a major issue worldwide. It is an important issue in the context of world food security since the estimates are that cetaceans consume 3 to 5 times the amount of marine resources harvested for human consumption (Tamura and Ohsumi, 2000). Many international fisheries organizations have urged the development of multi-species or ecosystem management systems (see for example, various reports from FAO, ICES, NAFO, NAMMCO, IOTC and others discussed in: Morishita and Goodman, 2001). Indeed, in 1998, the FAO's High-level Panel of External Experts in Fisheries expressed the view that FAO and all fishery bodies must increasingly develop an ecosystem approach to management. Given the FAO's projection for supply and demand of products from marine fisheries which shows that 10 years from now, only at the lower end of the range projected for demand, can this be met by supply (FAO, 1999), it is clear that fisheries management regimes must be based on multi-species models that take account of the consumption of fish by marine mammals.

Most significantly, at its 24th Session in 2001, COFI (FAO’s Committee on Fisheries) unanimously agreed that the FAO should conduct studies on the interaction between fisheries and marine mammals. This agreement was endorsed by the 120th Session of the FAO Council and reaffirmed in the October 2001 Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem. The Reykjavik Declaration also affirmed that the incorporation of ecosystem considerations implies increased attention to predator-prey relationships and agreed that it is important to advance the scientific basis for incorporating ecosystem considerations including the study of diet composition and food webs, species interactions and predator-prey relationships.

In the North Atlantic, the feeding ecology of top predators has already been studied. According to the Norwegian feeding ecology research conducted between 1992 and 1994, the prey species consumed by minke whales change conspicuously according to area, season and year, and minke whales have flexible feeding patterns to match the local abundance of prey species (Haug *et al.*, 1995a). By inputting these data into a Multspec model it was shown that, when minke whales increase, important fish resources such as cod decrease by predation, resulting in serious consequences for fisheries targeting these species.

Competition between top predators and fisheries has also been discussed at IWC meetings since at least the 51st meeting in 1999 (Tamura and Ohsumi, 1999). After modification of estimates, the estimated prey consumption by cetaceans worldwide was reported as 248 to 434 million metric tons (Tamura and Ohsumi, 2000). At its 53rd meeting in 2001, the IWC unanimously decided to make the study of interactions between whales and fish stocks a matter of priority.

The above summary clearly demonstrates strong international support for research on marine mammal interactions with fisheries including predator-prey relationships as a basis for incorporating ecosystem considerations into fishery management regimes.

In order to respond to the recommendations from the JARPN Review meeting and to address the issues of the competition between marine mammals and fisheries, JARPN II was initiated as a feasibility study for the years 2000 and 2001 (Government of Japan, 2000). The priority research in JARPN II is on the feeding ecology. In addition to minke whales, Bryde's and sperm whales were added to the feeding ecology study, as these species are very abundant in the research area and almost certainly play an important role in the ecosystem. Baird's beaked whales (*Berardius bairdii*), short-finned pilot whales (*Globicephala macrorhynchus*) and Dall's porpoise, (*Phocoenoides dalli*), are also included as samples because these three species are available from the commercial fisheries.

JARPN II feasibility study had an unprecedented design, which involved concurrent surveys of whales and their prey species. One dedicated fisheries research vessel was added to the normal whale research fleet. Many useful results have been obtained from the two-year feasibility study (see report of the feasibility study for details) for example:

(a) The diet of minke whales was very diversified and flexible. Both quantitative and qualitative data have to be accumulated in order to assess the extent/impact of their feeding on commercial fisheries resources.
(b) Bryde’s whales were distributed in the southern and offshore waters and fed mainly on krill and Japanese anchovy. They fed on different size of same prey species (Japanese anchovy) compared to minke whales which occurred in nearly overlapping areas.
(c) Sperm whales were abundantly distributed in the whole research area and mainly fed on deep-sea squids. Although the information on the ecology of the deep-sea squids is quite limited, sperm whales may have important effects on the pelagic ecosystem.
(d) The first concurrent whale and prey surveys were conducted without serious practical problems. Preliminary analyses showed minke and Bryde’s whales had a negative preference to lanternfishes and Bryde’s whales had a positive preference to larger fish among small-sized anchovy.

This full JARPN II research plan was built on these findings and designed to obtain further data on the feeding ecology of whales and the whole marine ecosystem of the research area.

2. Environmental study

Organochlorines (OCs) such as PCBs, DDTs and HCHs are generally produced on land, then move to coastal and pelagic waters in run-off as well as by atmospheric transportation and other ways. The monitoring of these and other contaminants in the marine environment through the examination of biological tissues of marine mammals is of importance since marine mammals can serve as useful biological indicators of environmental conditions and because they can be most affected by pollutants. The IWC/SC has noted that physical processes affect body condition and the abundance of whales through availability of food, and emphasized the need for such research (IWC, 1997).

Environmental study has been a part of Japan's whale research programs and has produced valuable information on the kinds, distribution, and magnitude of pollutants such as heavy metals and PCBs through the examination of various tissues of sampled animals. The study has shown that it is important to continue to monitor the movement and fate of these pollutants.

3. Stock structure

In 1994 the Japanese Whale Research Program under Special Permit in the Western North Pacific (JARPN) was initiated with the main objective of addressing the issues of the stock structure and stock mixing rates of minke whales, as requested for the Implementation Simulation Trials (IST) of IWC/SC (Government of Japan, 1994). Specifically, objectives were to clarify whether or not W Stock exists in offshore areas of the North Pacific, to examine the mixing rate of the hypothesized W Stock with O Stock (the Okhotsk Sea-the east coast of Japan) and to assess the validity of O sub-stock scenario. Clarifying further when and to what extent J Stock whales mix in sub-areas 7 and 11 is also important for the IST.

An IWC/SC workshop was held in Tokyo in February 2000 to: a) review methods and results of the JARPN, b) assess the further potential of existing data and c) evaluate whether the main objectives have been achieved. Although most of the scientific evidence presented at the JARPN review meeting did not support the existence of the W Stock, the workshop agreed that, in the light of the results of mtDNA analysis, the possibility of the existence of some group of minke whales to the east of Japan that differ from the O Stock could not be ruled out. One of the recommendations of the workshop was to obtain further genetic samples from sub-areas 12, 9 and possibly sub-area 8. This full JARPN II program continues to address this issue and the issue of J/O mixing around the Japanese coast.

In 1998 the IWC/SC agreed that for Bryde's whales, there should be two sub-areas (sub-area 1 and sub-area 2) within the Western North Pacific Stock area divided at 180°. In response to some concerns expressed by some SC members that sub-area 1 is very large and that there is limited information for some parts, the JARPN II feasibility surveys were concentrated in some areas previously not covered for stock structure analysis.

The attainment of stock structure data from sei and sperm whale samples will contribute to the future comprehensive assessment of these species.

III. SUMMARY OF RESULTS OF JARPN II FEASIBILITY STUDY IN 2000 AND 2001

1. Introduction

The JARPN II feasibility study was designed to respond to the recommendations from the 2000 JARPN Review Meeting and to address the issue of competition between cetaceans and fisheries with the overall goal of contributing to the conservation and sustainable use of marine living resources including whales in the western North Pacific, especially within Japan's EEZ (Government of Japan, 2000). The priority for the research was feeding ecology and ecosystem studies. Other objectives were related to continuing studies on the stock structure and monitoring environmental pollutants.

JARPN II began as a two-year feasibility study in order to evaluate, among others, the practicability and performance of concurrent whale and prey surveys for estimation of prey preference. The "feasibility" also applied to the addition of Bryde's and sperm whales to the research. The research area was off the coast of Tohoku and southern Hokkaido, (sub-areas 7, 8 and 9) which is Japan's richest fishing grounds and therefore provides an ideal area to study the interactions between cetaceans and fisheries. A total of 140 minke whales, 93 Bryde's whales and 13 sperm whales were sampled. The first feasibility survey of JARPN II was conducted from 1 August to 16 September 2000. The second year survey was conducted from 14 May to 3 August in 2001.

With regard to feeding ecology and ecosystem studies the feasibility studies addressed questions such as: whether information on the diet composition and daily and seasonal consumption can be obtained with adequate precision through the examination of stomach contents of the whales; whether the weights of the stomach contents can be measured for large whales such as Bryde's and sperm whales as is the case for minke whales; whether the first concurrent whale and prey surveys with six research vessels involved are practicable and; whether these provide data to assess prey preferences. This latter point is important since it is a key parameter for most ecosystem models.

Regarding the stock structure of minke whale, following the discussions and conclusions of the JARPN review meeting, the objective was focused on investigating whether or not the W Stock exists in sub-area 9, and if so, to investigate the spatial and temporal extent of its occurrence. Another objective for the 2-year feasibility study was to investigate the pattern of mixing between O and J stocks in sub-area 7. Since there were no genetic samples for Bryde's whales in the research area, one of the objectives of the feasibility study was to determine whether samples for stock structure studies could be collected from such area. Also whether the analysis of such samples could provide additional information on the stock structure.

The research plan also included the monitoring of PCBs, DDTs and other pollutants in whales and their prey as well as in their environment.

2. Results

(1) Prey consumption by cetaceans

Prey species of minke whales varied both geographically and temporally (similar to the result obtained during the JARPN). Japanese anchovy was the most important prey species. Walleye pollack was an important prey species in sub-area 7. On the other hand, Pacific saury was consumed in low proportion compared to the results obtained during the JARPN. This may be due to the low abundance of Pacific saury in recent years. There is evidence of competition between minke whales and commercial fisheries. For example, dip-net fishermen complain about impediments by minke whales more frequently in recent years. This topic needs to be addressed with further research. Estimates of the daily prey consumption were 1.4 to 8.2 % of body weight. More precise daily consumption rates can be calculated with more data of the caloric value of prey species on a seasonal, area and annual basis.

One of the objectives of the feasibility study was to check how to sample and measure Bryde’s whales. There were some few problems related to sampling cow/calf pairs. Prey species of Bryde’s whales varied temporally within the research area. The major prey species were krill and Japanese anchovy. They fed on different size of same prey species (Japanese anchovy) compared to minke whales which occurred in nearly overlapping areas. More data are needed to better understand the geographical and temporal changes of prey species. Most of the Bryde’s whale sightings occurred close to the fishing grounds of skipjack tuna. Both Bryde’s whales and skipjack tuna feed mainly on Japanese anchovy. Therefore, further research is necessary to understand the nature of this competition. Estimates of the daily prey consumption were 3.3 to 8.2 % of body weight.

Another of the important objectives of the feasibility study was to examine methods for sampling and examination of stomach contents of sperm whales. Sperm whales could be sampled at random except for the large bull whales. A variety of species and sizes of deep-sea squids were found in the stomach contents. The species were identified by examining beaks in the case of squid and otolith in the case of fishes. The body length and weight of the main prey species could be estimated using regression equations to the otolith length or lower rostral beak length. The sperm whale seems to feed on prey during the daytime in the meso- and epi-pelagic layers. As the sample size is small (13 animals), no conclusion can be drawn on the role and contribution of this species to the surface ecosystem.

(2) Prey preference of cetaceans

The most important objective in the feasibility study was to evaluate the practicability and performance of concurrent whale and prey surveys. Such concurrent surveys were conducted for the first time in the North Pacific and involved many research vessels operating at the same time (Government of Japan, 2000 and 2001). Several small blocks were set in the research area and both surveys were conducted concurrently in each small block. Stomach contents were examined and compared to the biomass of each prey in the sea, which was estimated with an acoustic device and mid-water trawl net.

There were no serious practical problems in the conduct of the concurrent surveys. Close cooperation between the two surveys is indispensable for good performance. Preliminary analyses showed evidence of prey preference of cetaceans. For example, the preference of minke and Bryde's whales to lanternfishes is judged as zero. Bryde's whales may prefer larger fish among small-sized anchovy. The prey preference of cetaceans can be estimated if the concurrent whale and prey surveys continue.

(3) Ecosystem modeling

Some initial analyses were conducted using eco system models: Ecopath and Ecosim. These analyses were conducted to assess the potential effectiveness of these models in relation to the goals of JARPN II. Ecopath and Ecosim models indicated possible competition between cetaceans and fisheries and that the ecosystem of the western North Pacific may be affected on a large scale by trophic interactions and changes of fishing. The results of many tests suggested the utility of the Ecopath and Ecosim models to study the western North Pacific ecosystem. Cetaceans, especially minke and sperm whales, are probably important key species in the western North Pacific ecosystem because removals of these species brought fluctuations in the biomasses of direct and indirect prey species. Long-term information on diet composition is needed to clarify the characteristics of the ecosystem. More precise estimates of other biological parameters are also necessary, particularly temporal and spatial migration and prey preference of cetaceans.

(4) Stock structure

MtDNA analysis detected some genetic heterogeneity among the samples collected from the western part of sub-area 9 in some years. These results might suggest that putative W stock individuals, if they exist, enter sub-area 9 only every few years. However, analysis of other biological data does not show any differences among samples collected from sub-areas 7, 8 and 9. Therefore, conclusions about the putative W stock in the east side of western North Pacific are still pending.

Using the same maximum likelihood method used to estimate the mixing rate in sub-area 11 (Pastene *et al.*, 1998), J-stock proportion in sub-area 7 was estimated at 0.08 (SE: 0.08) and 0.07 (SE: 0.04) for the 2000 and 2001 JARPN II surveys, respectively. These rates are much smaller than those recorded for some months in sub-area 11, indicating that very few J stock animals migrate into the sub-area 7.

JARPN II in 2000 and 2001 sampled Bryde's whales in regions within sub-area 1 not covered previously. Even by adding samples from regions in sub-area 1 not previously covered, no strong evidence of additional stock structure within this sub-area was found.

(5) Pollutant monitoring

For the concentration levels of organochlorines such as PCBs, DDTs and HCHs, some of contaminants in sea water and air samples taken in JARPN II feasibility studies showed a decrease from past levels. However no conclusive results were obtained due to small sample size.

IV. RESEARCH OBJECTIVES AND NEEDS

1. Objectives

The overall goal of JARPN II is to contribute to the conservation and sustainable use of marine living resources including whales in the western North Pacific, especially within Japan's EEZ. Toward the overall goal, three objectives are set, (a) feeding ecology and ecosystem studies, (b) monitoring environmental pollutants in cetaceans and the marine ecosystem and (c) elucidation of stock structure. The priority is put on the first objective, which will contribute to the understanding the nature of competition between cetaceans and fisheries. Therefore, it is important to collect data and materials related not only to cetaceans, but also to prey species and their fisheries, oceanographic conditions, and other environmental factors, to analyze them, and finally to integrate them by using ecosystem models.

At the start of the full-scale JARPN II, the cetacean species to be sampled under special permit include minke, Bryde's, sperm and sei whales. Sei whales were not sampled in the feasibility study. Baird's beaked whales, short-finned pilot whales and Dall's porpoises will be examined using the samples from the commercial fisheries as in the feasibility study.

Hypotheses to be addressed are mainly related to the interactions among species as well as the competition between cetaceans and fisheries. Specifically: Do cetaceans consume a large quantity of fisheries resources compared to the catches of commercial fisheries? Does the consumption by cetaceans have a significant impact on natural mortality and recruitment of the prey? Inversely, does the abundance and distribution of the prey species affect the migration pattern, recruitment and geographical segregation by sex of cetaceans? Is there direct and/or indirect competition among cetaceans and between cetaceans and other top predators such as fur seals, tunas and sharks? Do sperm whales have an impact on the surface ecosystem?

2. Research needs

(1) Feeding ecology and ecosystem studies

This is the top priority research in the program, including both prey consumption and prey preference of cetaceans, as well as an assessment of how cetaceans use their habitats through feeding activities.

Baleen whales, as is well known, feed on relatively low trophic level organisms such as krill and small schooling fishes, while toothed whales feed on relatively high ones such as squids and larger sized fishes, thus they occupy different ecological niches in the marine ecosystem. For this reason, the two groups should be considered separately in considering the species to be sampled.

One of most important issues for choosing target species is their abundance and biomass, but biomass may be more important from the view of ecosystem studies. For baleen whale components, as given in Appendix 1, minke, Bryde's and sei whales are the primary baleen whale components in the western North Pacific region. Their biomass in summer is 164 thousands tons, 408 thousands tons and 477 thousands tons, respectively. While sei whales are almost same as minke and Bryde's whales in terms of their abundance, their relative biomass is second following sperm whales, and bigger than that of minke and Bryde's whales because their average body mass is larger. As the commercial hunting of sei whales was banned in 1976, the stock has increased. Among toothed whales, the biomass of sperm whale is overwhelmingly dominant being nearly 2 millions tons. Short-finned pilot whale is at 57 thousands tons and Baird's beaked whales are also important especially in sub-area 7 (16 thousands tons).

Ecological niches are obviously another important issue for choosing target species. Both minke and Bryde's whales are main components and feed on krill and small schooling fishes (Appendix 2). Although the recent food habits of sei whales are not known, past information tells us that sei whales also feed on schooling fish and squid as well as krill in the JARPN II research area while copepods are important in the northern North Pacific. Biology and fisheries of the prey species are shown in Appendix 3. Comparison between these three baleen whale species should be examined for clarification of species-specific nature of feeding habits of baleen whales in the same region.

For deep-sea feeders, both sperm and Baird's beaked whales are typical deep diving predators feeding mainly on deep-sea squids and fishes. The clarification of their feeding habits and food consumption are important to investigate the relationship between the surface marine ecosystem and the deep-sea ecosystem. Toothed whales also feed as surface feeders on pelagic fishes and squids. Dall's porpoises are typical surface feeders. They are the most abundant toothed whale (over 554,000 animals) although their biomass is not so great. Short-finned pilot whales feed mainly on pelagic squids.

In the two-year feasibility study, it was planned to examine whether sperm whales had direct and/or indirect relationship with the surface ecosystem or not. Sperm whales taken in the feasibility study mainly fed on a variety of non vertical migratory deep-sea squids and some deep-sea squids which conduct daily vertical migration between the deep sea (say, deeper than 400m in depth) in the daytime and the surface layer (shallower than 200m) at night. Preliminary examination of ecosystem models suggested that sperm whales might have some impact on the surface ecosystem. However, as the total number of samples is only 13, final conclusions require that sampling be continued as a feasibility study.

In addition, further comparison of feeding habits among the species with similar feeding habitats (e.g. minke, Bryde's and sei whales) may provide information on how cetaceans use, share and compete in their habitats through feeding activities. This is important for better understanding of the marine ecosystem.

In summary, sampling should be prioritized according the two issues discussed above, biomass (or abundance) and ecological niches, therefore the following species should be examined at the start of the full-scale JARPN II project:

(a) Krill (zooplankton) and small schooling fishes feeders: Minke, Bryde's and sei whales by research take.
(b) Deep-sea feeders: Sperm whales by research take and Baird's beaked whales by commercial harvests.
(c) Pelagic squids and fishes feeders: Short-finned pilot whales and Dall's porpoises by commercial harvests.

In building ecosystem models, information on prey species of whales is also essential. During the two-year feasibility study, attempts were made to collect the information and data indicated below. Substantial progress was made during the feasibility study (Appendix 3) and this research will continue being an important component of JARPN II.

(a) Distribution of prey species in place and time where the target whale species were sampled.
(b) Biomass of the prey species in the target ecosystem.

(c) Biological information on the prey species including their migration pattern, age and growth, feeding, etc.

i) Prey consumption by cetaceans

Many papers have reported on the prey species of cetaceans in the western North Pacific. Quantitative information on diet and prey consumption, however, is not sufficient because the stomach contents were not weighed and not identified to the species level. Also, past analyses were mostly limited to the commercial catches that were taken in particular fishing grounds and seasons. In addition, whalers usually damaged the stomach by cutting the abdominal cavity and then it was difficult to weigh and analyze the stomach contents. The following information on the diet of each cetacean species is based on limited literature updated with the results from the JARPN and JARPN II feasibility study.

Minke whales feed on schooling fish such as Japanese anchovy, Japanese pilchard, Pacific saury and walleye pollock and swarming zooplankton such as krill. There were geographical, seasonal and yearly changes of prey species in the western North Pacific during JARPN survey in 1994-1999. On the Pacific side, Japanese anchovy (*Engraulis japonicus*) was the most important prey species in May and June, while Pacific saury (*Cololabis saira*) was the most important prey in July and August (Tamura *et al.*, 1998; Tamura and Fujise, 2000a). Walleye pollock (*Theragra chalcogramma*) was also important in the coastal waters. In the southern Okhotsk Sea, krill was the most important prey species in July and August. During JARPN II feasibility study the main prey species of minke whales in the coastal areas was Japanese anchovy, followed by walleye pollock and common squid. Few Pacific sauries were found in the stomachs in September 2000, when the saury fishery had a poor fishing season. These changes in the prey species reflect the changes in the availability of prey species in these areas. It should be emphasized that this species is a fish feeder rather than zooplankton feeder in this research area. Daily prey consumption rate was estimated as 1.8 – 5.7 % of body weight. These values are similar to the estimates in the eastern North Atlantic and the Antarctic.

Bryde’s whales feed on krill and schooling fish. Off the Pacific coast of Japan, they fed on krill, Japanese anchovy and chub mackerel (*Scomber japonicus*). In the waters around Ogasawara Islands, they fed on krill and lanternfishes. In the East China Sea, they fed mainly on Japanese pilchard (*Sadinops melanostictus*), Japanese anchovy and horse mackerel (*Trachurus japonicus*). During JARPN II feasibility study, Bryde’s whales were distributed in the southern and offshore part of sub-area 7. The main food was krill and Japanese anchovy; the former dominated in the early season and the latter in the late season. The change may reflect the abundance and distribution of both species in the research area. As skipjack tuna also feeds on Japanese anchovy and Bryde’s whales are known to swim with skipjack (Japanese fisherman call Bryde’s whales “skipjack whales”), some interaction between skipjack tunas and Bryde's whales is suspected.

Sperm whales feed on squids and fishes. The most important squid species in the Tohoku-Hokkaido were Kurage ika (Japanese name) (*Histioteuthis dolfleini*), *Octopoteuthis sp.*, Giant squid (*Moroteuthis robusta*) and Neon flying squid (*Ommastrephes bartrami*). Neon flying squid supports the large jigging fishery in the North Pacific. There were few quantitative data on the stomach contents for sperm whales in the western North Pacific. During JARPN II feasibility study, sperm whales were the most abundant species and distributed in the whole research area. The main food was deep-sea squids such as *H. dolfleini*. Relatively fewer squids, which may conduct vertical migration to the surface at night, were found in the stomachs. This may be related to the recent unsuccessful jigging fishery for neon flying squid.

Sei whales feed on common squid, schooling fish such as Japanese anchovy, Pacific saury and Chub mackerel, and zooplankton such as krill and copepods (Nemoto, 1959; 1962). More varied food items are found in the coastal area, including gregarious fishes and even squids (Nemoto and Kawamura, 1977). There is no information on the diet of sei whales in sub-areas 8 and 9.

Baird's beaked whales mainly feed on deep-sea squids in waters off northern Japan, and on bottom fishes in waters off central Japan (Nishiwaki and Oguro, 1971; Walker and Mead, 1988; Ohizumi *et al.,* in prep.). During JARPN II feasibility study, Baird's beaked whales from the commercial samples fed on deep-sea cod-like fishes such as longfin grenadier (*Coryphaenoides longifilis*) and crustaceans.

Short-finned pilot whales (northern form) mainly feed on ommastrephid squids and octopus in the northern Pacific coast. During JARPN II feasibility study, northern form short-finned pilot whales from the commercial samples fed mainly on neon flying squid (*O. bartrami*), and Japanese common squid (*Todarodes pacificus*). Both are the main target species of Japanese jigging vessels.

Dall's porpoises were studied in almost all their distribution area including Sea of Japan, Sea of Okhotsk, Bering Sea, and northern North Pacific. Generally, they feed on smaller fishes and pelagic squids. Most of the prey items are mesopelagic micronekton in the North Pacific and Bering Sea, but limited to the fishes and squids that perform diurnal vertical migration to shallower waters at night. In contrast to the North Pacific and Bering Sea, epipelagic fishes such as Japanese pilchard and Japanese anchovy are important food items in the Sea of Japan and the Sea of Okhotsk, as well as benthos which are alternatively utilized when epipelagic prey are less abundant. Estimation of the daily prey consumption rate was 5.0 % of body weight (Ohizumi, 1998).

As mentioned above, although quantitative data on stomach contents of these cetaceans were collected during JARPN and JARPN II feasibility study, the data are still not sufficient for estimating the temporal and spatial variation in consumption of those species. Prey consumption by cetaceans is therefore the main part of the research. Data obtained in the full-scale JARPN II will be analyzed together with data already obtained in JARPN and JARPN II feasibility studies in order to contribute to the construction of ecosystem models.

Furthermore, the data collected to date have been limited in time and areas. Specifically, the data on the competition between marine mammals and fisheries are missing from early spring (April to May) and late autumn (September to November) and from waters very close to the coast, because the current research fleet of JARPN is available only between mid-May and mid- September and the research vessels are too big to conduct efficient research in inshore areas. This poses a serious problem to the research because many important Japanese coastal fisheries are conducted during these seasons in the inshore areas. Therefore, it will be useful to conduct the survey using the small type whaling catcher boats, which have more mobility in these inshore areas.

ii) Prey preference of cetaceans

Prey preference of cetaceans to be estimated in JARPN II is not that for an individual animal but that for the species within the particular ecosystem. This data will be inputted to the ecosystem models as one of the key parameters. Minke whales feed on Japanese anchovy, Japanese pilchard, Pacific saury, walleye pollock, krill, etc. (Omura and Sakiura, 1956; Government of Japan, 2001). Prey species of Bryde's whales are krill, Japanese anchovy and chub mackerel (Nemoto, 1959; Government of Japan, 2001). For Sei whales, copepods, krill, Japanese anchovy, mackerel, saury and squid are reported (Nemoto, 1959; 1962). However, no useful data have been reported on the prey preference of these cetaceans.

In JARPN II feasibility study, the concurrent whale and prey surveys designed mainly for minke and Bryde's whales were conducted and the practicability and performance was evaluated. There were no serious problems in the conduct of the concurrent surveys. Some preliminary results on prey preference of cetaceans were obtained: negative preference of minke and Bryde's whales to lanternfishes and Bryde's whale preference to larger fish among the small-sized anchovy. These results are encouraging but more data from the concurrent surveys are needed. Also direct observation of feeding behavior and integrated analysis combined with oceanographic data may be needed to understand the prey preference of cetaceans.

iii) Ecosystem modeling

The final goal of JARPN II is to contribute to the conservation and sustainable use of all marine living resources including whales in the western North Pacific, especially within Japan's EEZ. Although Japan's fisheries management has been depending upon input control measures such as limited entry licensing system, Japan has recently initiated substantial reforms in its fisheries management systems including; establishment of a unique system of the combination of input and output control management measures, announcement of the principle for the fundamental policy on fisheries and its action program to implement the policy and, amendments to the Fisheries Law.

In this new fisheries management regime, an ecosystem approach is supposed to play an important role because marine living resources and its habitats around Japan are quite diversified and their relations are very dynamic. Understanding of the marine ecosystem around Japan needs to be substantially strengthened in order to take, for example, the following factors into account in prescribing fisheries management measures:

(a) Drastic decrease of Japan's fisheries catch from 12,785 thousand metric tons in 1988 to 662 thousand metric tons in 2000.
(b) Introduction of the moratorium on commercial whaling since 1988 and resultant increase of whales around Japan.
(c) Historical drastic fluctuation of the pelagic fisheries resources in a process so-called “species replacement” in the western North Pacific.

JARPN II is designed to provide important data in order to build ecosystem models that would be used to promote the understanding on the factors above. The ecosystem models are expected to provide insights to the relations between different species in the marine ecosystem and the dynamics of the ecosystem. For example, a total allowable catch (TAC) for a particular species can be calculated taking into account factors such as the impact of the removal (i.e. catch under the TAC) on other species in the marine ecosystem. The models are expected to provide information on the extent of the predation by the increased marine mammals on the fisheries resources and, therefore, some optimal stock levels for marine mammals, which will balance the need for the effective utilization of fisheries resources and the conservation of marine mammals. The need for such multi-species management approaches or ecosystem approaches is now widely recognized by many international resource management organizations including the FAO.

(2) Monitoring environmental pollutants in cetaceans and the marine ecosystem
There is concern related to the effects of environmental pollutants on marine resources, especially whale stocks. Therefore, this program includes comprehensive monitoring and assessment of chemical pollutants. For this objective, the following three components are included:

i) Pattern of accumulation of pollutants in cetaceans

Yearly variation of mercury levels was observed in liver of Antarctic minke whales during 1980's to 1990's (Fujise *et al.*, 1997; Watanabe *et al.*, 1998). Furthermore, similar yearly variation was also observed for PCBs in blubber of the minke whales (Tanabe *et al.*, 1995; 1999). These authors emphasized that monitoring of the pollutants in the whale should be continued to determine whether they are increasing or not. On the other hand, geographical differences of the accumulation levels were also reported for organochlorines and heavy metals such as Hg and Cd and between Antarctic and North Pacific minke whales (Aono *et al.*, 1997; Fujise *et al.*, 1997). The differences were expected to reflect the degree of pollution by contaminants and their prey species.

In order to understand the accumulation characteristics of pollutants in cetaceans, it is essential to consider biological information such as age, sex and maturity. It is known that the concentrations of most lipophilic pollutants and several trace elements increase with age in males because input exceeds the ability of the organism to excrete these compounds. Various proportions of the pollutant load are transferred to offspring during gestation and lactation, therefore tissue concentrations in adult females are generally lower than in adult males (IWC, 1999a). Therefore, the general expectation is that older male whales and females which have not experienced gestation and lactation tend to show higher accumulation level of pollutants than other growth and reproductive stages of the whales. The accumulation is also different for whales having different biological and ecological processes such as gestation period, number of foetuses, migration route, and prey species and feeding rate. However, it has not been determined exactly to what degree these biological and/or ecological processes effect the accumulation of pollutants. The JARPNII program will collect the biological information necessary to examine the relationship between biological parameters and accumulation characteristics.

ii) Bioaccumulation process of pollutants through the food chain

It is also known that differences in the accumulation levels of organochlorines such as PCBs and DDTs are observed between baleen and toothed whales. These differences reflect the fact that their prey species are in different trophic levels and/or have different contamination levels. This research plan includes monitoring of several types of whales, which have different feeding habitats (i.e. krill and small schooling fish feeder, and deep-sea feeder). Analyses of pollution levels in the prey species collected from the stomach contents of whales, and from catches by the trawling surveys as well as that of seawater and air will also be done. This information is not available for the period since the 1980s (Iwata *et al.*, 1993). From the preliminary results of the analyses of the samples taken during the 2001 feasibility cruise, concentration levels of some organochlorine compounds in the environment has tended to decrease, but such trend is not observed for the levels in the whale blubber (See the report of the feasibility study: SC/54/xx). Continuation of these analyses is important to understand the bioaccumulation process through the marine food chain.

iii) Relationship between chemical pollutants and cetacean health

Chemical pollution is known to have considerable effects on cetaceans inhabiting the coastal area of the Northern Hemisphere, such as beluga, bottlenose dolphin and harbor porpoise. For these species, the POLLUTION2000+ was conducted to examine cause-effect relationships (IWC, 1999b).

In the western North Pacific, a considerable number of minke whales are observed with anomalous testis tissues. It is necessary to continue the monitoring of the occurrence of these anomalies and also continue to examine the cause(s). To this point, histopathological and immunological examinations were conducted but such examinations had not determined the cause of the anomalous testes. Efforts to identify the cause are continuing. Recently another bacteriological examination was initiated from 2001. It is also interesting that such anomalous testes were found in Bryde's whales. Monitoring of the occurrence rate is very important for the conservation of resources.

Recent studies have used biomarkers to examine the health condition of cetacean presenting some level of contamination (Fossi *et al.*, 1992; Hugget *et al.*, 1989; Subramanian *et al.*, 1987; Urian *et al.*, 1996; Watanabe *et al.*, 1989). In the Bergen workshop, it was suggested that "hazard assessment could be aided by biomarker data since this gives information on effects rather than merely documenting residue levels". As an ideal, they considered that "cetaceans in the open ocean should be physiologically normal, i.e. that human activities should not result in their physiological functions being outside normal limits"(IWC, 1999a). In this context, North Pacific minke whales and Antarctic minke whales are considered as normal condition individuals compared with species inhabiting coastal habitats such as small cetaceans. Therefore, toxicological examinations using these minke whales are considered to have advantages over the sampling of polluted individuals.

In the program, some biomarkers will be examined for the relationship with some contaminants in light of metabolic ability and sensitivity of the pollutants in the whales. Possible indices for biomarkers will be examined for: P450, AH receptor, sex hormone and composition of PCBs.

(3) Stock structure

i) Minke whale

The following objectives are defined:

a) Investigate the stock identity of minke whales distributed in offshore sub-area 9

Following discussions at the JARPN review meeting, the JARPN II feasibility surveys were focused to investigate whether or not a different stock (W) exists in sub-area 9, and if so, to investigate the spatial and temporal extent of its occurrence. Results of the mtDNA analysis showed a certain degree of heterogeneity in samples collected from these surveys in the western part of sub-area 9 in 2000 and 2001, similar to that observed from samples collected in 1995. Microsatellite analysis also provided some evidence (weak) of genetic heterogeneity in the western part of sub-area 9 in 2001. It seems that, if a different stock exists, its occurrence in sub-area 9W is not consistent every year. A possibility is that the genetic heterogeneity observed in sub-area 9W reflect a mixed assemblage scenario between the O Stock and a putative W Stock distributed mainly to the east of sub-area 9W, including sub-area 13. The JARPNII feasibility study demonstrated that further genetic samples from sub-areas 8, 9, and possibly 13 (see objective c) are required to facilitate clearer discrimination among alternative W stock hypotheses. The results will allow us to select the best scenario for IST.

b) Systematic monitoring of the occurrence of J Stock like animals in sub-area 7 to determine the dynamics (spatial and temporal) of its occurrence

In order to ensure adequate management of coastal whaling in future, the occurrence of J Stock like animals in sub-area 7 should be investigated. The frequency of their occurrence, regions and period in which they occur, will be investigated by systematic monitoring. The results will be necessary for the management of coastal whaling in future.

c) Investigation of the stock identity of minke whales in sub-areas 12 and 13

Sub-areas 12 and 13 are two potentially important sub-areas for surveys. The rational for sub-area 13 is the same as in a). It should be noted that sub-area 13 is not a target area for the feeding ecology study. This sub-area may be surveyed for the stock structure study considering the time available and practicability of deployment of fleet in each survey, after the surveys on feeding ecology have been completed in other sub-areas.

Surveys in these sub-areas are very important, as only limited information on stock structure has been available for these sub-areas so far. O and J Stock animals occur in the southern part of the Okhotsk Sea (sub-area 11) and it is possible that they also occur in the northern part (sub-area 12). It is important to investigate whether J, O and other putative stocks occur in this sub-area and if so, the frequency of their occurrence and mixing proportion. The results will allow us to select the best scenario for IST. If permission is granted by the Russian Federation, sampling of minke whale will be conducted in sub-area 12. It should be noted that even if sampling is allowed in this sub-area the total sample size for minke whale will be the same. If permission for whale sampling is not granted, an alternative is biopsy sampling if permission for such survey is granted.

ii) Bryde's whale

While JARPNII feasibility study in 2000 and 2001 covered some previously unsurveyed regions within sub-area 1, there are other regions west of 180° not covered yet, which should be investigated. Effort should be spent to cover these regions. On the other hand the genetic analysis based on the feasibility surveys revealed a weak mtDNA heterogeneity between recent JARPNII samples and historical samples from Ogasawara. This heterogeneity should be tested with the analysis of additional samples from the same region. The results of this study will definitely contribute to the IST for Bryde's whales.

iii) Sei whale

Samples of sei whales will be obtained mainly for the objective of feeding ecology. The CA for the NP sei whale has not been conducted yet. Very little is known on the stock structure of the sei whale in the North Pacific. The attainment of data on stock structure will contribute to the comprehensive assessment of this species in the future. As a first step, recent molecular genetics techniques will be applied to estimate genetic diversity of sei whales, and compare it with those in other ocean basins.

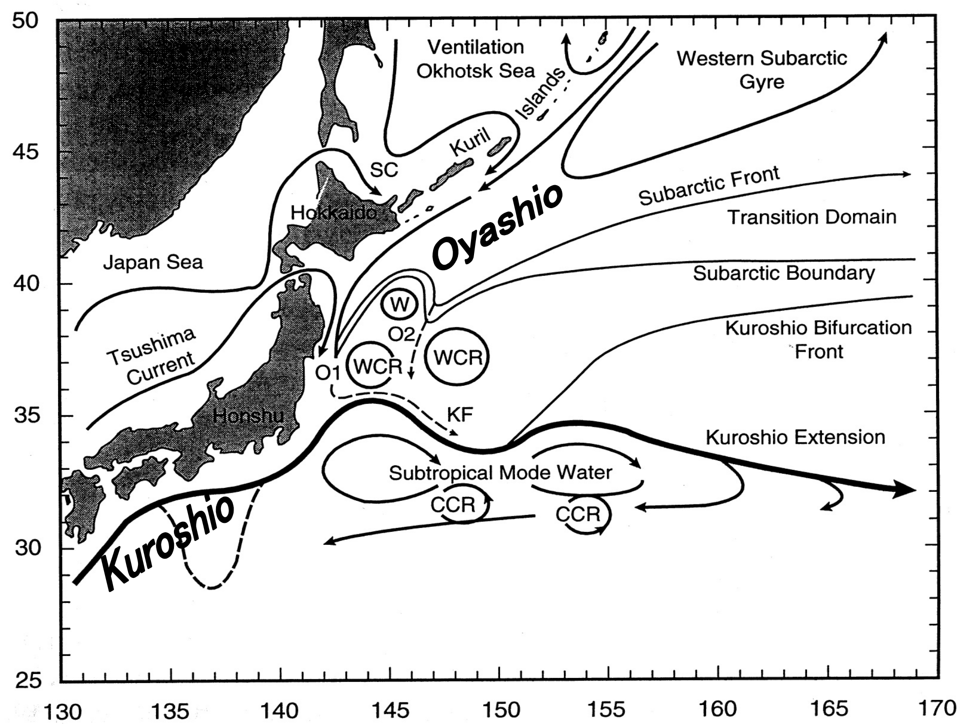

Fig. 1. Schematic representation of the current and frontal systems in the western North Pacific (Yasuda *et al.*, 1996; modified from Endo, 2000). SC: Soya Current, TW: Tsugaru warm current, O1: Oyashio first branch, O2: Oyashio second branch, WCR: worm core ring,
CCR: cold core ring, KF: Kuroshio Front.

iv) Sperm whale

Samples of sperm whales will be obtained mainly for the objective of feeding ecology. The IWC/SC has conducted preliminary discussion to start the CA for the North Pacific sperm whale. The attainment of data on stock structure will contribute to the future comprehensive assessment of the species.

V. RESEARCH DESIGN

1. Research area

In the western North Pacific, there are numerous fronts and water masses (Fig. 1). The Kuroshio, which is one of the strongest west-boundary currents of subtropical gyre, flows northward from the offshore area of the Philippines to the waters off Japan with warm high-salinity water. It turns eastwards off the Pacific side of Japan as the Kuroshio Extension. On the other hand the Oyashio flows southward along the Kurile Islands with cold low-salinity water. It branches into two flows off the northern Japan. The Kuroshio and the Oyashio flows eastward, and the area between the Kuroshio Extension and Oyashio east off Japan was usually called the Kuroshio-Oyashio Inter-frontal zone or the Transition Zone.

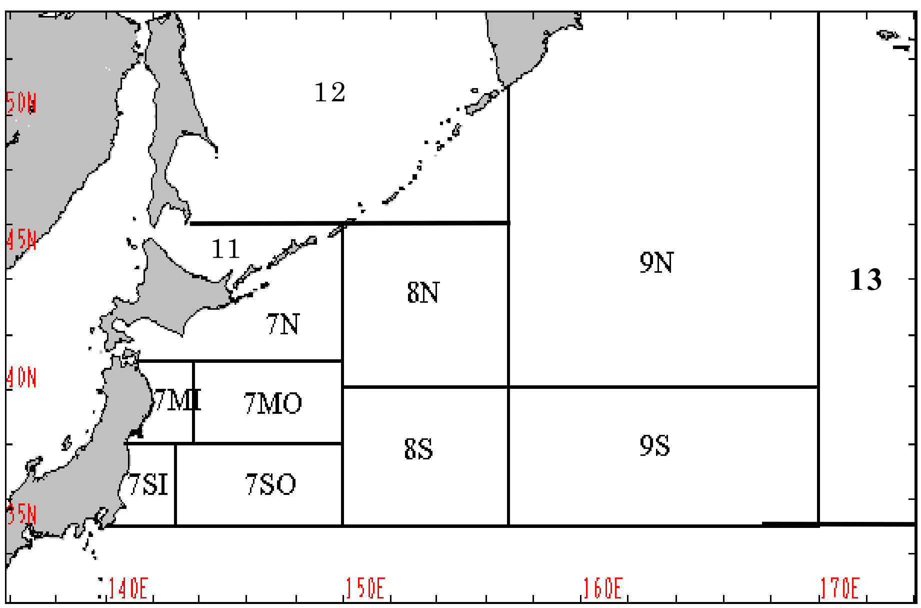

Fig. 2. The research area and strata for the full-scale JARPN II surveys.

The research area covers the Kuroshio, the Oyashio and the Transition Zone between them (Fig. 2). It is east of northern Honshu Island, north 35ºN, west of 170ºE, south of Hokkaido (sub-areas 7, 8 and 9 for the North Pacific minke whale management). The research area in the full-scale JARPN II is extended eastward to 170ºE to cover the fisheries resources caught by Japanese fisheries. Especially Pacific saury is distributed in sub-areas 8 and 9 in summer just before they recruit to the Japanese fishing grounds in autumn (Fig. 3). For stock structure of minke whales, important areas are sub-areas 9 and 8 to investigate whether or not a different stock exists, and sub-area 7 to determine the dynamics of J stock type occurrence.

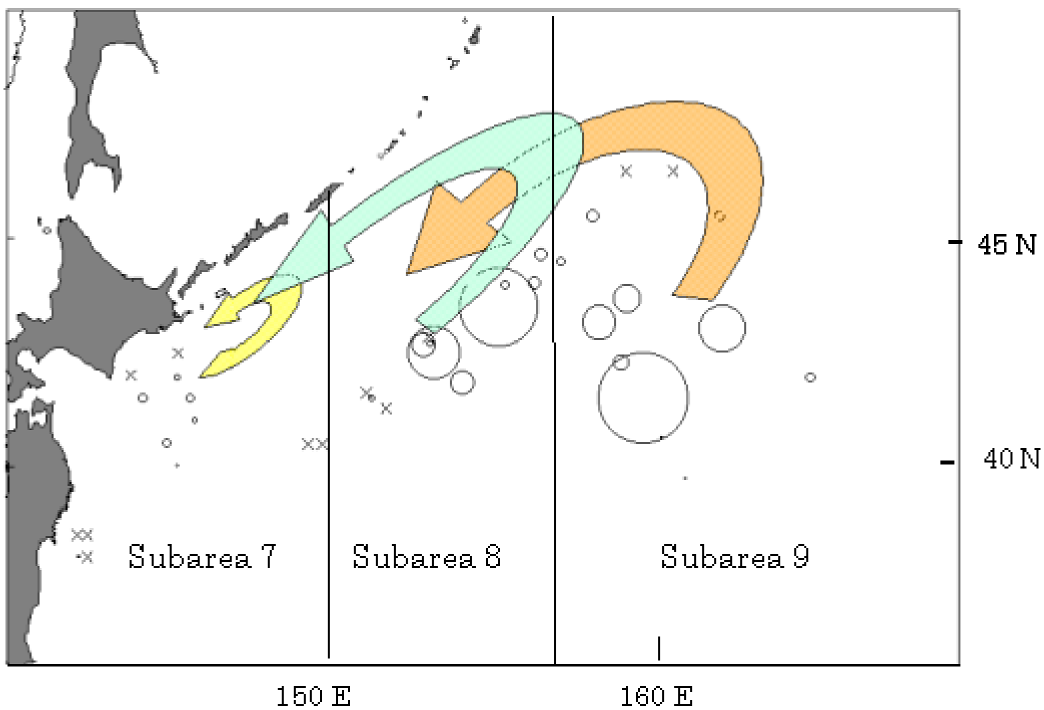

Fig. 3. Distribution of Pacific saury at pre-fishing season (June-July) and recruitment to the Japanese fishing grounds (from HP of Tohoku National Fisheries Research Institute). The area of each circle indicates the number of saury taken by research drift nets (x: no catch).

2. Research duration and period

Pelagic fish resources in the research area have sho[illegible] drastic fluctuations in a process called “species replacement” for the past 100 years (Wada, 1997). The most abundant species were replaced successively in the order of pilchard, saury and anchovy, chub mackerel, and pilchard again in periods of 10 to 20 years. Currently, anchovy is dominating (Fig.4 and

Fig.1 of Appendix 3). The last period of anchovy dominance started about 10 years ago. Chub mackerel may replace anchovy in the several years, possibly. To monitor the above-mentioned process, the program will be continued without setting the research duration and will be comprehensively reviewed after every 6 years by the IWC/SC and/or other organizations. In this program, data from two years will be considered as one set because early (March-June) and late (July-October) seasons should be covered in two years. In order to examine the fluctuation of the research results, at least three data sets are required. Therefore, the comprehensive review is planned to be conducted every 6 years.

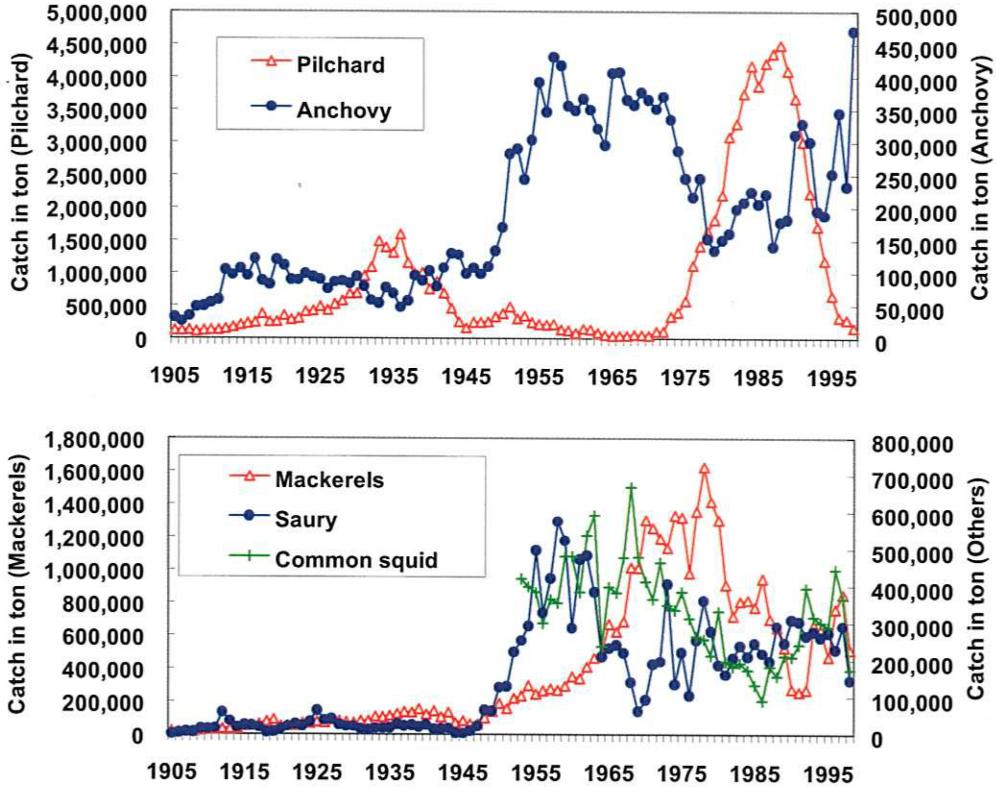

Fig. 4. Commercial catches of major small pelagic fishes by Japan (after Yatsu *et al.*, 2001). Mackerels mainly consist of chub mackerel, *Scomber japonicus*.

JARPN in 1994-1999 and JARPN II feasibility study in 2000-2001 have covered only 4 months in real terms from mid-May to mid-September. Other parts of the year from late autumn to early spring have not been covered because the *Nisshin Maru* research fleet was not available. Preliminary calculations from the Multspec-type model showed that whether or not minke whales feed during the seasons outside that covered by the *Nisshin Maru* fleet is very important as the distribution of the predators and prey overlap each other (Appendix 4). At least spring and autumn should be covered fully. This is why the two-year feasibility survey was planned in these seasons by employing the small type whaling catcher boats in the coastal waters, where the competition between cetaceans and fisheries is likely to be severe.

The survey plan for the first two-year period is as follows. The surveys in 2002 will be conducted in late season from June to October. The small type whaling catcher boats will cover mainly Stratum 7N in September and October. The survey in 2003 will be conducted in early season from April to August. The small type whaling catcher boats will cover Strata 7MI and 7SI in April and May. The logistic feasibility of sampling using small type whaling catcher boats will be evaluated after the first two-year period. Basically the same pattern will be repeated three times until the 6-year comprehensive review.

3. Target cetacean species and sample sizes

In the full-scale JARPN II, 150 minke whales (effectively O Stock and putative W Stock), 50 Bryde’s whales (Western North Pacific Stock), 50 sei whales (Asian Stock) and 10 sperm whales (Western Division Stock) will be sampled in each year under special permit. Of the 150 minke whales, 50 will be sampled by small type whaling catcher boats to cover the temporal and spatial gap of the research to date. Sei whales are newly included as target species in this program as sei whales are expected to consume a large quantity of fisheries resources such as Pacific saury just recruiting to the Japanese fishing grounds. These cetacean species are found in abundance (Appendix 1) and could readily be subject to sustainable harvesting. Furthermore, Baird’s beaked whales, short-finned pilot whales and Dall's porpoises will be also included in the program using the samples from the commercial fisheries in the coastal area.

(1) Target cetaceans species

JARPN (1994-1999) and JARPN II feasibility surveys (2000-2001) showed that minke whales are distributed in the coastal areas in sub-area 7 and the northern offshore areas in sub-areas 8 and 9. Minke whales fed on krill and schooling fish such as Japanese anchovy, Pacific saury, walleye pollack and Japanese common squid. All of these are major target species of Japanese fisheries in the coastal waters. The competition between cetaceans and the fisheries appears to be the most severe in the case of minke whales. In the full-scale JARPN II, minke whales should be the main target cetacean species. However, seasons from late autumn to early spring have not been covered in JARPN and JARPN II feasibility study because of the lack of availability of the *Nisshin Maru* research fleet. Also the coastal areas on the continental shelf have not been surveyed because the *Nisshin Maru* research fleet is too big to operate in the coastal areas. Thus, in the full scale JARPNII survey, the small type coastal whaling catcher boats will be used for the feeding ecology surveys.

Bryde’s whales were only taken in JARPN II feasibility surveys. They were densely distributed in the southern offshore area of sub-area 7 and the main food was krill and Japanese anchovy. The former dominated in the early season and the latter in the late season, although the seasons were covered in different years. Bryde's whales are known to feed on krill and schooling fish as do minke whales. The sampling of Bryde's whales will be continued in the full-scale JARPN II in the wider areas.

Sei whales are also known to feed on krill and schooling fish. Off the Pacific coast of Japan they feed on krill, Japanese anchovy, chub mackerel, saury and squids (Nemoto, 1959). They feed on copepods in the northern North Pacific (Nemoto, 1962). As the commercial take was banned in 1976, the stock appears to have increased. Both absolute and relative abundances in JARPN and JARPN II feasibility studies are higher than those in previous surveys. Samples are required for information on diet, especially in sub-areas 8 and 9 where recruits of Japanese saury are distributed in summer.

Sperm whales were taken in 2000 and 2001 as a feasibility study. The total number of samples was only 13. They were commonly found throughout the whole research area. Sperm whales were the most abundant species and were distributed in the whole research area as it was the case in JARPN surveys. The food was composed of a variety of species of deep-sea squids (Tamura *et al.*, 2002). Squids known to occur in the upper layer or migrate to the surface at night were relatively scarce in the stomachs except for some species such as *Gonatopsis borealis*. A few neon flying squid (*Ommastrephes bartrami*), which is the main target of squid jigging vessels, was found in the stomachs. This is partly due to the extreme low abundance of neon flying squid in the recent years.

The issue of whether sperm whales should be retained as part of the full-scale JARPN II or not has been also examined using Ecopath with Ecosim (Okamura *et al.*, 2002). In most of the test runs, prey species were influenced by the removal of sperm whales as well as in the case of the removal of minke whales, although these results were strongly dependent on the input parameters of deep-sea squids and their prey and predators. Deep-sea squids may have massive biomass in the western North Pacific, judging from the huge consumption by sperm whales. But little on the ecological niche of deep-sea squids is known. Whether or not sperm whales have a relationship with the surface ecosystem still being an interesting question to resolve. Because of their large biomass it is desirable that sperm whales be retained as one of the target cetaceans in the full-scale JARPN II, and that the ecological study on deep-sea squids be conducted in the near future.

(2) Sample sizes

JARPN surveys during 1994-1999 showed that there are geographical and seasonal changes of prey species of minke whales in the western North Pacific. For the feasibility study of JARPN II, the sample sizes for estimating prey consumption with good precision

(Coefficient of Variation; C.V.=0.2) were calculated by the Norwegians method (Government of Norway, 1992). The same method and precision were applied to the full-scale JARPN II. In this method sample sizes are calculated for the estimation of prey consumption of important prey species.

Two surveys, one by the *Nisshin Maru* research fleet and the other by the small type whaling catcher boats, will be conducted every year. The former will cover total research area (sub-areas 7, 8 and 9), and the latter will cover only minke whales in the inshore areas of sub-area 7. Therefore the required sample sizes for minke whale were calculated separately (the total research area and the inshore areas of sub-area 7). Required sample sizes of Bryde's and sei whales were calculated for the total research area. For sei whales the data used were the number of the dominant prey species (squid, fishes and krill) from commercial whaling and the average stomach contents weight and its standard deviation of Bryde's whales examined in JARPNII feasibility study. Results are shown in Appendix 5.

For minke whales (case of total research area), a minimum of 66 to 138 animals are required in each year. These calculations did not use the data from 1998 and 1999 because the research area in these years was limited compared to that in other years. One hundred animals should be maintained.

For minke whales (case of inshore areas of sub-area 7), a minimum of 26 to 102 animals are required in each year. Fifty animals should be adopted. The sample size may be modified using new data obtained after two-year (small type whaling catcher) feasibility survey.

For Bryde's whales (total research area), a minimum of 50 animals are required in each year. To improve the accuracy of this estimation, a re-calculation will be made after more data become available.

For sei whales (total research area), a minimum of 50 animals are required in each year. The past commercial whaling data and the stomach contents data from Bryde's whales were used for the calculation. New data are required to improve the accuracy of this estimation. The sample size will be recalculated after the first two years making use of the new data accumulated.

For the pollution study, in the Barcelona meeting related to 'POLLUTION 2000+', it was noted that 'in order to investigate cause-effect relationships of pollutants in cetaceans would require the ability to obtain a large enough sample size for each of the groups to be compared, to allow robust statistical analysis (preferably n>30)' (IWC, 1999a).

Comparing this sample size and those of the present research plan (150 minke, 50 Bryde's, 50 sei, and 10 sperm whales), sampling in JARPNII is too small for monitoring temporal and spatial variation in pollution burdens. A large scale and long-term sampling is needed to monitor the pollution in the marine ecosystem surrounding Japan. Therefore, the Environmental Ministry of Japan and many other organizations including universities are now conducting a wide variety of such investigations. For example, the Environmental Ministry is conducting a monitoring project of the contaminants mainly in the North Pacific so-called 'SQUID WATCH', which monitor the pollutant burden in squid liver (Yamada *et al.*, 1997). Furthermore, the Fisheries Agency has been conducting similar research for the fish resources.

In the JARPNII, the major part of the environmental component is to construct a comprehensive monitoring and assessment system for monitoring impacts of pollution on cetaceans and marine ecosystem. Therefore, at least at the present stage, no definitive conclusions related to the sample size for this purpose have been reached. It would be preferable to use as large sample size as possible. Adequate sample size for pollution studies may be determined in the future if further information becomes available.

In the genetic studies, the necessary sample size will generally depend on the degree of genetic differentiation between putative stocks and on the resolution of the genetic technique to detect such differentiation. Several workshops have recommended a similar sample size to that proposed here. For example the Workshop on the Genetic analysis of Cetacean Population 'recommends sample sized of 20-50 from each population are desirable and that these should be taken throughout the geographical range' (Hoelzel, 1991). The Special Meeting on the Comprehensive Assessment of Right Whales also suggested that 'samples should be collected from a minimum of 20-50 individuals' (IWC, 1999c).

Finally, it also should be further noted that sample size was determined mainly based on the objective of feeding ecology and ecosystem studies. We will use samples and data as effectively as possible for other objectives within the limited framework.

In conclusion, although necessary sample sizes are different depending on objectives and methodologies, the sample sizes for estimating prey consumption of baleen whales are adopted. These are 150 for minke, 50 for Bryde's and 50 sei whales. The sample size for sperm whales remains as it was in the feasibility study (10).

(3) Sampling scheme

Whale sampling will be conducted using the random sampling scheme adopted in the JARPN.

During the JARPNII feasibility studies, a total of nine calves of Bryde's whale were collected with cows. The examination of these individuals for feeding ecology showed that the stomach contents of cows were not different from other animals and calves only had milk in the stomach. Consequently, calf samples are of less value for the studies of feeding ecology. On the other hand, calf animals are excluded from the genetic analysis. Therefore in the full-scale surveys, cow and calf pairs will not be targeted for sampling.

Sampling of sperm whales will be restricted to individuals below 10m in body length due to the limited capacity of the research base ship *Nisshin Maru*.

4. Research vessels

The whale research fleet will consist of a dedicated sighting vessel, the *Kyoshin Maru No.2* and three sighting/sampling vessel the *Kyo Maru No.1*, the *Toshi Maru No.25* and the *Yushin Maru*. The *Nisshin Maru* will act as the research base. The survey on prey species will be conducted by the *Shunyo Maru*, a new trawler-type research vessel equipped with a sophisticated acoustic device. For the study of prey preference of cetaceans, it is required that all of these research vessels are operated cooperatively.

In addition, three small type whaling catcher boats will be employed as sampling vessels for minke whales in the inshore areas of sub-area 7 in spring and autumn. These surveys will be also conducted together with prey species surveys. One researcher will be placed on board each catcher boat and two researchers will be deployed at a land base where collection of data and samples will be conducted.

5. Non-lethal components

The dedicated sighting survey vessel (*Kyoshin-Maru No.2)* will cover the research area to collect information on the distribution and density of whales as well to conduct biopsy sampling and oceanographic surveys. Oceanographic surveys will be also conducted on the *Shunyo Maru*. .

6. Research organizations

(1) The Institutes of the Fisheries Research Agency (FRA) such as
National Research Institute of Far Seas Fisheries (NRIFSF),
National Research Institute of Fisheries Science (NRIFS)
(2) The Institute of Cetacean Research (ICR)
(3) Other research institutions

7. Participation of foreign scientists

Participation of foreign scientists, especially those from neighboring countries, is welcome, insofar as their qualifications meet the requirements set by the Government of Japan. These requirements are the same as those for JARPN.

VI. RESEARCH METHODOLOGY

Basically the research methods follow those of the two-year feasibility study conducted in 2000 and 2001. Major changes in the full-scale research are the addition of 50 minke whales taken by small type whaling catcher boats, the inclusion of 50 sei whales, an eastward extension and stratification of the research area for the feeding ecology and ecosystem studies. The methods may be changed in the course of the program after reviews by IWC/SC and/or other organizations.

1. Feeding ecology and ecosystem studies

No selection will be made as to sex and size in the sampling except for the bull sperm whales that are too heavy to lift on the board of the *Nisshin Maru* and the cow/calf pairs that will not be sampled. The sampled whales are measured in the same way as in the JARPN. Stomach contents are measured following the Norwegian procedure regarding number, weight and body size by prey species (Haug *et al*., 1995b). For fully digested prey, hard tissues (otoliths for fishes and beaks for squids) are used for species identification and body size estimation.

In addition, three small type whaling catcher boats will be employed to cover the temporal and spatial gap in the research, that is, the inshore areas in sub-areas 7 in spring and autumn. These vessels will conduct sampling in a designated area within the radius of approximately 50 nautical miles from a land base (e.g. Kushiro in Hokkaido and Ayukawa in Sanriku). Intensive fisheries are conducted in this area in spring and autumn. As the primary objective of this component of JARPNII is to collect information on direct competition between fisheries and whales, sampling will be conducted in the close proximity to ongoing fisheries. In principle, samples will be transferred to the land base where data and tissue sample collection will be conducted by two researchers. All the vessels will come back to port daily.

The concurrent whale and prey surveys will be conducted so that whales and fish are sampled as near to simultaneously as possible in both space and time. The surveys of prey species will be conducted on a trawler-type research vessel, the *Shunyo Maru*. The surveys will be supplemented with the dedicated sighting survey vessel, *Kyoshin Maru No.2,* equipped with a sophisticated acoustic device. Distribution and abundance of prey species by depth range is estimated using echo integrator.

Responses on the echo sounder are identified to species using mid-water trawl, drift-nets and jigging. The catch will be sorted by species and weighed. At each operation about 100 individuals of the main species will be selected at random and measured to nearest cm. Also 10 individuals will be sampled for biological measurement including stomach contents. Frozen samples of main prey species will be used to analyze the energy density and to extract hard tissues for species identification and body size estimation from digested stomach contents.

(1) Prey consumption by cetaceans

The amount of prey consumption by cetaceans per day is estimated using two methods: one is the indirect method based on standard metabolism and the other is the direct method based on the temporal changes of the weight of stomach contents in a day. For the former method, physiological parameters will be obtained for the time being from the past studies (e.g. Lockyer, 1981; Folkow *et al.*, 2000; Tamura and Fujise, 2000b). The energy density of prey will be estimated from the literature and samples collected during the research. With respect to the information needed for the latter method, evacuation rate from the stomach will be for the time being obtained in reference to Bushuev (1986) and other studies (e.g. Tamura *et al.*, 1997; Tamura and Fujise, 2000b). Seasonal consumption of each prey species by whales will be estimated from consumption per day, composition of prey species and the number of whales in the area.

(2) Prey preference of cetaceans

Prey preference will be estimated by comparing the prey composition in the stomach of whales and the prey composition in the environment, based on the concurrent whale and prey surveys in a narrow area (Lindstrøm and Haug, in press). Practicability and performance of concurrent whale and prey surveys was evaluated in the feasibility study, and there were no serious practical problems (Government of Japan, 2000 and 2001), however, close cooperation between the two surveys is indispensable in order to match the progress of both surveys.

As the research area is stratified into several strata, the strata and/or narrower areas with high abundance of cetaceans will be used for estimating the prey preference. A zigzag track line will be set within each narrow area. The surveys will be conducted on the same track line within one week. Diet compositions and body size composition of each prey species are estimated for digested stomach contents using hard tissues. Biomass of each prey in the sea will be estimated acoustically and the prey species will be identified with the mid-water trawl, IKMT and plankton nets. For squids and saury, the biomass is estimated with the mid-water trawlings from a 100m depth at predetermined stations. The body size compositions will be obtained with the direct measurement of catches. Two indices will be used to express the prey preference; the relative frequency of occurrence by number and the individual number index (Lindstrøm *et al.*, 1998). Also, the data on oceanographic conditions, preys and cetaceans will be analyzed in detail with the Geographical Information System (GIS).

2. Monitoring environmental pollutants in cetaceans and the marine ecosystem

Tissue samples will be collected from blubber, liver, kidney, muscle and other tissues as well as blood from each whale sampled and from some prey species taken from stomach contents of the whales and by the trawling survey. These samples will be analyzed for pollutants such as organochlorines and heavy metals. Furthermore, the contaminant levels of lower-trophic organisms such as krill will be also examined. The level of pollutants in sea water and air will be analyzed in the same way.

Chemicals to be analyzed include heavy metals (Fe, Mn, Zn, Cu, Pb, Cd and Hg), organochlorines (PCBs, DDTs, HCHs, HCB and CHLs) and dioxin related chemicals (PCDDs, PCDFs and coplanar-PCBs). As to physiological index (biomarker), sex hormone, P450, AH receptor and others will be examined. The analyses of organochlorines and heavy metals will be conducted by the procedures described in previous reports (Aono *et al.*, 1997; Honda *et al.*, 1982; Iwata *et al.*, 1993; Tanabe *et al.*, 1994; Tanabe, 1998; Kang *et al.*, 1997). Sex hormone and other physiological indices will be analyzed using standard analytic methods (e.g. Saito *et al.*, 1986; Subramanian *et al.*, 1987).

3. Stock structure

Stock structure will be investigated using the same methods used under the JARPN. Samples and data for genetics and other biological markers will be collected from each whale sampled. Internal tissue and biopsy samples will be used in the genetic analysis. Genetic variation will be analyzed using allozymes, mtDNA sequencing of control region and microsatellites. All the laboratory procedures for the genetic analyses are described elsewhere (Wada and Numachi, 1991; Goto and Pastene, 2000; Goto *et al.*, 2001).

To address O-W stock issues of minke whales, data will be analyzed following the IWC/SC recommendation that J stock whales should be removed for all comparisons (IWC, 2002). Suspected J stock animals are excluded from the analysis based on the genetic criterion, biological markers (such as conception date and accumulations of pollutants) and morphometrics.

Mixing rate between O and J Stocks in sub-area 7 will be estimated using two methods: maximum likelihood method (Kishino *et al.*, 1994; Pastene *et al.*, 1998) based on allele/haplotype frequencies obtained from the genetic markers mentioned above and individual assignment using mtDNA sequencing profiles complemented with other independent biological and ecological markers. If the putative W Stock is confirmed in offshore areas, the mixing rate between O and W Stocks will be also examined using genetic markers.

4. Others

In this program sighting records will be collected for all cetaceans. Observations involve whale species such as right, blue, minke, Bryde's, sei, fin and sperm whales. In addition to sighting records, photo-ID, observation of whale behavior, especially feeding behavior, will be also recorded.

Oceanographic surveys will be obtained using XCTD, CTD, EPCS. Echo soundings will be also made concurrently during the survey. Information on oceanographic conditions in the research area will be collected during the research activities using these instruments.

VII. ECOSYSTEM MODELING

Demands to develop and improve ecosystem model approaches to fisheries management are greatly increasing all over the world. Management based on multispecies models will be able to improve conventional single species management, even the RMP (Ulltang 1995). In the JARPN II project, ecosystem models suitable to the western North Pacific will be developed based on the models such as Ecopath (Christensen *et al.*, 2000) and Multspec (Bogstad *et al.*, 1997). These two models have been investigated separately as initial works (see Appendix 4).

The Ecopath model has the purpose to illustrate the trophic flows in the ecosystem of interest. It is being recognized in recent years that it is useful to construct food web and trophic structure using known data from fisheries and research activities. We will make use of this model to evaluate the relative importance of predator species and to know the distinction between keystone predators and trivial ones at the first stage. After the trials, Ecosim and Ecospace will be also used and examined to grasp dynamic change including changes in exploitation rates and the environment. Ecosim is a dynamic simulation model for predicting results of human and climatic impact on ecosystem components. Ecospace is a spatial equilibrium model and predicts biomass and exploitation distribution over two-dimensional space.

On the other hand, construction of the Multspec model, which is achieving some success in the Norwegian aquatic ecosystem, is to be undertaken. The model integrates the dynamic of each fish and marine mammal species and focuses on a few groups with direct interactions. Unlike Ecopath, there are some difficulties to include many species and complicated food web. However, it is possible to examine the dynamic changes of each entry in details. At the first stage, we will consider a simple model to include minke whale, Pacific saury, Japanese anchovy and krill (Appendix 4). This enables us to utilize available information to a maximum and describe dynamic changes including various uncertainties and predict future interactions among cetaceans and fisheries.

As mentioned above, each of Ecopath and Multspec has different characteristics. Ecopath is useful for understanding the overall ecosystem and Multspec for describing main interactions and detailed dynamics. Indirect and complicated effects can be comprehended through Ecopath-type model and the influences of the uncertainty of parameters and migration should be examined using Multspec-type model. The integrated model with advantages of Ecopath and Multspec will be constructed to be able to predict the dynamic changes more precisely. Through demonstration and quantifications of interactions between cetaceans and fisheries with sufficient precision, we can provide the basis of advice concerning multi-species management.

The construction of integrated model and the extensive sensitivity analyses for various parameters are likely to take several years before completion. At first, outputs from both models obtained over four years will make clear their advantages, faults and shortcomings in detail. In the subsequent years, we will make trials to integrate the two models into one model. Also new information obtained from JARPN II will be incorporated to the models as appropriate. The outputs from the models should also be fed back to the JARPN II surveys. These ecosystem model trials will be reviewed at IWC/SC along with a comprehensive report of JARPN II following six-year research.

VIII. EFFECTS ON THE RESOURCES

The effects on the minke, Bryde's, and sei whale stocks of future catches under special permit of JARPN II are examined in Appendix 6. The assessment is based on the standard HITTER method (Butterworth, 1996).

For minke whales, one case is examined. Total 150 minke whales will be sampled, 90 of which are to be caught from sub-areas 7 and 30 from each of sub-areas 8 and 9. Incidental catches same as option Jii) in IWC/SC is taken into account (IWC, 2001b). Two scenarios on O Stock are used. i) all of sub-areas 7+8+9+11+12 are O Stock, and ii) sub-areas 7+8+9+11+12 (70% in sub-area 9 and 81.3% in sub-area 12) are O Stock. The effects of the catch on the stock are assessed from the trend of abundance. HITTER calculations show that, for all cases, the minke whale stocks would increase. Therefore it can be concluded that the effect on the minke whale stocks is negligible. Details of the calculations are shown in

Appendix 6.

Fifty Bryde's whales will be sampled from the Western North Pacific Stock. Because the proposed sampling area is far from the coastal region of southwest Japan, in which the East China Sea Stock extends (Pastene *et al*., 1997; Yoshida *et al*., 1997; Yoshida and Kato, 1999), it is unlikely that Bryde's whales from other stocks will be taken. Two scenarios are used according to the recent IST. i) a single stock exists in sub-areas 1 and 2, and ii) a single stock exists in sub-area 1. The effects of the catch on the stock are assessed in the same way as in the minke whale. HITTER calculations show that for all cases the Bryde's whale stocks would increase. Therefore it can be concluded that effect on the Bryde's whale stock is negligible. Details of the calculations are shown in Appendix 6.

As for sei whales, 50 animals will be sampled. One scenario that there is two stocks in North Pacific divided by 180 degrees longitudinal line is examined. The effects of the catch on the stock are assessed in the same way as in minke and Bryde's whales. HITTER calculations show that for all cases the sei whale stocks would increase. Therefore it can be concluded that effect on the sei whale stock is negligible. Details of the calculations are shown in Appendix 6.

Sperm whales will be sampled from the Western Division Stock. While no calculation was made for sperm whales, the sample size is so small (10 animals) compared to the abundance and obviously well below the critical level to affect the stock.

IX. OTHER MATTERS TO BE CONSIDERED

1. Processing of cetaceans sampled

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

2. Reports to the IWC/SC

A report of each cruise will be submitted to annual meetings of IWC/SC and to other organizations. A report on the two-year feasibility surveys by small type whaling catcher boats will be submitted to the IWC/SC following completion of the survey to check the logistic feasibility. At the same time the results of sample size recalculation for sei whales will be reported using the new data. A comprehensive report following six-years of research will be submitted to IWC/SC.

3. Killing methods

All the whale sampling will be carried out in a quick and effective manner by means of explosive harpoons. When whales are not killed instantly with the primary killing method, an appropriate secondary killing method will be chosen according to the whale species and whale condition. For minke whales, a large caliber rifle will be used in principle as a secondary killing method. For Bryde's, sperm whales and sei whales, appropriate quick and efficient methods such as large caliber rifle and second explosive harpoon will be used as secondary killing method, if necessary.

X. SUMMARY OF PROGRAM IN RELATION TO THE IWC GUIDELINES FOR RESEARCH TAKE

A number of guidelines for the review of scientific permit proposals have been given by the Commission. All the guidelines grouped under five headings (Donovan, 2001) are follows,

(A) The Proposal

The research plan adequately specifies the four sets of information required under paragraph 30 of the Schedule; (a) objectives of the research, (b) number, sex and stock of the animals to be taken, (c) opportunities for participation in the research by scientists of other nations, and (d) possible effect on conservation of stock.

(B) Objectives

The overall goal of JARPN II is to contribute to the conservation and sustainable use of marine living resources including whales in the western North Pacific, especially within Japan's EEZ. Toward the overall goal, three objectives are set, 1) feeding ecology and ecosystem studies, 2) monitoring of environmental pollutants, and 3) elucidation of stock structure. The first and second priorities are placed on the first and second objectives, respectively.

The information obtained from the feeding ecology and ecosystem studies is needed to understand the role of cetaceans in the ecosystem. Also, the competition between cetaceans and fisheries is one of the major issues at IWC/SC. In relation to these matters, several hypotheses will be examined in the studies: Do cetaceans consume a large quantity of fisheries resources compared to the catches of commercial fisheries? Does the consumption by cetaceans have a significant impact on natural mortality and recruitment of the prey? Inversely, does the abundance and distribution of the prey species affect the migration pattern, recruitment and geographical segregation by sex of cetaceans? Do sperm whales have an impact on the surface ecosystem? The answers to these hypotheses will contribute to the science-based rational management of whales as well as to the management of fisheries resources.

The monitoring of environmental pollutants in cetaceans and the marine ecosystem, is a significant component of the IWC's concern regarding environmental change. The information obtained through this program is expected to document levels of environmental pollutants and contribute to our understanding of the process of bioaccumulation through the food chain.

Questions addressed for the stock structure studies of minke and Bryde's whales are clearly relevant for the RMP/IST of these species in the western North Pacific. For sperm and sei whales, the Comprehensive Assessment (CA) has not yet been carried out. The attainment of information on stock structure as well other biological information such as growth rate and maturity will contribute to the future CA of these species in the North Pacific.

The proposed numbers of minke, Bryde's, and sei whales to be sampled are necessary to estimate the amount of prey consumption with appropriate accuracy. The calculation of sample size is based on the data obtained from JARPN surveys and JARPN II feasibility study (Appendix 5). Furthermore, these levels of samples are necessary for the studies on stock structure. Although larger samples are required for detailed pollution monitoring, these sample sizes are adequate for some analyses.

(C) Methodology

Both lethal and non-lethal methods will be used in JARPN II. The objectives cannot be attained only by means of non-lethal methods for practical and scientific reasons described below.

Among baleen whales, minke whales are opportunistic feeders and their prey composition shows drastic changes reflecting the distribution pattern and level of abundance of prey species (Kasamatsu and Tanaka, 1992). Existing data on stomach contents are only qualitative data from the commercial whaling period for all whale species, because the stomach contents were not weighed and not identified to the species level. Also, past analyses were mostly limited to the commercial catches that were taken in particular fishing grounds and seasons. In addition, whalers usually damaged the stomach by cutting the abdominal cavity. Quantitative research on stomach contents began in JARPN for minke whales and in JARPN II feasibility survey for Bryde's whales. Research on excrement does not give very reliable results on the prey composition in the stomach (e.g. Smith and Whitehead, 2000). Prey preference can be studied only by using the lethal method, in which whales are caught and their stomach contents are examined in parallel with the concurrent survey of prey species. The concurrent whale and prey surveys have been conducted for the first time for the North Pacific in JARPN II feasibility survey. In the full-scale JARPN II, the concurrent surveys will be conducted so that whales and fish are sampled as near to simultaneously as possible in both space and time. Further, data on body condition, especially fat, cannot be obtained by means of non-lethal methods.

The effect of pollution on cetaceans can be monitored by measuring the accumulated amount of pollutants such as organochlorine compounds and heavy metals as well as the observation of abnormalities in viscera and tissues. In addition, the interpretation of the level of contaminants should be made by taking into consideration other biological information such as the reproductive status and age. Age information is an important factor in examining the contamination levels, because these pollutants are accumulated with age. Usually lethal methods provide a more comprehensive and faster approach to this issue as compared with non-lethal methods such as biopsy sampling.

The methods proposed for studying stock structure are the same as in the JARPN, i.e. genetic and non-genetic analyses. While the genetic approach is considered the most useful method to examine stock structure, it should be recognized that DNA-based genetic analyses are complemented with the analyses of other biological data such as morphometrics and conception dates, which only can be obtained using lethal methods. The best strategy to examine stock structure is the use of different and independent approaches both genetic and non-genetic (example for this comprehensive approach is that used under the JARPN and presented and discussed at the JARPN review meeting and IWC/SC) (e.g. Hakamada and Fujise, 2000; IWC, 2001a; Fujise *et al.*2001). DNA-based genetic analyses can be conducted using biopsy samples, however, biopsy sampling is difficult to conduct for minke whales, especially in the open sea due to their quick and fast movement as well as the limitation of the cost.

Whales will be killed in a manner consistent with the provisions of Section III of the schedule as described in Item 3 of Chapter IX of the research plan.

(D) Effect of catches on the 'stock'

The most recent information on the stocks concerned is reviewed in Appendix 1 of the research plan. The possible effects on the minke, Bryde's, and sei whale stocks of future catches under special permit of JARPN II are evaluated using the standard HITTER method (Appendix 6). HITTER calculations show that minke, Bryde's and sei whale stocks would increase. Therefore it can be concluded that the effect on the stocks is negligible. While no calculation was made for sperm whales, the sample size is so small (10 animals) compared to the abundance and obviously well below the critical level to affect the stock. The research can be conducted without adversely affecting the success of the comprehensive assessment of all stocks.

(E) Research cooperation

Arrangements for participation by scientists of other nations are described in Item 7 of Chapter V of the research plan.

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